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The Shaping of Transport Model-Based Knowledge Production

An embedded case study of Danish transport modelling practice in a contemporary and historical perspective

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Publication date:
2013

Document Version
Tidlig version også kaldet pre-print

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Andersen, J. (2013). *The Shaping of Transport Model-Based Knowledge Production: An embedded case study of Danish transport modelling practice in a contemporary and historical perspective*. Institut for Samfundsudvikling og Planlægning, Aalborg Universitet.

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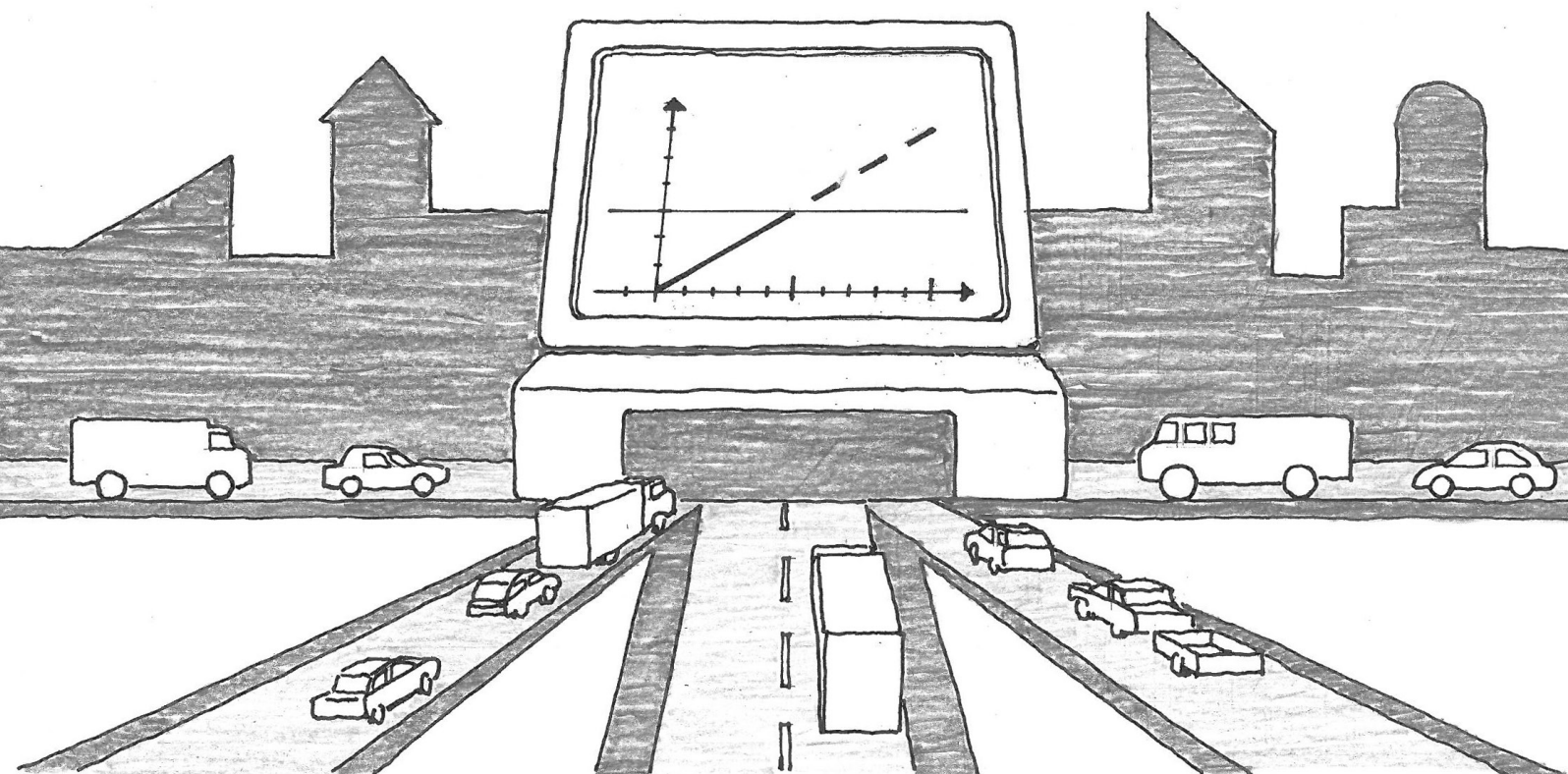
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The Shaping of Transport Model-Based Knowledge Production

*An embedded case study of Danish transport modelling practice in a
contemporary and historical perspective*



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An embedded case study of Danish transport modelling practice in a contemporary and historical perspective

PhD thesis by Jeppe Astrup Andersen
Department of Planning, Aalborg University
October 2013

PhD Thesis:

The Shaping of Transport Model-Based Knowledge Production: An embedded case study of Danish transport modelling practice in a contemporary and historical perspective

Final draft for submission

October 2013

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Cover illustration:

Anders Astrup Andersen & Mogens Bjørn Andersen, after idea by Jeppe Astrup Andersen

Printed by:

Uni-print, Aalborg

This PhD thesis is partly founded by the Danish strategic research council. The thesis is prepared as part of work packed 2, in the research project: Uncertainties in Transport Project Evaluation (UNITE).

Chapter 6 in this thesis is based on a rewriting of the following two co-authored papers:

Næss, P. & Andersen, J. A. (2010): Modeller, miljø og manipulation: Vidensfiltrering og magt i beslutningsprocessen omkring den 3. Limfjordsforbindelse. *Økonomi og Politik* vol. 83, no. 2, pp. 20-35.

Andersen, J. A. & Næss, P. (2010): Models, Environment and Manipulation: Power and Knowledge Filtering in the Decision-making process about the Third Limfjord Crossing. In: *Space is Luxury: Selected Proceedings of the 24th AESOP Annual Conference*. (Eds.) Peter Ache & Mervi Ilmonen, 2010. pp. 459-477 (Aalto University - School of Science and Technology - Centre for Urban and Regional Studies).

This thesis has been submitted for assessment in partial fulfilment of the PhD degree. The thesis is based on the submitted or published scientific papers which are listed above. Parts of the papers are used directly or indirectly in the extended summary of the thesis. As part of the assessment, co-author statements have been made available to the assessment committee and are also available at the Faculty. The thesis is not in its present form acceptable for open publication but only in limited and closed circulation as copyright may not be ensured.

Table of contents

Acknowledgments	I
Summary.....	II
Dansk resumé	IV
1 Introduction.....	1
1.1 Setting the scene	1
1.2 Research questions.....	4
1.3 Structure of the thesis	5
2 The content and contexts of transport models.....	7
2.1 Transport models - a technical planning tool.....	7
2.2 Comprehensive planning and computerized transport modelling	12
2.3 Problematic aspects of transport modelling practice	22
3 Theoretical perspectives on causes of bias and inaccuracy in traffic forecasting.....	29
3.1 Ontological perspectives	29
3.2 Technical perspectives	30
3.3 Psychological perspectives	31
3.4 Political-economic perspectives	32
3.5 Institutional/organizational perspectives.....	35
3.6 Selection bias.....	38
3.7 Need to widen the conceptual scope.....	38
4 Re-conceptualization - a multi-perspective framework.....	40
4.1 Expanding the conceptualization of power.....	40
4.2 Creation of order beyond the social.....	56
5 Methodology	72
5.1 Research design.....	72
5.2 Sources of empirical evidence.....	77
5.3 Exploring the embedded cases.....	81
5.4 Reflections on the process of the thesis.....	88
Embedded case 1.....	93
6 Neglect of induced traffic and acceptance within contemporary practise.....	94
6.1 Some main conclusions of the EIA report	96
6.2 Scrutinizing the assumptions of the traffic model	97
6.3 The complaint.....	99

6.4	Rationalizing acceptance of not including induced traffic.....	100
6.5	The role of the model	105
6.6	Sum up	106
7	A genealogy of induced traffic and transport project evaluation practice.....	107
7.1	From Royal decree to business case	107
7.2	From present to future demand	110
7.3	Induced traffic and the large infrastructure schemes of the 1960s	114
7.4	Sum up	123
8	Towards a sustainable transport policy	125
8.1	Development of a computerized transport model for Aalborg.....	125
8.2	The Dag Hammarskjöld breakthrough street	128
8.3	Adoption of land reservations for a Lindholm Line	129
8.4	Towards a sustainable transport policy	130
8.5	Reassessment of a third Limfjord crossing	132
8.6	The broader picture	136
8.7	Sum up	137
	Embedded case 2	138
9	Emergence of computerized transport modelling.....	140
9.1	Towards a comprehensive perspective on planning	140
9.2	The spatial policy controversy	162
9.3	The objective of developing a computerized transport model	174
9.4	Sum up	184
10	Development of a computerized transport model.....	186
10.1	Presenting the forecasting group	186
10.2	Initial considerations about the forecast's basic assumptions	187
10.3	Data Collection.....	190
10.4	Computer models	202
10.5	A new transportation study	207
10.6	Re-politicization of spatial planning and reopening of the computerized forecast	210
10.7	Completing the preliminary computerized forecast.....	228
10.8	Sum up	235
11	The partial results and the battle of Amager - a battle of truth.....	237
11.1	A forecast for the harbour crossing traffic.....	237
11.2	Bringing the secrecy to light	244

11.3	War on the knife: The battle among planning peers	247
11.4	The Copenhagen City Council.....	255
11.5	Sum up.....	257
12	Finalizing the preliminary forecast and the decision on the Lake-ring	259
12.1	The third progress report	259
12.2	The City Council's decision on the Lake-ring.....	265
12.3	The computerized forecast and de-reification of the Lake-ring.....	274
12.4	Did the State accept?	277
12.5	Epilogue	282
12.6	Sum up.....	289
13	Conclusion	292
13.1	Mechanisms shaping transport model-based knowledge production.....	292
13.2	Contributions to the understanding of why induced traffic often is neglected.....	292
13.3	Contribution to literature on the cause of inaccuracy and bias.....	307
13.4	Future work	315
	Bibliography.....	318
	Published material.....	318
	Unpublished material	329
	The Copenhagen City Archive/Københavns Stadsarkiv.....	329
	The State Archive/Rigsarkivet	330

Acknowledgments

This PhD thesis is the result of a long struggle, but also a rewarding process. There have been movements of excitement as well as despair. Even though I acknowledge myself for carrying through the PhD process and take full responsibility for the content of this thesis, I will certainly have to acknowledge others for the outcome as well.

First of all, I will like to give credit to two of my supervisors, who have guided me almost through the entire PhD process: Petter Næss, my main-supervisor and Tim Richardson, my co-supervisor. The quality of your work, has been far beyond expectations. Moreover, the combination of your respective skills and focus, has been the perfect set up for me. I could not have wished for a stronger team. I know that you did not always have an easy job in supervising me. However, even though that I did not always managed to convince you, I did, in most cases, take your comments into account. Indeed your critique and support have helped me overcome many obstacles and put me back on track, which I am grateful for. Maybe you don't see it yourself, but to me of you are both very present in this thesis.

I also owe big thanks to the Danish Council for Strategic Research and the Department of Planning at Aalborg University, for funding this PhD, which is part of a larger research project, titled: *Uncertainties in Transport Project Evaluation* (UNITE). The project includes five work packages in total, of which my thesis constitutes the second. I will like to thank all of the partners in the UNITE project. The discussions we have had during the project meetings have been very stimulating and have contributed to widen my horizon.

I also acknowledge the people, who as respondents took time off, to engage in discussions and reflections on the practice of transport modelling. My research group at Aalborg University, Urban Planning and Mobility, deserve recognition too. Not only have you all been good colleagues, you have also contributed to a stimulating academic environment. Particular thanks to Enza Lissandrello, who took over the responsibility of supervising me, after Petter and Tim, in the beginning of 2013, left Aalborg University, in favour of fresh challenges.

Lastly I owe my family and close friends big recognition. Not only have you put up with me, and the great amount of time which I have spent away from you, you have also supported me throughout the entire process.

Summary

This thesis takes an exploratory approach to the research question: *How is transport model-based knowledge production shaped and by which mechanisms?*

The background of this thesis is that previous work, based on statically generated comparisons between forecasted and observed traffic, has shown that results from traffic forecasts, upon which political decisions on transport infrastructure investments were based, have often been inaccurate and sometimes even systematically biased. Within state-of-the-art literature there appears to be consensus on these findings, but the cause of the observed discrepancies is contested. In the debate, ontological, technical and a number of social explanatory causes have been put forward for the observed forecasting inaccuracies. Most of these theoretical perspectives are inferred from the results of ex post evaluation studies. In this thesis it is, however, argued that the evaluation of model results, as the only object of inquiry, is invalid for comprehending how diverse and complex mechanisms, unfolding during the planning and decision-making processes, can shape transport model-based knowledge production. Within state-of-the-art literature, however, an empirical knowledge gap exists regarding how processes of transport model-based knowledge production unfolds, and this gap impacts the firmness of the conclusions drawn in many previous studies on the causes of predictive inaccuracy and bias.

The thesis aims to make an empirical, methodological and theoretical contribution to the literature on causes of predictive inaccuracy and bias in travel forecasting and presents new knowledge on mechanisms that shape transport model-based knowledge production, which goes beyond the scope of previous work in important ways. In order to fill parts of the empirical knowledge gap and obtain a deeper understanding of mechanisms shaping transport model-based knowledge production, the object of inquiry, is, in this thesis, shifted from an evaluation of model outputs, towards an exploration of the transport model knowledge production within the context of the planning and decision-making processes. Moreover, while previous work has mainly applied quantitative approaches, this thesis is based on qualitative methodologies. The thesis also applies a multi-perspective framework, going beyond some of the limitations of previous theorization, particularly in two ways. Firstly, where previous work has applied the concept of power as mainly comprehending manipulation and lies, this thesis applies a multi-perspective and dynamic conceptualization of power. Secondly, the framework goes beyond the division between social and technical perspectives, evident in most previous work, and conceptualizes how social and technical mechanisms, can affect each other and shape transport model-based knowledge production through mutual interactions.

The research question is addressed based on a single embedded case study of Danish transport project evaluation practice. Temporal and historical dimensions are important elements of the research design. Empirically, data has been collected using the following units of data collection: the front-stage, the back-stage and the audience of transport model-based knowledge production. The empirical sources employed to collect information from the respective units of data collection are qualitative interviews, planning documents, short-hand minuetts from political sittings, newspaper articles and archival materials.

The single case study consists of two embedded cases. The first of these cases, analyses induced traffic in respect of the transport project evaluation practice. In a contemporary context, it is shown that despite the fact that neglect of induced traffic from transport project evaluation is likely to cause bias, this simplification is, somehow, accepted by several key stakeholders, who among others take it as a generally accepted practice. History is then used to problematize this practice, and it is shown that there is nothing natural about neglecting induced traffic from transport project evaluation. The narrative resulting from this critical historical approach also provides new knowledge on why the practice of omitting induced traffic emerged. On this basis new hypotheses are advanced on why induced traffic often is neglected from transport project evaluation practice.

The second embedded case analyses the process of developing the first computerized transport model within Danish planning practice, designed by the Municipality of Copenhagen from 1962-68. The forecast resulting from this pioneering work turned out to be overestimated. These forecast results are then rolled back in time through the planning and decision-making processes in which they were produced and applied. Based on in-depth investigations of these processes, the mechanisms which shaped the transport model-based knowledge production are inferred. It is shown that multiple, diverse, subtle and dynamic mechanisms, pertaining not only to social and technical mechanisms, but also spatial dimensions, interacted and shaped the transport model-based knowledge production. Based on an evaluation of the forecast's accuracy alone, it would have been impossible to comprehend these mechanisms and their workings.

Despite the conclusion that the existing theoretical perspectives do not give an exhaustive account of the mechanisms shaping transport model-based knowledge production, the relevance of these perspectives is nevertheless confirmed in the thesis. That said, the fact that all of the existing perspectives are found somehow relevant, implies, that in isolation, they are inadequate for comprehending how transport model-based knowledge production is shaped. In order to advance state-of-the-art research on causes of predictive inaccuracy and bias, an extension of the prevailing paradigm is therefore called for, in which the transport model-based knowledge production should be explored within the context of the planning and decision-making processes as the primary object of empirical inquiry. Moreover, these explorations should be approached from a multi-perspective framework that includes explicit theorizing as to how mechanisms pertain to social, technical and spatial dimensions can shape transport model-based knowledge production through mutual interactions.

Dansk resumé

Denne afhandling tager en eksplorativ tilgang til forskningsspørgsmålet: *Hvordan er transport model-baseret vidensproduktion formet og hvilke mekanismer former denne vidensproduktion?*

Baggrunden for afhandlingen er, at tidligere forskning, der er baseret på statistisk genereret efterevaluering af prognosticeret trafik, sammenholdt med den faktisk observerede trafik, har vist, at resultaterne fra trafikprognoser, som har dannet en del af beslutningsgrundlaget for politiske transport infrastruktur investeringer, ofte er unøjagtige og nogle gange endda systematisk misvisende. Inden for den nyeste litteratur synes der at være enighed om disse resultater, men årsagen til de observerede unøjagtigheder og bias anfægtes. I denne debat har ontologiske, tekniske og en række sociale forklaringer været fremført som årsagen til de observerede prognose unøjagtigheder. De fleste af disse teoretiske retninger er opstillet på grundlag af resultater fra statistiske efterevalueringsstudier. I denne afhandling, hævdes det dog, at efterevaluering af modelresultater, som det eneste genstandsfelt, er utilstrækkeligt for at begribe, hvordan forskelligartede og komplekse mekanismer udfolder sig under planlægnings- og beslutningstagningsprocesser, hvor de er med til at forme den transport model-baserede vidensproduktion. Inden for den nyeste litteratur, eksisterer der en empirisk videnskløft med hensyn til, hvordan de processer hvori transport model-baserede viden bliver produceret, udfolder sig. Dermed er der også en videnskløft i forhold til de mekanismer der udfolder sig gennem disse processer. Denne videnskløft påvirker validiteten af de konklusioner, der drages i mange tidligere undersøgelser om årsagerne til prognoseunøjagtighed og bias.

Afhandlingen har til formål at bidrage empirisk, metodisk og teoretisk til litteraturen om årsager til prognoseunøjagtighed og bias i trafikprognoser. Desuden præsenterer afhandlingen ny viden om mekanismerne, der er med til at forme den transport model-baserede vidensproduktion. Denne viden rækker udover tidligere forskning på centrale områder. I forhold til det empiriske, vil afhandlingen søge at udfylde dele af videnskløften. Derfor er genstandsfeltet i denne afhandling, flyttet fra efterevaluering af model resultater, til en udforskning af transport model vidensproduktion inden for rammerne af planlægnings- og beslutningstagende processer. I forhold til det metodiske, hvor tidligere forskning hovedsageligt har anvendt kvantitative tilgange, er denne afhandling baseret på kvalitative tilgange. Teoretiske, er afhandlingen baseret på en flerdimensionel ramme, som rækker ud over nogle af de eksisterende teoriers respektive begrænsninger, især på to måder. For det første, hvor tidligere forskning indenfor området om årsager til usikkerhed og bias i trafikprognoser har anvendt begrebet magt, hovedsagelig som manipulation og løgne, tager denne afhandling udgangspunkt i en flere-konceptuel og dynamisk teoretisering af magt. For det andet, den opstillede teoretiske ramme, som afhandlingen tager udgangspunkt i overskrider også opdelingen mellem sociale og tekniske teoretiske forklaringer, som er fremherskende i de fleste tidligere studier. I stedet for konceptualiserer afhandlingen hvordan sociale og tekniske mekanismer kan påvirke hinanden og forme transport model-baserede viden produktion gennem gensidige interaktioner.

Forskningsspørgsmålet som denne afhandling udforsker, er besvaret baseret på et enkelt integreret casestudie af dansk transport projekt evalueringspraksis. I forskningsdesignet er tidsmæssige og historiske dimensioner vigtige elementer. Empirisk data er blevet indsamlet fra den transport model-baserede vidensproduktions for-scenen, bag-scenen og publikum. De

empiriske kilder hvor data er indsamlet fra, er arkivalier, kvalitative interviews, planlægningsdokumenter, stenografier fra politiske møder og avisartikler.

Det integrerede casestudie består af to cases. I det første af disse cases, analysers trafikspring i forhold til transportprojektevalueringspraksis. I en nutidig kontekst, er det vist, at på trods af at negligering af trafikspring fra evalueringer af transport projekter er tilbøjelige til at forårsage bias, bliver denne forenkling, på den ene eller anden måde, opfattet af flere vigtige aktører, som en generelt accepteret praksis. Historien bruges derefter kritisk til at problematisere, at negligering af trafikspring mere eller mindre udgør en praksis der tages for givet, og det er vist, at der intet naturligt er ved ikke at medtage effekten af trafikspring i evalueringen af transport projekter. Den narrative som følger af denne kritiske historiske tilgang bidrager også med ny viden om, hvorfor praksissen med at undlade trafikspring opstod. Blandt andet på dette grundlag bliver nye hypoteser fremsat om, hvorfor induceret trafik ofte er forsumt i forhold til transport projekt evalueringspraksis.

Den anden integrerede case analyser processen med at udvikle den første edb-baserede transport model inden for Dansk planlægningspraksis. Denne blev udviklet af Københavns Kommune mellem 1962-68. De prognoser, som blev opstillet, baseret på dette pionerarbejde, viste sig dog at være overvurderet. I denne case er prognoseresultaterne rullet tilbage i tid gennem de planlægnings- og beslutningstagningsprocesser, hvori de blev produceret og anvendt. Baseret på grundige empiriske undersøgelser af disse processer udledes og forklares herefter de mekanismer, der formede den transport model-baserede vidensproduktion. Det er vist, at flere forskellige, subtile og dynamisk mekanismer, som ikke kun vedrører sociale og tekniske mekanismer, men som også rumlige dimensioner, interagerer med hinanden og former den transport model-baserede vidensproduktion. På grundlag af en efterevaluering af prognosens nøjagtighed som genstandsfelt alene, kan det konkluderes, at det ville have været umuligt at begribe disse mekanismer og at forstå deres virke.

Trods den konklusion, at de eksisterende teoretiske perspektiver ikke giver en udtømmende forståelse med hensyn til de mekanismer, der former transport model-baserede vidensproduktion, er relevansen af disse perspektiver, ikke desto mindre bekræftet i afhandlingen. Det faktum, at alle de eksisterende teorier på den ene eller anden måde er fundet relevante, indebærer dog, at de hver for sig er utilstrækkelige til at begribe, hvordan transport model-baseret vidensproduktion er formet. For at opnå vigtige fremskridt indenfor den nuværende forskning i årsager til trafikprognose unøjagtighed og bias, er det derfor nødvendigt at udvide det gældende paradigme samt at flytte dets hovedfokus. Det er nødvendigt at transport model-baseret vidensproduktion, indenfor rammerne af planlægnings- og beslutningsprocesser, bliver undersøges som det primære genstandsfelt, i en langt højere grad end nu. Desuden bør fremtidige studier tage udgangspunkt i en flerdimensionel teoretisk ramme, som omfatter en eksplicit teoretisering af, hvordan mekanismerne der tilhøre sociale, tekniske og rumlige dimensioner, kan forme transport model-baserede vidensproduktion gennem gensidig interaktioner.

1 Introduction

This chapter sets the scene for the thesis. It starts by briefly introducing the background and the problem of the study as well as the motivation for conducting it. Next the research objectives, the main research question and a number of sub-questions are presented. Finally, the structure of the thesis itself is laid out.

1.1 Setting the scene

Travel is vital for sustaining society. It is a precondition for overcoming spatial detachments between individual and social activities. For instance, goods need to be transported between suppliers, producers and consumers, and employees need to travel between places of residence and workplaces. Moreover in order to sustain social relations through face-to-face contact, travel is a precondition. Yet, even though travel has a range of effects, perceived as beneficial from a societal point of view, it also has a range of undesirable externalities. The transport sector is, for instance, one of the sectors in society with the highest environmental load and is also associated with considerable health impacts. Some of these impacts are local and regional in scope, while others are global (Holden 2007).

When planning new transport infrastructure projects, positive and negative effects have to be balanced against each other in accordance with political objectives. However, before the various impacts can be balanced, they will have to be rendered knowable. Because infrastructure provision is often very costly for society and because some of the impacts are more or less irreversible (e.g. landscape intrusion and global warming) a trial and error approach will not do. Instead, the impacts of transport infrastructure provision will have to be rendered knowable prior to implementation. This implies that the impacts will have to be predicted. Nevertheless, travel behaviour is a highly complex phenomenon, so predicting future travel accurately is difficult. Travel behaviour is the aggregated result of many individual choices. These choices are facilitated and constrained by social variables, spatial material structures¹ and technology. The social variables constitute age, gender, values and norms, discourses, status, income and household composition (Curtis & Perkins 2006). Material spatial structures shape travel behaviour by creating proximity and distance between activities, and thereby facilitate some forms of behaviour while constraining others (Næss 2006a). Technology also shapes travel behaviour. For instance the advancements within the field of transportation technologies have allowed for movement at higher speeds, larger capacity vehicles and a reduction in travel costs. Moreover, in accordance with material spatial structures, different transport technologies create different conditions of possibility for travel, facilitating some forms of behaviour while constraining others. The complexity of travel behaviour is, however, not constituted by social, spatial material and technical matters distinctly, but rather through mutual interactions between all of them.

¹ Material spatial structures consist of both natural structures (e.g. topography) and socially constructed material spatial structures (e.g. the layout of infrastructure systems and the geographical distribution of activities)

Predictions of travel behaviour can be carried out by various methods of knowledge-producing technologies ranging from qualitative to quantitative, from simplistic to sophisticated tools (Næss 2004b). Yet due to the complexity of travel behaviour, mathematical modelling is the forecasting method most commonly used within the contemporary planning practice. Mathematical transport modelling is a quantitative scientific decision support tool, consisting of a series of equations, representing assumptions about how people travel. Based on a number of input variables (e.g. car ownership, level of affluence, petrol price, employment, demographic development, geographical distribution of residents and jobs, etc.) transport models are used to predict future travel behaviour and a range of features tied up to this behaviour (time usage, vehicle kilometres travelled, modal split, route choice, etc.). Transport models are usually also used to evaluate different build-alternatives in comparison with a no-build alternative. In many cases the data and computing requirements needed to carry out the above-mentioned transport model computations are so great that it is practically impossible to do the calculations manually. Therefore transport models are commonly implemented in a software program and run on a computer. The outputs of transport model calculations are used as a base for sizing the capacity of proposed infrastructure projects, as well as optimizing layouts. Transport model outputs are also commonly used as inputs to the modelling of travel-related environmental and health impacts as well as to cost-benefit analyses (Rich 2010).

Hence, transport modelling underpins much of the knowledge production about implementation effects of proposed transport infrastructure projects. By rendering the implementation impacts of transport project proposals accessible to the appropriate individuals prior to decision-making, transport models potentially enable decision-makers to select projects for approval with the highest degree of goal attainment in respect to prevailing transport-political objectives, and to deselect projects unfavourable in that regard. On that ground it can be argued that accurate transport modelling contains a potential for rationalized decision-making on transport policy. Nevertheless, the background of this thesis is that previous work, evaluating the predictive accuracy of travel forecasts, has shown, rather consistently, that transport model predictions are often inaccurate and sometimes even systematically biased (see section 2.3). This implies a risk of projects, ineffective in respect to fulfilling prevailing transport political objectives, being approved on false grounds. Decision-making based on transport model outputs are hence less rational than it may appear.

Despite the fact that it is commonly accepted within the state-of-the-art literature that transport model predictions in general are inaccurate, the mechanisms constituting the primary causes of inaccuracy and bias are contested. In the debate, ontological, technical, psychological, political-economic as well as institutional/organizational theoretical perspectives have been put forward. Within the context of inaccuracy and bias in transport model-based knowledge production, this thesis aims to obtain a deeper understanding of mechanisms shaping transport model-based knowledge production and will present new empirical and theoretical knowledge, which in important ways goes beyond the scope of previous works.

Within the literature on causes of inaccuracy and bias in travel forecasting there is an empirical knowledge gap in respect to how the processes of transport model-based knowledge production unfold. Instead, current theorization of causes of inaccuracy and bias are primarily inferred from statistical comparisons between forecasted and observed traffic. However, transport model

outputs as the only object of enquiry are insufficient to account for the diverse, multiple and complex mechanisms unfolding during the planning and decision-making processes, potentially shaping transport model-based knowledge production. In order to advance understanding on the causes of bias and uncertainty, it is necessary to investigate in depth the processes of transport model-based knowledge production within the context of transport planning and the decision-making processes. There are, however, only a few previous studies which have investigated such processes and the fact is that we know only little about how processes of transport model-based knowledge production unfold. In order to fill parts of this knowledge gap and contribute to obtaining a deeper understanding of mechanisms shaping transport model-based knowledge production, the object of inquiry has, in this thesis, shifted from the evaluation of model outputs towards transport model knowledge production within the context of the planning and decision-making processes. Moreover, while previous work to a large extent is based on quantitative methods, this thesis applies qualitative methods to investigate the mechanisms that shape transport model-based knowledge production.

The shift in the object of inquiry has implications for the theoretical approach taken in this study. The mechanisms that influence the unfolding of the planning and decision-making processes, potentially shaping transport model-based knowledge production are multiple, complex and diverse. This implies that they cannot be contained by mono-causal theoretical perspectives, advanced in most previous work². In order to better account for the diverse mechanisms potentially shaping transport model-based knowledge production, a theoretical framework is developed, which goes beyond the scope of previous theorization, particularly in two respects. Firstly, while previous work has applied the concept of power as comprehending manipulation and lies, this thesis applies a multi-conceptual perspective, using a dynamic framework of power, revolving around acceptance and non-acceptance as key concepts. Secondly it goes beyond the division between social and technical perspectives and conceptualizes the social and technical as mutually interacting.

Even though the thesis is concerned with obtaining an understanding of mechanisms shaping transport model-based knowledge production in broad terms, a particular focus is put on the concept of induced traffic. The phenomenon of induced traffic is connected with the way in which the expansion of infrastructure supply can facilitate a range of behavioural responses, causing additional travel (see section 2.3.2). The special focus on induced traffic is motivated by the observation that within Danish planning practice, as well as within planning practices in a wide range of countries worldwide, it has traditionally been common practice to use transport models, neglecting this effect. The consequences of neglecting induced traffic from a model-based evaluation of transport infrastructure projects are that traffic-related environmental and health impacts tend to become systematically underestimated in the build-alternatives relative to non-build alternatives. This is particularly problematic because such results are misleading in respect to fulfilling current transport policy objectives of reducing the environmental load of the transport sector. Despite the fact that this practice has been criticized for decades, it nevertheless appears to have been accepted. This thesis also aims to increase the understanding of why and how the practice of neglecting induced traffic emerged as well as to query the grounds upon which it has been accepted within planning practice, and indeed continues to be

² See Næss (2011) for an important exception.

so. It also aims to problematize the sometimes taken-for-granted neglect of induced traffic within contemporary planning practice.

Summing up, the research objectives of this thesis are to:

- Contribute empirically, methodological and theoretically to the state-of-the-art literature on causes of inaccuracy and bias in travel forecasting.
- Contribute to gain a deeper understanding of why it is often accepted not to include the effect of induced traffic within standard transport models applied within contemporary planning practice; gain a deeper understanding of why the practice of neglecting induced traffic emerged and has been sustained; to problematize the contemporary practice of neglecting induced traffic.

1.2 Research questions

Based on the above, the following overall research question is addressed in this thesis:

How is transport model-based knowledge production shaped and by which mechanisms?

This research question will be approached, based on a single embedded case study of Danish transport modelling practice, including temporal and historical perspectives as important dimensions. The single case study design consists of two embedded cases relating to the overall research question differently. The first embedded case zooms in on induced traffic, and investigates mechanisms related to its inclusion or non- inclusion in transport project evaluation practice. The second embedded case is broader in scope than induced traffic and investigates mechanisms shaping transport model-based knowledge production in a more explorative manner. Laid out below, the two cases and the respective sub-research questions addressed in each case will be presented and it will be discussed how each embedded case relates to the research objectives.

1.2.1 Embedded case 1

An important issue shaping transport model-based knowledge production concerns whether the effects of induced traffic are included in the model assumptions or not. The first embedded case therefore analyses induced traffic in respect to Danish transport project evaluation practice, within a contemporary and historical perspective. The contemporary part of the embedded case, aims to fulfil the research objective of contributing to advance the understandings of why non-inclusion of induced traffic in standard transport models is often accepted within contemporary planning practice. The embedded case also serves to fulfil the research objectives about, problematizing the neglect of induced traffic within Danish planning practice, advancing the understanding of why the practice of neglecting induced traffic emerged and was accepted. In order to fulfil these two research objectives, a critical historical approach is taken, where the concept of induced traffic, in respect to Danish transport project evaluation practice, is rolled back in time through planning history. History is here used as a means to raise discursive consciousness about the fact that there is nothing “natural” about the contemporary practice of neglecting induced traffic. The historical enquiries also enable the testing of existing

propositions, about why induced traffic traditionally has been neglected, as well as to build new hypothesis. In the first embedded case, the following sub-questions are addressed:

- i. *How is acceptance of neglect of induced traffic rationalized within contemporary transport modelling practice?*
- ii. *Why was induced traffic not included in the structural framework of computerized transport modelling when this practice emerged within Danish planning practice?*
- iii. *How did transport modelling practice transform as a reaction towards increased prominence of environmental and health concerns on the transport political agenda?*

1.2.2 Embedded case 2

The second embedded case concerns the emergence, development and use of the first computerized transport model within Danish planning practice. The case is hence historical in scope but nevertheless it aims to make a contribution to the contemporary literature on causes of inaccuracy and bias in travel forecasting. In accordance with the dominant approach, the accuracy of the forecast results, which the model produced, is evaluated against observed traffic. However, instead of inferring the cause of the observed inaccuracy from ex post evaluation of the model output, the forecast is rolled back in time though the planning and decision-making processes in which it was produced and put to use. On the basis of in-depth empirical investigations into these processes are the mechanisms which shaped the transport model-based knowledge production inferred. The sub-research questions, addressed in the second embedded case are as follows:

- iv. *How and why did computerized transport modelling emerge within Danish planning practice?*
- v. *How were the development of the transport model and the making of alternatives shaped by various mechanisms?*
- vi. *How where the model results put to use and did they gain acceptance?*

1.3 Structure of the thesis

The thesis is structured as follows: In Chapter 2 the technical content as well as the planning context of transport models is introduced. The chapter also explores theories of planning which transport modelling has traditionally been tied to. Additionally, the presumable role of transport models within these approaches is discussed. Chapter 2 also elaborates on some problematic aspects of contemporary transport modelling practice, namely predictive uncertainty and bias. Next, Chapter 3 provides an overview of and discusses pros and cons of different theoretical perspectives on mechanisms shaping transport model-based knowledge production, which cause predictive uncertainty and bias. Chapter 4 sets out to develop a multi-dimensional theoretical frame, which conceptualizes mechanisms shaping transport model-based knowledge production. This framework acknowledges the contributions made by existing theoretical perspectives, but attempts to go beyond some of their respective limitations. Next, the research design and the methodological considerations concerning how to study mechanisms shaping

transport model- based knowledge production is elaborated upon in Chapter 5. The first embedded case study, concerning induced traffic with respect to the Danish transport project evaluation practice is analysed in Chapters 6-8. In the first of these, Chapter 6, it is investigated how non-inclusion of induced traffic is rationalized within contemporary planning practice. This is followed a genealogy of induced traffic in relation to transport project evaluation in Chapter 7. The objective of rolling the concept of induced traffic back in history is partly to problematize non-inclusion within contemporary practice and partly to gain a deeper understanding of why the practice emerged where it seemingly was perceived acceptable not to include the effect of induced traffic within transport modelling practice. Chapter 8 analyses induced traffic with respect to Danish transport project evaluation practice in the time span between the periods scrutinized in Chapter 6 & 7 respectively, namely the early-1970s to the late-1990s. The Chapter particularly explores the issues concerning how transport modelling practice transformed as a reaction towards increased prominence of environmental and health concerns on the transport political agenda. The second embedded case study concerns the emergence, development and use of the first computerized transport model with Danish planning practice and is analysed in Chapters 9-12. The situated context of how and why computerized transport modelling emerged within Danish planning practice is explored in Chapter 9. Here, the focus is particularly on transformations occurring within planning practice during the 1950s, facilitating the emergence of computerized transport modelling, as well as on the political context in which the emergence was situated. The process of developing the first computerized transport model is observed and discussed in detail in Chapter 10. Here, the focus is shifted back and forth between the content and the context of the model and the mechanisms shaping the development of the model is inferred. In Chapter 11 the first partial results produced on the basis of the computerized transport model is scrutinized. The way in which the model results were put to use is also elaborated upon, and whether they gained acceptance among planning peers. Next the process of finalizing the computerized forecast as well as how the completed results were put to use are analysed in Chapter 12. Whether the computerized forecast gained acceptance at the local and the national level respectively will be scrutinized. Lastly, the chapter elaborates upon different reasons as to why the computerized forecast never fulfilled. Chapter 13 concludes by synthesizing and integrating the knowledge produced in the two embedded cases. Based upon the findings, an answer to the overall research questions is drawn up. Lastly, the contributions of the thesis to the two main research objectives will be discussed.

2 The content and contexts of transport models

This chapter introduces the technical content of classical transport models and their planning contexts and is structured into three parts. In the first part, a definition of a model is provided and the technical framework of classical transport models is introduced. The second part elaborates the planning contexts of transport models and their historical emergence. Computerized transport models were originally developed in the USA in the 1950s and emerged and were institutionalized in a period of time where the discourse among planners was strongly influenced by the ideal of comprehensive planning, particular in the form of comprehensive-rational and system approaches to planning. These approaches were also manifested in the practice of comprehensive transportation studies, which early computerized transport modelling was tied into. In order to elaborate at a later stage how these planning approaches served as mechanisms shaping transport model-based knowledge production, their underlying assumptions are introduced and the role that transport models were envisioned to undertake within comprehensive transport planning is elaborated on. In the last part of the chapter some problematic aspects of contemporary transport modelling practice are elaborated upon, in respect of predictive inaccuracy and bias, with special attention on induced traffic.

2.1 Transport models - a technical planning tool

This section first provides a definition of transport models followed by an introduction to the technical framework of classical transport models. The purpose of this introduction is neither to discuss the-state-of-art within transport modelling, nor to give a detailed technical account of how transport models work. Rather the technical introduction serves a pedagogical purpose, giving the reader an insight into the basic principles of transport model-based knowledge production.

2.1.1 Defining a model

Before elaborating on the content of transport models, let us first and foremost zoom out and start more generally by defining what a model is. A model can broadly be defined as:

“... a simplified representation of a part of the real world - system of interest - which focuses on certain elements considered important from a particular point of view.” (Ortúzar & Willumsen 2011, 2)

According to Ortúzar & Willumsen (2011) a model is a simplified representation which is not universal but context-dependent and therefore problem- and viewpoint-specific. Within this broad definition both physical and abstract models can be categorized. Physical models are for example used in architecture to depict the physical design of a city, a district or a building. Abstract models include mental models (e.g. interpretation frames) and more formal models. For instance a theory is an abstract model which conceptualizes a simplified representation of the real world and how it works. Mathematical models are another category of abstract models. A mathematical model is a representation of a system of interest, which is based on mathematical concepts and languages. A transport model is a mathematical model and it consists of:

“a series of mathematical equations that represent how choices are made when people travel” (Beimborn, Kennedy & Schafer 1996)

No model is capable of including all factors influencing travel behaviour and models will hence not be able to replicate reality with perfect accuracy (Beimborn, Kennedy & Schafer 1996). Hence, despite the fact that transport models can be very complex and often require highly skilled engineering labour and large amount of data in order to be operated, they are, like any other model of the world, as per definition, a simplified representation. Simplification is not in itself a problem, but a condition for transport modelling. However, in situations where important variables or the relationship between them are systematically omitted from models, oversimplification equals bias. This will be returned to at the end of chapter.

2.1.2 Sequential four-step transport models

The main framework of classical transport modelling, consisting of four sequential steps, will briefly be introduced in this sub-section. Before elaborating on each step respectively, the necessary pre-work with collecting data and designing alternatives will be presented.

When preparing a forecast on the basis of the sequential four-step framework, it is first of all necessary to define a study area and divide it into a number of zones. Often the zones are smaller in the inner-city areas where residential and job densities are relatively high. The spatial resolution of the zones and the detail of the infrastructure network also depend on the problem at hand. The more detailed the results that are requested, the more a disaggregated geographical resolution is needed. Initially, it is also necessary to collect travel data for each zone resembling the base-year of the forecast. Broadly speaking, three units of data collection are usually considered necessary, namely: land use, travel and transport networks. In respect to land use, the type of data needed concerns population size, employment, shopping facilities, educational institutions, traffic facilities, etc. In respect to travel data, both information about household characteristics and travel behaviour is needed. Concerning the household characteristics, it is usually considered necessary to include data on income, family structure, level of education, car ownership, type of dwelling, etc. In respect to travel behaviour, it is usually considered necessary to include data on trip frequency, origin and destination of trips, mode choice, etc. This type of data is often obtained through interviews (either by phone or in people's homes), but as it is only information about people residing within the study area which are captured this way, the interview method is supplemented with traffic counts and roadside interviews in a cordon around the study area. Moreover, traffic is counted, which crosses a number of so-called screenlines dividing the study area into different segments. Thirdly, it is also necessary to collect data on the infrastructure networks overlaying the zones. The type of information needed concerns road length, capacity, travel speed, parking availability and cost, etc. In respect to transit, the system has to be characterized by the extension of net, timetables, travel time, capacity, fee levels, etc. The quality of the data is of course essential for the accuracy of the forecast. Limited data availability can be an obstacle for model sophistication. If there is no data on a variable that is considered salient for travel behaviour, this variable will be difficult to include in the model. Moreover, as the data requirement for drawing up a traffic model is very large, data collection is often very resource demanding and in many cases incomplete data

has been accepted as a foundation of models (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964).

Data do not only have to be provided for the base-year, but also have to be estimated for the forecasting year and distributed on the individual zones. If a land use plan is available for the study area, it can be used as base for drawing up the future geographical distribution of land use data. It is also necessary to draw up proposals for the future transport network. As transport models are often used to evaluate different development alternatives (either in respect to urban development or infrastructure systems) these also have to be defined for the forecast year (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964).

The model then has to be calibrated. This is often done by making a prediction for the base-year, which is then compared with traffic counted across a number of screenlines within the study area. The parameters of the model are then adjusted until an acceptable correspondence is reached between calculated and counted traffic. When the model has been calibrated, the next step in preparing the forecasting is to calculate future travel between origins and destinations, modes and routes. In other words it is time to run the data for the forecast year through the four model-steps. Basically, the issue addressed in each step corresponds to the following questions, namely:

1. Trip generation = shall I travel?
2. Trip distribution = where shall I travel to?
3. Modal split = which mode of transport shall I use?
4. Assignment = which route shall I take?

In the first step, trip generation, the number of trips produced (traffic out-bound from the area) and attracted (traffic in-bound to the area) within each zone is estimated based on the land use and socio-economic data. A zone's trip production is often based on a number of household characteristics (e.g. household size, number of employees, car ownership, income, etc.), while the amount of attracted trips usually is determined by employment rate, shopping facilities, cultural institutions, etc. The outcome is the total number of personal trips generated and attracted within each zone (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964).

In the second step, trip distribution, the outcome of the first step is used to estimate how many of the trips generated in each zone are attracted to each zone. The result of this computation is a trip matrix. Different methods can be used to calculate the distribution of trips between zones. However, the method most commonly applied (particularly in Europe) is the so-called gravity model. The gravity model is based on the principle that travel between a pair of zones is dependent on their individual force of attraction (e.g. number of workplaces, cultural institutions, etc.) as well as the distance between them. This implies that more traffic is distributed to zones with a high attraction than to zones with low attraction and that travel between two zones decreases as the distance between them increases. The gravity model was originally developed back in 1891 by the Austrian rail engineer Eduard Lill and was proposed as a solution to the problem of forecasting future ridership (Lill 1891[1969]). The gravity model has been widely utilized since then in various forms within road planning. As its name indicates, the

gravity model was originally developed in correspondence with Newton's theory of gravity. This is also evident from Lill's original mathematical expression of the formula:

$$T_{1-2} = k \frac{P_1 \times P_2}{d^2}$$

Where

T_{1-2} is the traffic volume measured in number of trips between the two areas 1 & 2

P_1 and P_2 is the two area's respective force of attraction

D is the distance between the two areas and its exponent is called the distance exponent

K is a constant

While Lill considered the gravity formula as a natural law, in accordance with Newton's theory, this assumption was later criticized and corrected in several regards. The subsequent modifications include use of other values for the distance exponent, different measures for an area's force of attraction (e.g. population size or/and car ownership), different indicators for the distance between the two areas expressed in generalized cost (e.g. road distance, travel time, travel costs, comfort). Instead of using 2 or other predefined values for the distance exponent, methods have been developed where the constant and the distance exponent are estimated based on empirical data, through an iterative process. Moreover, instead of using a uniform distance exponent for the entire study area, methods have been developed to estimate the exponent individually for each zone (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964). As we will see later in this thesis, the gravity model was deeply embedded in Danish transport planning practice both before and after computerized transport modelling emerged within Danish planning practice.

In the third stage, modal split, the traffic between zones calculated in the previous step is split on transport modes. It is, however, not all models which are multi-modal and the modal split stage is therefore not always included. Among those models, including modal split, the modes included can vary between two or more of the following type of road users: transit, car drivers, car passenger, cyclist and pedestrian, etc. Modelling of modal split can be done by many different methods and can be based on different variables e.g. travel time, convenience, price, parking availability and costs, level of transit service, the geographical distribution of trips (e.g. differentiating between city-oriented trips and trips oriented towards the urban outskirts), car ownership, socio-economic status, household structure, period of time (e.g. peak hour, night), reliability and regularity (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964).

In the fourth stage, assignment, traffic is distributed on the infrastructure network assumed in the model. In the assignment model the shortest path between origins and destinations is first calculated. Traffic between zones is then assigned to the network accordingly. If the process is stopped hereafter, the method is called an "all or nothing" assignment. This approach does not, however, account for how capacity restraints influence route choice. If all traffic is assigned by the fastest routes, this may imply that some links becomes congested, whereby travel speed

decreases and some road users would shift to another route. However, as this effect cannot be expressed in an all or nothing assignment, such an assignment model is therefore biased towards assigning too high a traffic volume on larger roads and too little a volume on smaller roads. In order to circumvent this problem it is necessary to iterate the assignment procedure until equilibrium in the network is reached between the different links. This implies that no individual can change route without increasing travel time. In order to calculate how capacity utilization influences route choice, it is necessary to define a number of speed/flow relations based on observations about how capacity utilization affects travel time (Beimborn, Kennedy & Schafer 1996; Ortúzar & Willumsen 2011; Overgaard 1964).

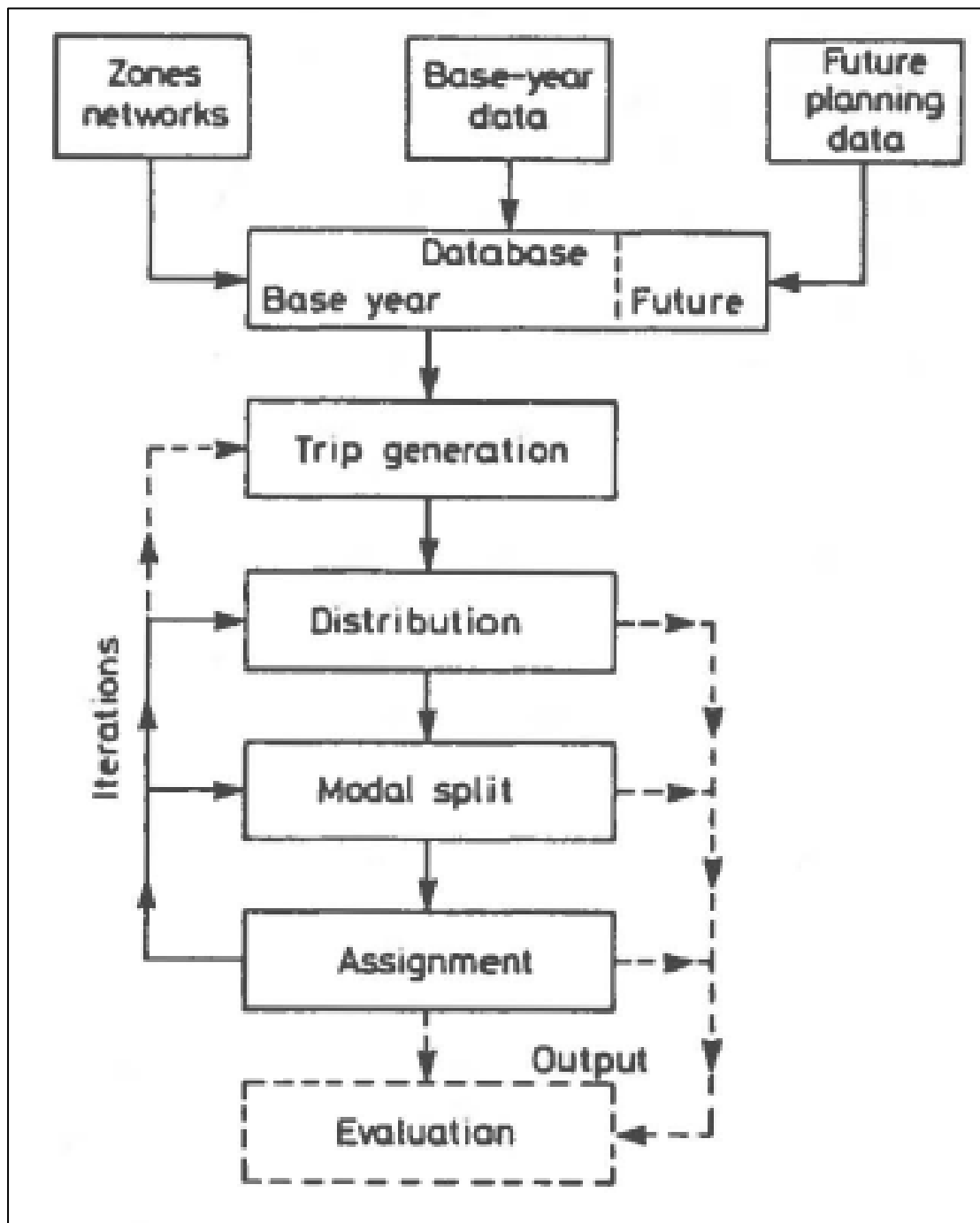


Figure 2.1: The structure of the classic four-step transport model, with feed-back loops (Ortúzar & Willumsen 2011, p. 21)

As the name of the sequential four-step procedure indicates, the individual steps were originally conducted one by one in a linear sequence. This procedure has been criticized, because the rational underpinning travel behaviour does not correspond to such a linear logic. For instance, congestion discovered along some routes in the assignment model may not only involve people choosing another route, but may also imply that people choose to travel by another mode or to another destination. The responses to these problems have been to include a feed-back mechanism between the different steps of the model. According to Mackett (1998) it is now rather common to include feedbacks from assignment to trip distribution and modal split which allows expression of how congestion influences both mode choice and destination choice. However, it is not as usual to include feedback loops all the way back to the trip generation or the underlining land-use assumptions (see figure 2.1). The effect of congestion does not, therefore, influence the underlining trip matrix which is treated as fixed. This implies that the behavioural response to congestion neither includes the choice to travel nor the travel's point of origin. Later, we will later return to the implications of these simplifications with respect to the modelling of induced traffic (see Section 3.2).

Even though the sequential four-step model structure, presented above, has traditionally been dominant within planning practice, alternative model structures have been available since the dawn of computerized transport modelling. One alternative is the so called trip-end modal-split model structure, where modal split composes the 2nd step, and trip distribution is the 3rd step. As can be seen, the order of the two steps is reversed relative to the above framework. The rationale behind the trip-end modal-split model is that personal features are regarded as the most important influencing mode choice. In the trip-end modal-split mode, modal split is often modelled based on income, residential density and car ownership only (some also included an accessibility index in order to depict the level of transit service) and does not account for journey features (e.g. trip purpose, time of day) or mode features (travel time, comfort, cost, parking availability). The computational needs of this model structure are less than for the model structure presented above. Moreover, the trip-end modal-split model has been proven very accurate within a short time frame, where the level of transit service is similar across the study area and there is no appreciable level of congestion. However, as the trip-end modal-split model does not include mode futures, calculation of modal split is an incentive to changes in the transit system. This type of model is hence not capable of reflecting the effect of transport policy initiatives on mode choice (e.g. improvements of transit service, road pricing, increased parking restrictions, etc.) and has on that ground been criticized for being closely tied up with the predict and provide paradigm (Ortúzar & Willumsen 2011, p. 209). This type of model structure was particularly applied in the early American transportation studies of the 1950s and 1960s, but was also used in Europe e.g. in the London and Glasgow transportation studies in the early 1960s (Black 1990; Ortúzar & Willumsen 2011; Overgaard 1964; Senior & Williams 1977). In the analysis of the embedded cases, it will be shown that this model structure was also applied within Danish planning practice.

2.2 Comprehensive planning and computerized transport modelling

After having introduced the technical content of transport models, we now turn to their planning contexts. The emergence of computerized transport modelling is often associated with comprehensive planning. In the second embedded case, it will be shown that this was also the

case in Denmark. In order to analyse how the increased prevalence of comprehensive planning generated a number of transformations in practice, facilitating the emergence of computerized transport models, the concept of comprehensive planning will be introduced hereafter. According to Altshuler (1965) comprehensive planning is defined by an emphasis on the city as made up of a complex system composing social and physical elements. This meaning of comprehensiveness is also embedded in Kent's definition of a comprehensive plan, or a general plan as he terms it:

“Comprehensive means, ..., that a general plan for physical development, in order to be a logical, reasonable and useful plan, must recognize and define its relationship with all significant factors, physical and non-physical, local and regional that affect the physical growth and development of the community.”
(Kent 1964, 99)

Because the city is framed as a complex interconnected system, this implies that planners, in order to plan comprehensively will have to approach planning at the scale of the city or region as a whole. Most planners do properly have some kind of conception of the city as a complex system consisting of interrelated elements. In fact, except from the incrementalist approach (Lindblom 1959), planning is often justified based on its claim to comprehensiveness (Campbell and Fainstein 2003). However, the implications of conceptualizing the city as a complex system differ widely among planning-theoretical positions. From a critical realist perspective, the non-closed character of reality and the working of multi-casual relations at different strata, imply that it is impossible to make accurate long-termed predictions (Næss & Strand 2012). Other implications are, however, drawn up within system theory and rational-comprehensive approaches to planning, which transport modelling has been particularly tied up to. Here, complex systems are regarded as predictable, if just the right modelling techniques are applied. Hereafter the system approach will first be elaborated upon, followed by the rational-comprehensive model. Lastly, the historical emergence of the sequential four-step transport modelling framework is briefly introduced and discussed in relation to system and rational-comprehensive planning.

2.2.1 Systemic planning theory

System theory is a highly technical and scientific approach to planning, seeking to embrace the city as a comprehensive system. The core of the system approach to planning is that the cities and regions are regarded as a complex and dynamic system, where the constituting parts of the system are all seen as inter-linked (Allmendinger 2009). Despite the fact that the urban fabric is regarded as a complex system composed of interrelated parts, this does not mean that systems are conceptualized as chaotic and unpredictable. Within the system theory people and organizations are conceptualized as behaving in accordance with constrained utility maximization. Under these conditions behaviour becomes predictable. The role of the planner is then to clarify casual relations between different elements of the system and on that ground predict the future state-of-affair. Ratcliffe puts it as follows:

“It is the planner's function to comprehend this tangled web of relationships, and where necessary, to guide, control and change their composition. To do this,

planning is concerned with prediction, not only of population size and land use in isolation, but also of human and other activities as well.” (Ratcliffe, 1974, p. 104; quoted in Allmendinger 2009, 51)

The assumed behavioural predictability of the system and its components implies that the system is regarded as amenable to control, through the means of regulatory planning. However, because the city is seen as a complex system this implies, that in order to predict properly, accounting for more variables than the human mind can comprehend is necessary. McLoughlin puts it as follows:

“The trouble is that when we try to take into account the inter-relations of more than about a dozen or so of these issues, their scores of immediate side-effects, their hundreds of indirect effects all merging and overlapping with different time-lags, we find the human brain cannot cope without assistance. We cannot model the city in our heads – its complexity overwhelms us. We know that the city is comprised of a myriad of relationships, but if we have the vision to identify and describe these in the right way they can be expressed in mathematical terms.” (McLoughlin 1969, p. 82f)

Hence, by expressing the innumerable relationships, constituting the urban system, mathematically, this allows them to be modelled and computerized and thereby to be rendered comprehensible. However, as the behaviour of the systems being predicted is conceptualized as complex and dynamic, this means that simple projections of the individual aspects of the system often will be inadequate. As McLoughlin puts it:

“Generally speaking, analytical methods are to be preferred over simple ones since they allow us to account for or assume differing patterns of change in the components of a situation; this usually leads to more accurate results than is the case with simple projections where the internal structure of a phenomenon is ignored.” (McLoughlin 1969, p. 169)

In order to comprehend the dynamics of complex systems, it is hence necessary to apply more analytic projections, addressing the components of the system from a comprehensive view. This implies that, rather than making a simple trend projection, prediction of a dependent variable (e.g. car ownership) will have to be based on a number of independent variables e.g. personal income, GDP, population, occupational status, etc. (McLoughlin 1969, 168f). This approach puts high demands on data requirements and computational power and the system approach to planning as formulated by McLoughlin (1969) for this reason strongly relies on computer models.

The system approach to planning’s heydays was in the 1960s and 1970s, the same decades that several computerized decisions support tools became institutionalized within planning practice. The system approach to planning has, however been criticized for neglecting the political side of planning, and for its hubris fait on science and technology as a means to social prosperity. However, despite the system approach to planning having lost ground, the widespread use of computer models with contemporary planning has its roots more or less explicitly in the so-called system approach to planning (Allmendinger 2009).

2.2.2 Rational-comprehensive planning

Besides the system approach, the use of transport models is traditionally also associated with the rational-comprehensive planning paradigm (also termed synoptic planning). In accordance with the system approach, the rational-comprehensive approach also embraces comprehensiveness, but while the system approach is concerned with comprehensiveness with respect to the substance-field of planning, the rational-comprehensive approach, is particularly associated with comprehensiveness at the procedural level of planning and is often characterized by stepwise planning procedures.

1. Problem diagnosis
2. Goal articulation
3. Prediction and projection
4. Design of alternatives
5. Plan testing
6. Evaluation
7. Implementation
8. Post-evaluation

The individual steps do not have to be carried out in the above sequential order and often feedback loops are included between the individual steps, allowing conclusions reached at earlier steps, to be revised based on the conclusion reached at later steps. Hereafter, the underlying assumptions of the rational comprehensive model will be presented in the form it was given in the post-war era.

Within the rational-comprehensive model, planning is adopted by organizations for a better attainment of certain community goals (ends, values, objectives). The existence of a common public interest is assumed and it is likewise assumed that planners, in their role as neutral experts, are able to identify it, through a scientific approach to analyses (e.g. reduce congestion, improvement of the urban environment, equal access to services and green areas, etc.). According to the comprehensive rational approach, planning is normatively perceived as an instrumentally rational activity. This implies that planning ought to be based on scientific methodological approaches to analyses and problem solving and should be concerned with choosing the most efficient means for reaching a given end. As Edward Banfield (1959) puts it:

“An actor (who may be a person or an organization) is considered as being oriented towards the attainment of ends. Planning is the process by which he selects a course of action (a set of means) for the attainment of his ends. It is “good” planning if these means are likely to attain the ends or maximize the chances of their attainment. It is by the process of rational choice that the best adaptation of means to ends is likely to be achieved.” (Banfield 1959)

“Good” planning then, increases effectiveness of goal attainment and is obtained through instrumental rational deliberation of alternative means. But what does rational choice of alternative means imply? Banfield gives the following definition:

“a rational decision is one made in the following manner: (a) the decision-maker lists all the opportunities for action open to him; (b) he identifies all the consequences which would follow from the adoption of each of the possible actions; and (c) he selects the action which he would follow by the preferred set of consequences.” (Banfield 1959)

According to the rational-comprehensive planning model it is possible to identify the most efficient means to an end and planning is truly rational and comprehensive if the best means is selected based on deliberation and evaluation of all possible means. Like the system approach, the rational-comprehensive model perceives that if sufficient knowledge about the casual relations is obtained, all future actions, in principle, become predictable. This positivistic belief in predictability is clearly put forward in the writing of Melville Branch, who puts it as follows:

“Projection into the future is as essential to planning as coordination. Projection is made possible by the mathematics of probability, trends based on accumulation of data and empirical and historical evidence. ... Since increased foresight is characteristic of the advance of knowledge, more reliable prediction is also to be expected; hence the frequent application of the “ability to predict” as the most meaningful measure of substantive achievement within the field. Planning, of course, is projectional by definition and its significance will grow as techniques become more reliable and are extended in scope and time.” (Branch 1966, p. 301)

Branch here expresses an optimistic viewpoint characteristic for the rational comprehensive model about the conditions of possibility for predictability.

Despite that several methods can be applied to evaluate the goal attainment of different means (Næss 2004b), the cost-benefit analyses is often as elevated as the very model of rational-comprehensive decision-making (Porter 2007). As Nathaniel Lichfield puts it in an early call for institutionalization of the cost-benefit analyses as a mean to enhance instrumental rationality within urban planning:

“Without cost-benefit analysis, rationality in city planning is difficult to achieve. With it we can perhaps move more surely towards the better attainment of community goals”. (Lichfield 1960, p. 279)

In the second embedded case it will be shown, that one of the reasons why both computerized transport models and the cost-benefit analysis emerged within Danish planning practice, was in fact tied up to a desire of rationalizing land use and transportation planning in accordance with the rational-comprehensive approach.

2.2.3 Comprehensive transport studies

After having introduced the concept of comprehensive planning in general and the particular meanings it was given within the rational-comprehensive and the system approaches to planning, this section zooms in on comprehensive transport planning and the practice of comprehensive transportation studies. The sub-section also explores the role transport modelling undertakes within comprehensive transportation studies and discusses this in respect

to system and comprehensive-rational approaches to planning. However before doing it, the genesis of the sequential four-step transport model's framework is introduced.

Before the framework of the sequential four-step transport model was developed in the USA during the 1950s-60s, urban transportation planning was often based on current rather than future travel demand. Moreover, often traffic was not assigned to the transport network, but so-called desire lines were used to depict the direct line between origins and destinations. If traffic was assigned to the transport network it was often done based on experienced engineers' subjective judgment. In fact it only became common practice to conduct urban travel surveys after World War Two. Before that time, traffic planning was mostly based on traffic counts. Counts do not, however, capture the origin and destination of traffic and were therefore inadequate as a base for assessing how new urban highway facilities influenced route choice. In order to overcome this problem, the home-interview origin-destination survey method was developed, which collected information on household members' travel behaviour the previous day. Moreover, if travel was forecasted, it was often based on a uniform trend projection. However, during the 1950s major advances within traffic forecasting techniques took place, which were made possible by the emergence of computers. In the mid-1950s Thomas Fratar developed a computerized method for distributing future origin-destination travel data using so-called growth factors. This method was innovative. It did not apply a uniform growth factor area wide, but tried to account for the fact that different parts of a town often grow at different rates (Overgaard 1964; Weiner 1997). The drawback of this method was, however, that it was unable to account for traffic generated by 'greenfield' developments (i.e. urban expansion into previously undeveloped areas). As there was no or very little traffic in these areas before, the growth factor could not be used to estimate future traffic. Due to the high urbanization rate and the rapid expansion of urban areas into the surrounding greenfields, characterizing the 1950s and 1960s, this limitation of the growth factor method was perceived problematic (interview Overgaard 2012). One of the largest breakthroughs, in respect to overcoming this problem, was the work undertaken by Robert Mitchell and Chester Rapkin (1954) on the relationship between land use and travel. They showed travel demand could be seen as a function of land use, and this hypothesis came to underline the framework of the classical four-step traffic model which soon after was developed. In 1956 Voorhees developed a gravity model for distributing trips between origins and destinations, linking land use with urban traffic. The following year work was published which advanced the methodology on traffic assignment between different routes in a network of roads. Edward F. Moore had developed an algorithm, originally developed for telephone networks, but which was adapted to assign traffic on the transport network according to the shortest path (Black 1990). These innovations within traffic forecasting were compiled in the 1950s and came to form the underlining base of the sequential four-step transport modelling approach, which has dominated transport planning practice across the world since the mid-1960s (Boyse 2002). But why did the sequential four-step transport modelling paradigm diffuse so widely?

One reason might be that it was taken up and developed within comprehensive transport planning. Overgaard (1964) defines, the overall framework of this concept, as applied in the USA in the 1950s and early-1960s, in the following manner:

1. *Planning concerns systems - not the single elements. Therefore account is taken of the fact that a change of traffic conditions at a single location leads to changes in other parts of the network (the system).*
2. *Planning includes multiple traffic categories.*
3. *Both person- and freight-traffic is considered.*
4. *The planning area is not only demarcated by the city, but also includes the outer areas which is likely to exchange appreciable amount of traffic with the city, in the forecast year.*
5. *Planning has participation from several administrative bodies.*
6. *Planning is performed by people from different disciplines.*

In accordance with the system approach (see section 2.2.1), comprehensive transport planning conceptualized transport systems as consisting of interrelated parts and approached urban transport planning from a regional scale.

Within this overall framework, comprehensive transport studies came to be the dominant urban transport planning practice in the USA in the 1960s. Based on extensive data collection, particularly in the form of home-interview surveys and traffic counts, these comprehensive transportation studies sought to predict future travel demand for an urban region and on those grounds prepare a master plan for a future transport system, accommodating predicted demand, under conditions of financial constraints. The comprehensive transport studies were comprehensive in terms of data collection, geographical scale, multi-modality, procedural rigidity and scientific approach. Four-step transport models' institutionalizations in the USA and their diffusion to abroad, were particular tied up to this practice, highly commensurable with the system and rational-comprehensive planning approaches. This will be elaborated upon below.

The earliest American comprehensive urban transportation study was initiated in Detroit in 1953. The second and perhaps most paradigmatic, was the so-called Chicago Area Transportation Study (CATS), initiated in 1955. Both of these were directed by Dr. J. Douglas Carroll, Jr. He firmly believed in rational planning and was of the opinion that planning ought to be as scientific as possible and CATS in particular pioneered electronic data processing. While many of the calculations in Detroit were conducted in hand or with the aid of tabulating machines, a computer was used in Chicago to assist executions of a traffic forecast. The forecast was based on a huge data collection process, including traffic counts, surveys of land use and transportation systems and a home interview survey of 3.3 % of the study areas' households, equalling 57.000 households (Black 1990; Weiner 1997). As Black notes:

“while there were precedents for most of the surveys, nothing on this scale had previously been attempted in transportation planning.” (Black 1990, p. 30)

Despite the fact that the modelling approach taken on in the CATS study seems rather simple relative to contemporary standards, it was perceived as a major advance in forecasting methodology at the time. It was based on a four-step sequential procedure. The structure of the model was, however, of the so called trip-end modal-split model, insensitive to changes in the transport system (see Section 2.1.2). The CATS study was, however, the first to apply Moore's algorithm to assign traffic on a transport network, and also introduced a capacity restraint

feature (Black 1990). The CATS study was based on the idea that urban traffic was structured, and due to its orderliness it could be predicted. In the first volume it is stated as follows:

“The Study design rests upon the central idea that travel within an urban area is extremely orderly, measurable and basically rational. Travel is, in fact, so much a condition of urban life and is so regular, that it can almost be described in terms of natural laws. If travel were chaotic or random, the planner would be helpless. As it is, the orderliness in travel permits plans to be prepared and, furthermore, to be tested. Hence it is one of the primary purposes of the inventories to determine where regularity exists in travel; it is the primary purpose of the planning process to use these regularities to develop and test plans.” (Chicago Area Transportation Study 1959, p. 5)

In accordance with the system and rational comprehensive approach to planning, the CATS study rested on the assumption that because traffic was ordered it was predictable. Moreover, like the rational comprehensive approach to planning, CATS was designed according to a series of the following six procedural steps, adopted from the Detroit study (Weiner 1997):

1. Data collection,
2. Forecasts
3. Goal formulation
4. Preparation of network proposals
5. Testing of proposals
6. Evaluation of proposals

In the first step, data were collected on travel, land use and transportation facilities. In the second, forecasts of population, economic activity and land use were prepared. Land use served as the input to the process of forecasting travel demands. The plan preparation stage utilized the forecasted travel demand and based on objectives and standards, several alternative transit and highway networks were drawn up. These alternatives were then tested and evaluated by the traffic model. With respect to the evaluation of the alternatives, a cost benefit analysis was applied. During the phases of testing and evaluation, several discrepancies between capacity and demand were detected and on that ground some of the alternatives were revised with the aim of optimizing. The testing and evaluation phase hence involved re-design of the alternatives through an iterative process (see figure 2.2). Despite some elements of the CATS being later criticized³, *“It set the standard for future urban transportation studies”* (Weiner 1997, 18) both in America and abroad – including Denmark. In the second embedded case, it will be shown that the role that computerized transport models undertook within CATS, allowing for iterative testing and evaluation of alternatives, was also the role computerized transport models were envisioned to undertake within Danish planning practice and this was one of the reasons why it was accepted.

³ E.g. its land use forecast and its model structure

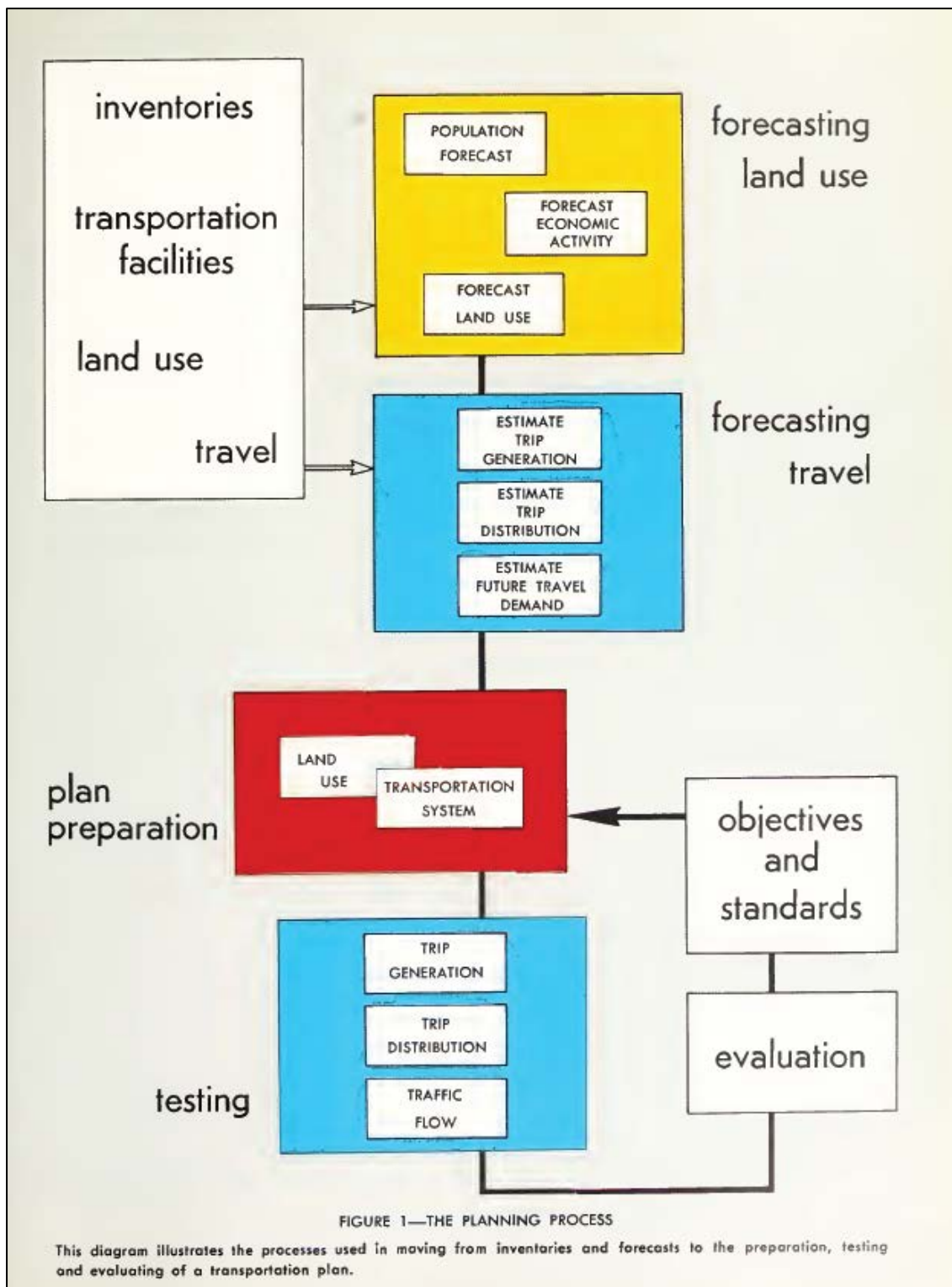


Figure 2.2: Iterative study design of the Chicago Area Transportation study and role of transport models within it (Chicago Area Transportation study 1959, p. 9).

Besides Detroit and Chicago, a number of other large scale transportation studies were also initiated in the late 1950s, including Washington 1955, Baltimore 1957, Pittsburgh and the Penn-Jersey (Philadelphia) in 1959. Of these, the Penn-Jersey study in particular was associated with considerable methodological innovation. With the passage of the Federal-Aid Highway Act of 1962, comprehensive urban planning became a requirement for obtaining federal funds and

therefore the number of comprehensive transportation studies exploded in the 1960s (Weiner 1997). In the 1960s, the practice of comprehensive transportation studies and computerized transport models was adopted in larger cities around the world. In Toronto a transportation study was conducted which was innovative in several respects. It advanced the incorporation of feedback loops between the individual model steps, and developed an iterative calibration method to estimate the parameters of the gravity formula based on travel data (Overgaard 1964). This transportation study also came to shape the emergence of computerized transport modelling within Danish Planning practice (see Section 10.4.1). In Europe some of the first comprehensive travel studies were conducted in Britain, in London and Glasgow in 1960. Both of these were conducted by a consortium between British and American consultancy firms. The joint UK/US partnership formed in London was the consultancy firm Freeman Fox Wilbur Smith & Associates. This consultancy firm also played an important role in a number of other European comprehensive transportation studies, both in the UK and on the continent (e.g. Birmingham, Helsinki and Rotterdam) (Drake 1962; Wotton 2004). In 1967/68, it also assisted in the execution of the Greater Copenhagen Regional transport Study, and the subsequent development of a computerized transport model. We will shortly return to this in the second embedded case.

Even though the transport modelling was largely conducted within a framework of sequential four-step modelling within these transportation studies, there existed a pluralism of methodological approaches with respect to the individual steps. Instead of reusing the same programs for different urban transportations studies, new transport modelling programs were usually developed for each of the early transportation studies. According to Overgaard there was a technological reason for this. He states as follows:

“The many different types and manufacturers of computers each requires its special program, however, the same program can be used with some modifications by closely related machines. Especially when the program is written in a language such as ALGOL or FORTRAN, it is possible to introduce minor changes. But as soon as it comes to slightly larger changes, it will be as easy for experts to write a new program as to reshape the existing.” (Overgaard 1964, p. 182; Own translation)

The non-standardization of computer language hence stimulated the non-standardization of evaluation methods. However, even though there was not a commonly accepted best methodology for the individual steps, the four-step framework prevailed and institutionalized. Despite the fact that the overall model structure of the sequential four-step transport model was originally developed back in the 1950s - 1960s, and considerable theoretical and methodological advance within transport modelling techniques has taken place since then, many features of the classical model recur in contemporary models. As Bates notes:

“... the development of mainstream techniques has been evolutionary rather than revolutionary” (Bates 2000, p. 11)

Accordingly, Nielsen argues that:

“it is remarkable how many reminiscences of earlier model development which are evident in the practical work with models” (Nielsen 1995, p. 1; Own translation)

Not only is the content of many contemporary models shaped by this early modelling paradigm, the sequential model structure has obtained a hegemonic position within contemporary planning practice. As Boyce (2002) argues:

“For most urban transportation planners, whether they are practitioners or researchers, the sequential, or four-step travel forecasting procedure is regarded as a cornerstone of our field. The sequential procedure is not just unquestioned; it has achieved the status of a universal truth, appearing as it does in all textbooks.”
(Boyce 2002, p. 169)

According to Boyce (2002) the sequential modelling paradigm is hence more or less taken for granted within planning practice. Nevertheless, the optimism about predictability of travel behaviour held within the system and rational-comprehensive approaches to planning, has, according to a range of studies not been manifested in the accuracy of traffic forecasts. This will be elaborated on hereafter.

2.3 Problematic aspects of transport modelling practice

This section presents some problematic aspects of transport modelling practice. It starts by discussing previous works that study the accuracy of traffic forecasting. This is followed by a discussion about induced traffic and the biases that follow when this effect is neglected in transport project evaluation. Next the assumptions of transport models used within Danish practice will be scrutinized and the implications of potential shortcomings will be discussed. Lastly, the section discusses some current innovations within Danish transport modelling, which attempt to overcome some of the problematic practices within Danish transport modelling practices.

2.3.1 Inaccuracy and bias in transport model-based predictions

Because transport model calculations underpin much of the quantitative knowledge production in transport infrastructure planning and decision-making processes, their predictive accuracy of the future number of trips, lengths of trips, distribution of trips, modal split and route assignment, all serve as a condition (but not a sufficiency) for making sound predictions of various transport-related socio-economic, environmental and health impacts. If there are large inaccuracies and even bias in transport model-based output, serving as a basis for political decisions, there is a risk of societal resources being misallocated, and a risk that projects are implemented which do not fulfil, or are in direct contradiction to, political objectives. Predictive capabilities of transport models are therefore of key importance for their quality as a decision-makers support. The issue of predictive accuracy has also received interest from both academia and public administrations. Based on ex post evaluation of implemented transport infrastructure projects, a considerable number of studies have investigated uncertainty in transport model-based forecasting (Bain 2009; Flyvbjerg et al. 2005; Mackinder and Evans 1981; Parthasarathi and Levinson 2010; Pickrell 1990; Tennøy 2003; Welde and Odeck 2011) (see Nicolaisen 2012 for a detailed review of these and other studies). Contrary to the system and the comprehensive-rational approaches’ belief in the predictive capabilities of complex models (see Section 2.2.1 & Section 2.2.2), these studies have quite consistently documented considerable inaccuracies in

transport model outputs. The most cited study to date on inaccuracies in transport forecasting has been conducted by Bent Flyvbjerg and his colleagues. Flyvbjerg *et al.* (2005) showed that among 183 investigated road projects in 14 different countries, one half had a deviation between the forecasted and actual traffic of more than $\pm 20\%$, and one fourth had more than $\pm 40\%$. Flyvbjerg *et al.* (2005) found that forecasting errors for rail projects were even larger. Based on a sample of 27 rail projects they found that for 9 out of 10 passenger forecasts are overestimated with the average overestimation at 106% (see Figure 2.3). According to Flyvbjerg *et al.* (2005) it is mostly within appraisal of rail projects that a systematic tendency to overestimation of ridership can be observed. Within the road sector the occurrences of under- and overestimations are more equally distributed.

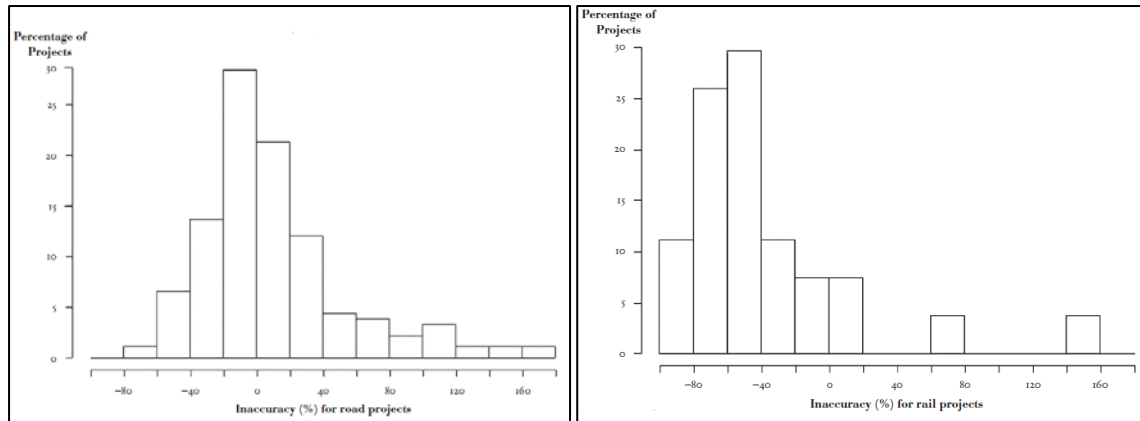


Figure 2.3: Distribution of inaccuracy found by Flyvbjerg *et al.* (2005) for 210 road projects (left) and 27 rail projects (right) respectively.

The most recent ex post evaluation study is by Nicolaisen (2012). Based on a sample of 146 road projects and 31 rails projects he found similar distributions of inaccuracy as Flyvbjerg *et al.* (2005), with a clear tendency towards overestimation of traffic in rail projects, and a less biased distribution for road projects, which still tends to underestimate traffic (see Figure 2.4).

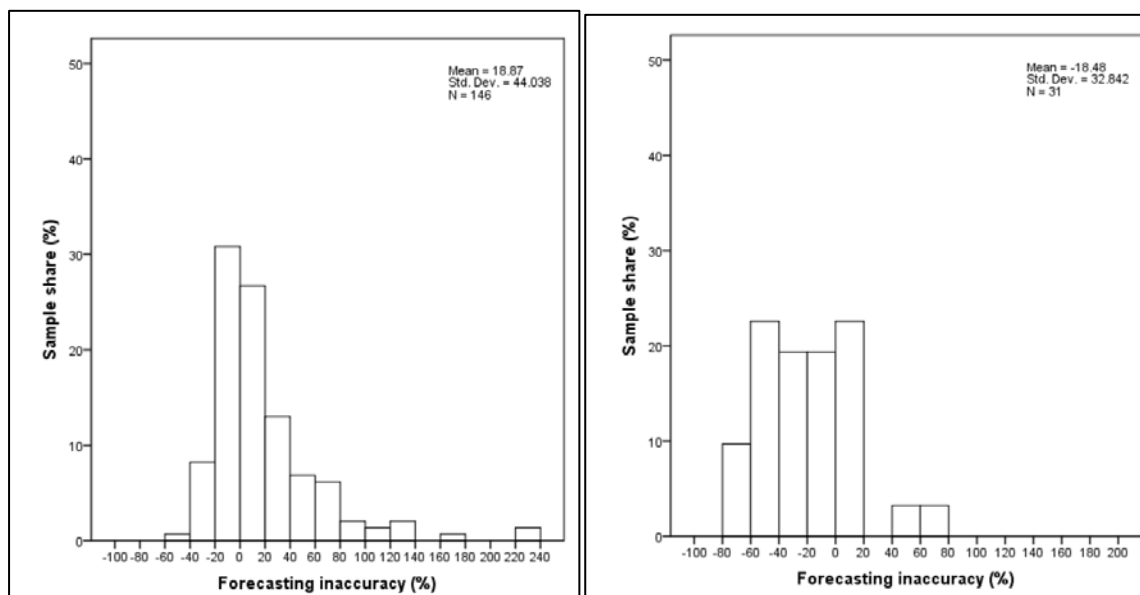


Figure 2.4: Unadjusted distribution of inaccuracy for road projects (left) and rail projects (right) found by Nicolaisen (2012)

Nicolaisen (2012) has also developed an improved method for comparing forecasted traffic with observed traffic, adjusting for delays in the opening year. According to this method, the measured level of predictive inaccuracy increases a bit for the rail projects, while it decreases for road projects (see Figure 2.5). These results of Nicolaisen (2012) nuance, but do not contradict the overall conclusions of previous works, that is, that road traffic forecasts are inaccurate. His work however also contributes to highlight the uncertainties associated with measuring predictive inaccuracy itself.

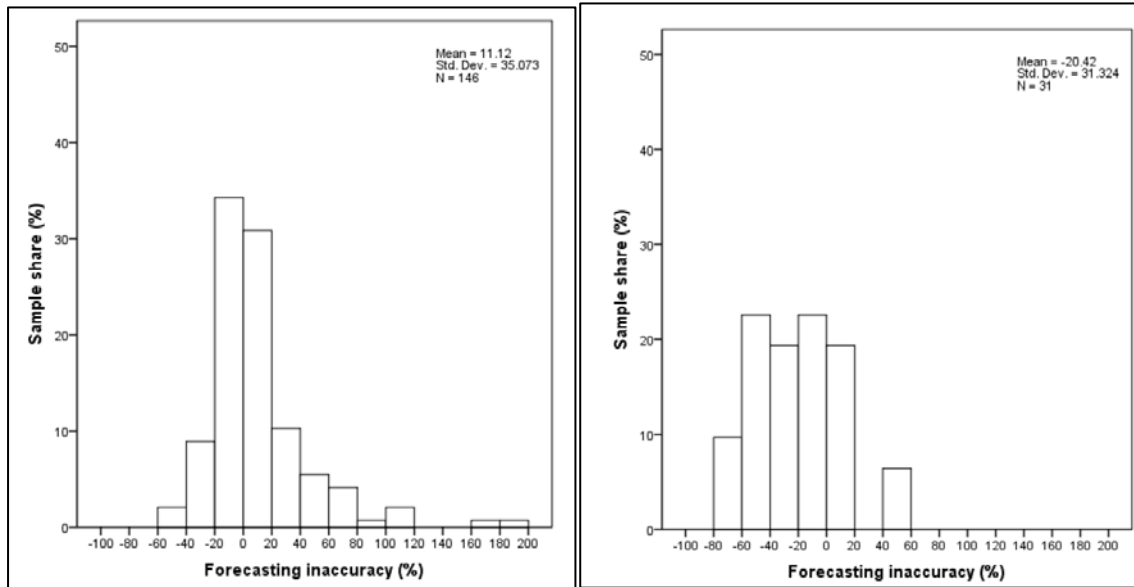


Figure 2.5: Uncertainty in road projects (left) and rail projects (right) found by Nicolaisen (2012), when adjusted for delays of opening year.

2.3.2 Induced traffic and bias in transport models

Næss (2011) argues that the absence of a clear pattern of deviation between predicted and actual traffic volumes for implemented road projects in ex post evaluation of traffic forecasts does not necessarily imply that traffic forecasts for road projects are not systematically biased. Bias does not necessarily manifest itself in inaccurate forecasting of different do-something scenarios. Instead, defective forecasting can be manifested as bias in the base scenarios. This type of bias is not captured in most ex post evaluation studies. However, based on a pool of 35 behind schedule or non-executed road projects, Nicolaisen (2012) conducted a comparison between forecasted and actual traffic for zero alternatives. He found that traffic was on average overestimated by 7% in the 'no-build' alternatives, while it was, on average, underestimated by 10.9% for build alternatives (for two other recent Danish empirical studies on induced traffic see Nicolaisen & Næss 2011; Twitchett 2013). An issue which can cause this type of bias is the neglect of induced traffic. The concept of induced traffic concerns how capacity expansions and lowering the cost of travel influences travel behaviour by increasing the total amount of vehicle kilometres travelled. The phenomenon of induced traffic is theorized with reference to the 'law of demand', stating that consumption of a good increases as its price drops (Litman 2009). In congested road systems, capacity expansion will reduce the generalized cost of travelling (usually in the form of time-saving benefits) and thereby release a latent travel demand, entailing an increase in vehicle kilometres travelled.

It is, however, important to bear in mind that induced traffic is facilitated by and not caused by enlargement of capacity. Induced traffic results from individuals' choices to realise the potentials, created by the new travel conditions and not by the infrastructure facilities themselves (Næss & Strand 2012, 283). Induced traffic should hence not be conceptualized as a deterministic natural law, but rather as a tendency on the aggregated level. The manner in which the road capacity expansions can influence peoples' travel behaviour, causing induced traffic in the short term, is through decisions to travel more frequently, to travel to destinations further away and to change mode of transport from transit to private motoring. In the longer term, road capacity expansions often shape land use patterns in a manner that facilitates outward and low density development. The travel behaviour effects resulting from such land use changes will usually manifest itself in longer than average travelling distances and increased levels of car dependency (Hills 1996; Litman 2009).

If induced traffic is not accounted for in transport project evaluation, this is likely to generate a number of biases. First of all, it can mean that erroneous project designs are implemented. Underestimation of the traffic might imply that the capacity of an implemented project is underdimensioned and congestion problems soon occur again. If congestion is not politically accepted, this can result in decisions about costly capacity expansions at a later point in time. Moreover, in situations where a latent demand for travel exists, additional traffic implies that the capacity limit will be approached faster than expected and can impose increased downstream congestion (Litman 2009). Non-inclusion of induced traffic can hence give a false impression of the effectiveness of capacity enhancement as a mean to cope with congestion problems.

The errors of not including induced traffic in models used to forecast future traffic volumes will not only have consequences for evaluation of the vehicle kilometres travelled but also for evaluation of financial and socio-economic viability, as well as environmental and health impacts. In toll projects, exclusion of induced traffic mean that monetary revenues are relatively underestimated. This is also the case in evaluation of transit projects' ridership revenues. On the other hand, in evaluation of transit projects there is also a risk of overestimating ridership revenues, if modal shifts are ignored, for example increased car use, following an enhancement of road capacity in congested urban corridors. Also, with respect to the estimation of time benefits, the consequences of neglecting induced traffic are context dependent. The new infrastructure users, resulting from induced traffic, obtain a benefit from the travel they undertake. If this benefit is not accounted for, there is a risk of underestimating time benefits.⁴ On the other hand, in situations where induced traffic affects the capacity utilization to an extent which decreases the traveling speed among the existing infrastructure users, the time-saving benefits of the new infrastructure users will in most cases be offset by the time cost imposed on existing users. In this situation time benefits from the assumed congestion relief becomes overestimated, particularly in the long term. This has made Nielsen and Fosgerau state that:

⁴ According to economic theory, the last new trips that are induced only provide small user benefits, as they are marginal value trips, and within the Danish cost-benefit framework, the benefits obtained by new users are assumed to be on average only half of the benefits obtained by the exciting infrastructure users (Litman 2009; Trafikministeriet 2003).

“time-saving benefits tend to be clearly– and systematically – overestimated in the analyses on which decisions about larger Danish road projects are based” (Nielsen & Fosgerau 2005; Own translation).

While the risk of underestimating time benefits are most likely to occur within non-congested contexts (e.g. rural projects), overestimations are most likely to occur within congested networks, particular in an urban context. While the effect of not including induced traffic in evaluations of time benefits is context dependent, the consequences of ignoring it, from the evaluation of environmental impacts are one-sided and will result in a consistent underestimation of the impacts resulting from an increase in vehicle kilometres travelled (Næss 2011).

2.3.3 Transport models used in current Danish transport planning practice

The above shows that simplifications and non-inclusion of relevant causal mechanisms from transport modelling can result in biased and misleading evaluations. Hereafter, transport models used in Danish transport planning practice are scrutinized with respect to whether the above-mentioned simplifications constitute a problem within contemporary practice.

Induced traffic has traditionally been ignored in many standard traffic models, both in Denmark and abroad. At the municipal and regional level in Denmark the effect of induced traffic due to infrastructure improvements is not included in the majority of traffic models, neither in the form of increased number of trips nor in the form of increased travelling distance (modal split will be dealt with below) (Vejdirektoratet 2011). As a consequence the total vehicle kilometres travelled will be relatively underestimated. Omission of induced traffic is not, however, only a problem at the regional and urban level in Denmark. It was not incorporated into the model used to support the work of the recent Danish Infrastructure Commission (Infrastrukturkommissionen 2008).

Despite the fact that induced traffic traditionally has been ignored within Danish transport modelling practice, there are several exceptions. All the corridor-based transport models used to assess traffic of the Danish fixed links (the Great Belt, the Oresund and the Femern Belt) have incorporated the effects of induced traffic. Moreover, induced traffic has also been included in recent feasibility studies on a fixed Kattegat link (Grontmij|Carl Bro & DAMVAD 2009; Niras 2008). There are also exceptions at the regional and urban scale, particularly within the Greater Copenhagen area. Short term effects of induced traffic, namely, increased trip production and mode shift, are included in the so-called Ørestad traffic model (OTM), covering the Copenhagen metropolitan area, and the Copenhagen-Ringsted model. Induced traffic was also included in the predecessor of the OTM model, the so-called HTM model developed in 1990, but not in the model used before that time. Despite induced traffic having traditionally been ignored in Jutlandic and Funen regional and urban transport models, the so-called “Jutland/Funen” model was upgraded in 2010 to include increased trip production. The “Jutland/Funen” model covers Funen, Langeland and Jutland, but not the northern part of Jutland (Region Syddanmark & COWI 2011; Vejdirektoratet 2011). In 2011, as part of the preparation for a recent Environmental Impact Assessment for a third Limfjord road crossing, some aspects of induced traffic were also included in the transport model of Greater Aalborg. Induced traffic was, however, included in a rather dubious manner. We will return to this in Chapter 6.

Another simplification, contained in most Danish regional and urban transport models is that they are largely uni-modal, only accounting for automobile traffic. These models neglect how infrastructure improvements influence the field of competition between different transport modes and hence they also neglect the following induced traffic. Exceptions are the OTM model, the regional model for Århus, and the urban models of Odense (Brems et al 2007; Vejdirektoratet 2011).

The above shows that omission of various effects of induced traffic from Danish regional and urban transport models has traditionally constituted a problematic aspect of Danish transport modelling practice. Distinct from the evaluation of travel time, the implications of ignoring induced traffic with respect to the evaluation of environmental and health impacts are, as already mentioned, pulling in a uniform direction – a systematic underestimation of costs. However, in the official Danish socio-economic model, environmental impacts do not represent as large a value as time. In respect to uncertainty in the outcome of a cost-benefit analysis (the range of error), incorrect evaluation of travel time is a much more important factor than environmental impacts. This does not, however, mean that systematic miscalculations of increases in vehicle kilometres travelled and related environmental impacts are of minor importance and represent less of a problem compared to the accuracy of travel time evaluations. Although quantitative reduction targets have been politically abandoned in Denmark, since 1990 it has been a policy objective to reduce the transport sector's CO₂ emissions and a range of other negative environmental and health externalities. Moreover, as part of a new transport policy agreement reached in 2008 between all the political parties in the Danish Parliament except the Red/Green Alliance, a new policy objective was set up concerning almost 0% growth in future vehicle kilometres travelled by car. According to the agreement, future increase in vehicle kilometres travelled should instead be absorbed within the transit sector. Use of the above mentioned simplified transport models, which either only partially account for effects of induced traffic or ignore them altogether, is hence unsuitable and even misleading for providing policy guidance on fulfilment of important transport policy objectives. Non-inclusion of induced traffic is hence not only problematic because it provides shaky ground for calculations of monetary rate of return (Næss, Nicolaisen, Strand 2012) but over the last couple of decades it has also come to represent a democratic problem because impacts that have implications for fulfilling political objectives are systematically miscalculated.

2.3.4 Current innovations within Danish transport modelling practice

Despite that many of the regional models mentioned above are based on oversimplified assumptions about how changes in infrastructure influence travel behaviour, this does not mean that transport modelling in Denmark is static. In addition to refinement of the existing transport models, innovations are also currently going on with respect to the development of new models. At national level a new multi-modal traffic model is under development. When its full version is completed it should account for more aspects of induced traffic than previous Danish models. From the outset this model seems more suitable for the evaluation of transport projects' degree of compliance with current transport policy objectives. If the model lives up to the expectations, when it was commissioned, usages of all the above-mentioned simplified regional models will likely come to an end. Another innovation within Danish model development currently taking place is an activity-based transport model for the Copenhagen area. This model will represent a

new modelling paradigm within Danish transport modelling practice and is based on an improved theoretical foundation compared to previous types of Danish transport models.

This development indicates two issues. First of all, it highlights the practice of using simplified regional and urban transport models that fail to account for several relevant aspects of induced traffic and that therefore produce potentially misleading results, in fact does appear to be less acceptable than it was previously. At least it is the ambition that use of these models is to be substituted by the new National Traffic Model.

Secondly, despite there seems to be an increased non-acceptance of simplified transport models, and that this non-acceptance does seem to relate to the emergence of a new paradigm within transport project evaluation, this paradigm is not radically different. Rather, the innovative development seems to point towards increased acceptance of complex models. This trend towards increased complexity may imply that transport projects in the future will be evaluated on a less biased basis, in regard to the prevailing transport political objectives. It is, however, naïve to believe that the new models are capable of eliminating predictive inaccuracy.

Above, problematic aspects of transport modelling practice were discussed in respect to predictive inaccuracy and bias in previous forecasts, and how the underlying assumptions of Danish regional and urban transport models rest on a simplified basis, not accounting for several aspects of induced traffic. In the following chapter we will turn towards theoretical explanations for the observed predictive inaccuracy and bias in traffic forecasting.

3 Theoretical perspectives on causes of bias and inaccuracy in traffic forecasting

After having presented the content and context of transport modelling as well as some problematic aspects of contemporary transport modelling practice, this chapter turns towards existing theoretical perspectives on the observed discrepancy between forecasted and observed traffic. The existing theoretical perspectives are categorized as follows: ontology, technological content and social context, depending on where they respectively locate the source of bias. Based on the philosophy of science, the ontological perspectives contest the conditions of possibility for making accurate transport model predictions. The technical perspective focuses on the content of transport models, and explains predictive inaccuracy in terms of technical insufficiencies. The contextual perspectives locate the source of error within the social environment of transport models. Four different social contextual theoretical perspectives can be identified, namely psychological, political-economic, organizational/institutional and selection bias. The six theoretical perspectives presented and discussed in turn are not necessarily mutually exclusive, but they have traditionally been treated separately (for an exception see Næss 2011).

3.1 Ontological perspectives

The first perspective elaborated upon is the ontological perspective. In accordance with the system approach to planning (see Section 2.2.2) Næss & Strand (2012) approach the city as a complex system. However, distinct from the system approach, they argue from a critical realism perspective that travel behaviour is so complex in its structure and is constituted through non-deterministic processes, that the conditions of accurate long-term predictions are impossible. Næss & Strand (2012) differentiate between the closed, open and semi- open/closed system. The more closed a system is, the higher the possibility for accurate predictability and vice versa. Because so many elements of the system influencing conditions of future travel (e.g. political, economic, cognitive and physical dimensions) are of an open character, long-term accurate predictability is impossible. They put it as follows:

“The system in which the general, ‘background’ level of mobility in a given society develops must ... be characterized as a predominantly open one, with low degrees of conjunctural regularity between the mechanisms and low event regularity among phenomena causing the aggregate result.” (Næss & Strand 2012, p. 285)

Næss & Strand (2012) do not argue that travel behaviour is random or that the semi-open systems do not contain some degree of predictability. They distinguish between the conditions of possibility for predicting the typical impact of a given effect and the conditions of possibility for predicting the future situation. The former is positive, the latter is negative. Due to the non-closed character of the future, it is impossible to make accurate model predictions about future travel situations. However, if the aim is to forecast changes in traffic due to short-term and

relatively small changes in the infrastructure system, then this may be modelled with some degree of accuracy.⁵

The ontological perspective often holds a marginal voice in the debate on uncertainty and bias in transport planning. Yet, the ontological perspective makes an extremely important contribution. It questions the belief that if more efforts were put into improving modelling techniques and data quality, or if institutional measures were implemented to rectify the potential contextual biases, then accurate and unbiased forecasting would be attainable. The conditions of possibility for predictability are uncertain in themselves and therefore, predictability cannot, as claimed by Brach (1966), be regarded as “*the most meaningful measure of substantive achievement*” within planning (see section 2.2.3). Planners should not be ashamed of uncertainty and instead of putting all their efforts into annihilating it, planners should embrace it.

Acknowledging the limited conditions of predictability on ontological grounds does not, however, rule out the importance of content and contextual perspectives. The assertion that one should not expect the future to be highly predictable does not of course explain why certain transport models, based upon assumptions, which have been subjected to a longstanding critique are nevertheless widely used.

3.2 Technical perspectives

Technical perspectives explain accuracy and bias in transport model based knowledge production, with reference to insufficiencies in the *content* of transport models. According to Flyvberg (2009) this is the most common type of explanation towards inaccurate traffic forecasting. The technical perspectives explain predictive inaccuracy with methodological problems, incorrect definitions of study areas, incomplete model structure, insufficient data, incorrect land use assumptions, mis-estimations of parameters and elasticities, incorrect descriptions of alternatives, neglect of system effects, incorrect opening year, etc. (see e.g. Flyvbjerg *et al.* 2005; Mackett 1998; Mackie and Preston 1998; Welde & Odeck 2011).

The technical issues appear to be an important aspect of reaching an understanding of the neglect of induced traffic from ordinary Danish transport models. The four-step/sequential modelling paradigm has traditionally been based on fixed-trip matrixes (see Section 2.1.3) and this approach obstructs the inclusion of both some short and long-term aspects of induced traffic. With regards to short-term aspects, modal shifts and route changes can be accounted for within a fixed travel matrix but the same cannot be said for an increase in trip-generation neither changes in trip distribution. With respect to long-term effects of induced traffic, behavioural changes resulting from changes in land use will also be completely ignored within a fixed matrix framework (Hills 1996; Mackett 1998). Another technical constraint for including induced traffic is the assignment model. An all-or-nothing assignment is incapable of reflecting behaviour response due to congestion effects (see Section 2.1.3). It is therefore unable to reflect how the new road users can impose time costs on the existing ones.

⁵ van Zuylen *et al.* (1999) also contest the conditions of possibility for making accurate predictions but from a chaos system approach.

A one-sided focus on the content of transport models cannot, however, explain why the technical content is formed as it is. Despite the fact that model structure can constrain the inclusion of some dimensions of induced traffic, the model structure cannot explain why other dimensions facilitated by the model structure are not always included (e.g. modal shift and route choice due to congestion). Neither can the technical perspectives account for why transport planning organizations that are applying simplified transport models, in many cases do not describe the neglected impacts qualitatively. What is missing in the technical explanations is a focus on the social context of models and how this context influences choices concerning the model content. Designing a model is not solely technical but also social. Model designers are required to identify the key causal mechanisms as well as their internal relationship that are perceived to be the most salient in representing a system of interest. This conceptual framing of contextual factors attached to the problem at hand as well as the system of interest become critical for determining which mechanisms are deemed important to include and which are not. In this sense, it is inevitable that transport modelling contains social elements not captured by the technical perspective. Let us turn, therefore, towards psychological, political-economic, organizational explanations as well as the hypothesis on selection bias. Each of these perspectives, except selection bias, questions the role of the planner as a neutral and objective expert, assumed by the system and rational comprehensive approaches to planning (see Section 2.2.2 & Section 2.2.3).

3.3 Psychological perspectives

The psychological perspective highlights how tacit favouritism can be inscribed into the content of transport models. This is conceptualized as optimism bias and is related to the bounded capacity of the human mind to process information. Distinct from both the rational comprehensive and system approaches, this position holds that judgment is not based on rational calculations, rather, cognitive mechanisms in the human mind have a tendency to highlight positive aspects while disregarding negative ones (Flyvbjerg 2007; Lovallo and Kahneman 2003). In traffic forecasting, optimism bias will therefore manifest itself in the form of overoptimistic specifications of various model variables based on subjective judgment. However, according to my understanding of optimism bias, the overoptimistically subjective judgment is not guided by institutionalized interpretation horizons. In other words, the common feature of inaccurate travel forecasts due to optimism bias is an unconscious overestimation of benefits, but this overestimation is not systematic across a wide range of appraised projects. With respect to induced traffic, this means that optimism bias can mostly be associated with optimistic judgment about the amount of induced traffic a given project will generate, but it does not form a solid base from which biases, in the form of systematic neglect of causal mechanisms, such as induced traffic, can be explained. Particularly not when the long-standing criticism levelled at traditional types of sequential transport models for neglecting induced traffic is taken into account. Moreover, induced traffic is not only disregarded in situations where it is undesirable and has negative effects on the socio-economic evaluation, but it is also more or less systematically neglected in situations where induced traffic would have a positive effect.

3.4 Political-economic perspectives

Political-economic explanations state that model results are strategically misrepresented in order to make the promoted infrastructure projects appear more beneficial, and thereby increase the likelihood of political acceptance (Flyvbjerg *et al.* 2003; Flyvbjerg 2007; Kain 1990; Pickrell 1992; Wachs 1989). To explain the phenomenon, Flyvbjerg (2007) has drawn up the following formula which he terms 'survival of the unfittest':

$$\text{underestimated costs} + \text{overestimated benefits} = \text{funding}$$

According to the formula, strategic misrepresentation automatically results in the approval of the projects that provide the least possible benefits. Within the political-economic perspective, the concept of power is used to explain forecasting bias. In this regard, power is conceptualized as deliberated manipulation and is exercised with the objective of promoting vested interests over the interest of society. Based on the evidence provided in previous studies it seems likely that strategic misrepresentation does in fact shape transport model based knowledge production (see e.g. Flyvbjerg *et al.* 2005; Kain 1990; Pickrell 1992). Among the studies which elaborate strategic misrepresentation, the study of Kain (1990) is particularly emblematic. Kain investigates the efforts of Dallas Area Rapid Transit (DART) to obtain acceptance from voters for a large transit plan. He found that DART made use of clearly unrealistic forecasts in order to persuade voters. For instance, unlikely levels of high employment growth within the Central Business District were assumed, despite a trend towards decline in employment having been observed. Moreover, all alternatives evaluated by DART were based on very optimistic assumptions. Even the so-called conservative alternative was in fact rather optimistic and could only be termed as conservative relative to the other alternatives in the evaluation. DART also withheld inconvenient forecasting alternatives from the general public, showing that a cheaper all-bus alternative would provide almost the same user benefits as a rail alternative. However, due to pressure from interest groups, the withheld reports were released just before the referendum and in spite of DART's attempt to deceive, it did not succeed in persuading votes to accept approval of the rail plan. What makes Kain's (1990) study special is that distinct from the vast majority of studies within the field, it is not based on a comparison between forecasted and actual traffic volumes, but on an in-depth case study of the planning process and a critical scrutiny of the model assumptions. Due to the depth of Kain's inquiry, his explanation of the model insufficiencies carries much more weight than most other theoretical deliberations within the field. Kain's (1990) study is a major contribution to the field, as he inquires into both the content and the context of the forecast. Yet, Kain's following conclusion can be contested:

"While the specific findings presented in this article are limited to Dallas, abuses similar to those described here are commonplace and occur in varying degrees in virtually every metropolitan area, both in the United States and overseas." (Kain 1990, p. 184)

Despite the fact that Kain provides a good case for claiming that strategic misrepresentation occurred in Dallas, it is doubtful whether the generalization he makes, based on his findings, is valid. As opposed to, for example, Thomas (2011) I do not contest the possibility of generalizing

from case studies,⁶ but Kain (1990) does not elaborate on how his choice of case enabled him to do so. One might suspect that his choice of the case was originally based on a suspicion that some form of misrepresentation was occurring in Dallas. If this is the case, then the possibility of generalization is limited.

Flyvbjerg (2007) also holds that strategic misrepresentation is the major source of bias in traffic forecasting. Distinct from Kain (1990), he supports his argumentation by findings from, among others, ex post evaluation of a large sample of projects (see Section 2.3.1). Flyvbjerg builds his argument in three stages. Firstly, similar to arguments put forward by Pickrell (1992), he dismisses technical explanations, arguing that technical deficiencies as a primary source of uncertainty would result in an unbiased inaccuracy distribution, which is not the case. Moreover, he dismisses technical explanations on the grounds that model sophistication should have made newer forecasts more accurate, while the observed inaccuracy remains fairly constant over time. Secondly, he dismisses cognitive explanations, arguing that practitioners should have learned from past mistakes. Thirdly, he presents interview and questionnaire support for strategic misrepresentation as the primary source of bias.

I will, however, argue that Flyvbjerg's base for dismissing technical and cognitive explanations is not well grounded. With respect to the technical explanations, I do not accept the argument that technical insufficiencies would necessarily result in an unbiased distribution of predictive inaccuracy. For instance, systematic neglect of induced traffic or overestimation of the general traffic growth both create biased forecasting results. However, as argued by Eliasson & Fosgerau (2013), even if technical insufficiencies do result in an unbiased distribution, technical issues cannot be dismissed on the basis of biases observed ex post. This claim will be enlarged on in Section 3.6. It can also be contested that technical explanations can be dismissed on the grounds that predictive accuracy has not improved in line with model sophistication. Despite the fact that model sophistication can somehow be expected to yield less biased and more accurate results, it is not a matter of fact. If we accept uncertainty as an inevitable ontological condition for long-term predictions, as opposed to both the system and rational comprehensive approaches to planning, then model sophistication will not, per se, result in improved predictive accuracy. Flyvbjerg does not, therefore, prove conclusively with his argumentation that technical explanations can be dismissed as a major source of error. Likewise, Flyvbjerg's argument for dismissing cognitive explanations on the grounds that modellers should have learned from past mistakes can also be doubted. First of all, it is not common practice to conduct ex post evaluation of forecasting results and the process of learning from previous mistakes is therefore somewhat limited. Moreover, when ex post evaluation is conducted it often only contains information about whether the forecast was accurate, over- or underestimated. The modeller is not provided with information concerning which variables or assumptions of the model were mis-estimated and the opportunities for learning on that ground is also limited.

However, despite the fact that it can be argued that Flyvbjerg dismisses technical and cognitive explanations on invalid grounds, he does, in my opinion, provide a good case for the significance of strategic misrepresentation. Even though based on current available evidence strategic

⁶ See e.g. Flyvbjerg 2001 for a good discussion about conditions of possibility to generalize from different types of case studies

misrepresentation cannot be validated as the dominating cause of bias, Flyvbjerg presents results from both interviews and questionnaires, supporting the argument that strategic misrepresentation is a relevant cause of bias. Moreover, I will argue that the political-economic perspective makes an important contribution by highlighting the politicized milieu in which modelling takes place and putting the issue of power at the forefront of the analysis.

From the outset it also seems that the political-economic perspective does provide some explanatory efficacy with respect to the inclusion/exclusion of induced traffic within Danish planning practice. A recent case concerning a potential fixed link across the Kattegat Sea, connecting Zealand with Jutland has raised debates on the potential problems of partisan behaviour among consultancy firms. Different consultancy firms, ordered by different clients, have in their respective assessments of the project's financial viability, reached opposing conclusions. All reports have been accused of being pieces of special pleading, respectively based on either too low or too high assumptions with respect to forecasted traffic growth and estimation of induced traffic. To be sure, the underlying premises of the assessments have been open enough to lead to discussions in several engineering magazines regarding the plausibility of the various assumptions on which the different assessments been based. Nevertheless, the assumptions under which a so-called sensitivity analysis, conducted in a report ordered by the lobby group 'The Kattegat Committee' appear too biased not to be considered deliberately partisan. In this report, elasticities to calculate induced traffic for heavy vehicles, private cars and transit was assumed at 1.35; 1.4; 1.5 respectively, which is very high. Sensitivity, however, was only calculated by +/- 0.10. In a worst case scenario, induced traffic was hence still assumed very high and can be considered misleading (Grontmij|Carl Bro & DAMVAD 2009). In fact, it is more than double the elasticity at the 0.5 assumed the reports, ordered by the Ministry of Traffic (Niras 2008).

The political-economic explanations seem, therefore, to offer a perspective, relevant for understanding how transport model based knowledge production is shaped. However, the theory of strategic misrepresentation does not seem to be able to provide a proper account of the sustained use of oversimplified regional transport models. From the perspective of strategic misrepresentation, one would expect to see a pattern where induced traffic is omitted from model based infrastructure evaluation in situations where it is expected to have a negative impact on the rate of return and vice versa. One might expect that induced traffic would mainly be omitted from evaluations of large non-toll road projects, but included in evaluations of smaller projects. In practice, however, this pattern of inclusion and non-inclusion cannot be observed. Whether induced traffic is included or not in Danish regional and urban models does not seem to depend on the type of project but rather on the particular model which is used. Moreover, neither do the incentive structures promoting strategic misrepresentation explain adequately why induced traffic is partially included in models covering the Greater Copenhagen Area, while it has traditionally been ignored from urban and regional transport models in other parts of the country. From a theoretical perspective, it is within the Copenhagen region that the likelihood of induced traffic causing shortfalls in time benefits is highest. Thus we see that induced traffic is best accounted for in the transport model covering the geographical area, where the incentive to ignoring it is strongest. Likewise in the rest of the country, where induced traffic has traditionally been completely ignored in the regional models, inclusion of induced traffic could in many cases be expected to provide a positive contribution to a transport project's

rate of return. Seen from a cost-benefit point of view, the geographical pattern of bias in the regional models does not reflect the incentive structures of strategic misrepresentation. This does not, however, imply that strategic misrepresentation on this ground should be dismissed as an important cause of bias. A model can be manipulated in many other ways than through the inclusion and non-inclusion of different dimensions of induced traffic.

3.5 Institutional/organizational perspectives

The organisational/institutional perspectives focus on how interpretation horizons, practices, values, norms and identities prevailing within an organizational environment can influence the framing of problems and solutions, as well as the choice of tools and assumptions for addressing the problems. Despite the fact that organizational theories have traditionally tended to conceptualize the role of technology as either determining organizational structures or have left it largely unexamined (Orlikowski, 2007), new theoretical developments highlight how organizational practices, norms and worldviews can be inscribed into technological artefacts. Orlikowski expresses it as follows:

“[H]uman agents build into technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define the organizationally sanctioned way of executing that work).” (Orlikowski 1992, p. 410)

According to the organizational/institutional perspectives, organizational interpretation horizons give meaning to policy tools, and the tools are then developed in accordance with this meaning. In that sense, the organizational affiliation of individuals is perceived to be reflected in the model framework and results, through choices of modelling approaches, input data, assumptions, calibration and different logic about cause and effect, etc. (Tennøy 2004; Wachs 1982). As multiple meanings can be ascribed to the same empirical phenomenon depending on the interpretation horizon within which it is perceived, various variables can be conceptualized as salient for representing a given system of interest. This means that some simplifications, which seem to be from just one perspective, can be conceptualized as biased from other perspectives. A model is not then, an objective technological artefact which represents a given system in a neutral manner. Rather, a model resembles a particular conceptual frame and the choices and simplifications inscribed are imbued with social meaning. In an empirical study on the motivations of policymakers to select and use policy assessment tools within various policy domains, Nielson *et al.* (2008) found that the core beliefs prevailing within bureaucracies appeared to have a strong influence on the selection of tools, and these beliefs often correlated with organizational or functional affiliations. Flyvbjerg *et al.* (2003) illustrates how the cultural and national background of consultants can influence the assumptions embodied in traffic forecasts by use of an example from the planning of a high-speed rail link between Melbourne and Sydney. Japanese, French and American consultants arrived at widely differing ridership forecasts, which reflect differences in their home countries in regards to the share of public transport in intercity travel.

With respect to induced traffic, the organizational perspectives explained the neglect in standard traffic models by the assumed prevalence of a particular interpretation horizon shared

among a particular community of transport planners and modellers. This interpretation horizon is the so-called 'predict and provide' paradigm and is marked by an overriding rationality concerning predictions of future travel demand and then providing sufficient infrastructure capacity to accommodate it (Owens 1995). Several authors (see e.g. Cerwenka & Hauger 1998; Noland & Lem 2002) argue that within the predict and provide paradigm, traffic engineers have traditionally regarded travel demand as inelastic with respect to price and time costs. Therefore they have delimited the behavioural responses generated by infrastructure enhancement to route shifting, and less so to mode shifting. Hence, according to this organizational perspective, induced traffic is framed as an insignificant phenomenon within the predict and provide paradigm and on that ground its omission is justifiable within the paradigm.

Besides focusing on how practices and interpretation horizons can shape transport model assumptions, organizational perspectives also focus on how interpretation of the model results can be shaped by organizational affiliations. As Tennøy (2004) argues, if the results of a transport model show that the expected amount of traffic will exceed the capacity limit of the road system, a so-called "predict and prevent" oriented urban planner will frame the problem as one of reducing car traffic by means of spatial planning, while a planner working within a predict and provide interpretation horizon most likely will suggest other means of actions, such as road expansion.

The organizational perspective seems promising for overcoming some of the shortcomings of the psychological and political-economic perspectives. By referring to a prevalent interpretation horizon, organizational characteristics can, distinct from the psychological perspective, provide an explanation of the more or less systematic neglect of induced traffic in Danish urban and regional traffic models outside the Greater Copenhagen Area. Moreover, distinct from the political-economic explanation, organizational explanations can provide an account of why induced traffic is widely ignored which is not based on incentive structures (which do not always encourage such neglect). However, despite the fact that the organizational perspective can seemingly provide very valuable insights into how organizational interpretation horizons influence the meaning assigned to transport models, the organizational perspective also contains some drawbacks.

First of all, the basic assumption about the link between "predict and provide" and the neglect of induced traffic is that transport planners working within the paradigm have traditionally regarded the relation between travel demand and infrastructure supply as inelastic. The validity of this basic assumption can and should be contested. Several authors (Goodwin 1998; 2011; Ladd 2008; 2012; Williams 2004) hold that induced traffic, in fact, has been known since the dawn of the motor-age, also among planners who work within a predict and provide paradigm. These authors, however, point at that acceptance of induced traffic, until nearly the 1960s, generally signified a benefit rather than a cost, in regard to transport project evaluation. As Williams puts it:

*"It has always been appreciated by analysts that expansion of infrastructure **would** induce additional traffic (or vehicle miles) under a fall in equilibrium travel times - on the basis of simple economic arguments. However, it was thought that such additional traffic or vehicle miles generated by responses other than route*

*switching would, first, be very small and, second, contribute **positively** to scheme benefits. FM [fixed matrix] estimates of user benefits were therefore seen as robust and inherently conservative. If a scheme could be justified by cost benefit analysis on the basis of the FM assumptions it would have an even stronger justification under variable trip matrix (VM) methods which accommodated other demand responses.” (Williams 2004, p. 12)*

Goodwin (1998, 151) puts two hypotheses forward, concerning why induced traffic was neglected within British planning practice between the 1970s and 1990s, despite being accepted in the 1930s-1960s. The first hypothesis is based on the assumption that even though it was the intention to include induced traffic within the formal cost-benefit appraisal system for road projects, developed by the Ministry of Transport in the late-1960s/early-1970s it was not included in the early version, primarily due to convenience. The longer this procedure was sustained, the more it became accepted, resulting in resistance to modify it. Goodwin's second hypothesis suggests that because induced traffic in general was perceived as a benefit, weighting in favour of the road proposals, inclusion of induced traffic in a number of controversial road projects in London was contested by project opponents, who perceived the inclusion to be illegitimate. As a reaction to non-acceptance among project opponents, recalculations were conducted without induced traffic. Neglect of induced traffic was hence regarded as a conservative practice, and this practice became favoured by the Treasury.

According to these perspectives, induced traffic was neglected not because it was empirically unaccepted, but rather because the effect of induced traffic was given meaning within another interpretation horizon where omission was considered conservative and, therefore, was perceived to be just. If Williams (2004) and Goodwin (1998) are correct, this does not imply that organizational perspectives do not have a contribution to make. Neglect of induced traffic is still understood with reference to a particular interpretation horizon. The meaning which induced traffic signified within Danish planning practice if any will be explored in the first embedded case.

The second point of critique towards the organizational perspective concerns the lack of attention paid to how inscriptions of meaning into the content of transport models can be facilitated or constrained by the technical content of models. For instance, a technical constraint could be, for example, that in order for the implementation of particular forms of model modifications to be feasible, it requires the model to be implemented with a new software programme (Beimborn, Kennedy & Schaefer 1996). If a transport model output is explained solely with respect to organizational context, there is a danger of black-boxing the technical dimension. From the outset it seems inadequate to conceptually treat the technical dimensions of transport models as nothing more than neutral bearers which, like a mirror, replicate the social relations prevalent within their organizational operational environment. This point of criticism does not only apply to the organizational perspectives, but also to the physiological and political-economic explanations. While the technical perspective was criticized for missing a link to social factors' influence on technicalities, the contextual perspectives fail to account for how social action is technically constrained. If we accept that technical dimensions of transport models can impose constraint on attempts to inscribe meaning into the content of transport models, not all attempts to inscribe meaning can be expected to be equally successful. Because

of technical constraints, there is not necessarily a one-to-one relationship between the model properties found desirable from an organizational perspective, and the type of properties incorporated into a model which the organization accepts and agrees to implement.

3.6 Selection bias

The above contextual perspectives are all based on the basic premises, namely that traffic forecasts are biased in accordance with the results of a range of ex post evaluation studies (see section 2.31). Eliasson & Fosgerau (2013) have however recently advanced a new explanation which challenges this very basic premise. They argue that the existence of bias ex post does not equal the existence of bias ex ante. Rather the existence bias ex post can be caused by bias in the political selection process. If it is assumed that the transport model predictions ex ante are noisy but unbiased, some projects will be overestimated while others will be underestimated in regard to project benefits. If it also is assumed that the political selection process is somehow influenced by these predictions, then the projects which are the most overestimated will be selected for implementation. Hence, bias ex post can result from the selection process, rather than bias ex ante. However, just as the ontological perspective did not imply that the relevance of other perspectives could be ruled out, neither does the hypothesis on the selection bias. As Eliasson & Fosgerau state:

“Of course, the demonstration that selection leads to selection bias does not rule out the existence of bias in the ex-ante evaluation of investment projects. We have merely shown that it is not possible to conclude from the observation of ex post bias that there must have been bias in the predictions ex ante.” (Eliasson & Fosgerau 2013, p. 11)

The implication of the hypothesis on selection bias is hence that ex post evaluation of traffic forecasts as the only object of empirical inquiry is insufficient for proving strategic misrepresentation as well as the other contextual perspectives introduced above. In other words the possibility of selection bias implies that ex post evaluation studies are insufficient for inferring the cause of inaccuracy and bias as well as whether bias exists at all. In Chapter 5, it is argued too, but on the basis of another line of argument, that ex post evaluation as the only object of inquiry is insufficient for establishing the cause of inaccuracy of bias and an alternative methodological approach is drawn up instead. The theoretical implications of the above discussion will be elaborated next.

3.7 Need to widen the conceptual scope

Above, it was argued that the existing theoretical perspectives have each made important contributions to the theorization of causes on transport model predictive uncertainty and bias, and hence to the theorization of mechanisms shaping transport model based knowledge production. However, despite the fact that they all point towards promising dimensions, none of the perspectives seem in their singularity to offer a framework which captures the complexity and diversity of mechanisms shaping transport model-based knowledge production. This is not surprising. It is unlikely that a single perspective is able to account for the complexity and diversity of mechanisms potentially causing inaccuracy and bias in transport model results. Hence, in order to elaborate on the research question, it will be necessary to go beyond the

mono-causal perspectives evident in the vast majority of existing studies. In order to better conceptually grasp the diversity and complexity of mechanisms potentially shaping transport model based knowledge production, a multi-perspective framework which re-conceptualizes and expands existing theoretical perspectives is needed. Such a re-conceptualization needs to go beyond the respective limitations of the existing theoretical perspectives, particular in two ways.

First of all, despite the fact that the political-economic perspective makes an important contribution by putting the issue of power at the fore of the analysis, the conceptualization of power, within this perspective, as intentional manipulation and lies appears too narrow to capture the variety of power mechanisms that are potentially shaping transport model based knowledge production. Power should not, however, be disregarded as an important analytic concept on that ground. Power is not a mono-dimensional concept which can be contained within a single entity, and manipulation and lies only constitute one dimension of power. Rather, power is a plural concept, consisting of complex and diverse mechanisms which buttress and counteract each other through dynamic interactions (Carter, Clegg & Kornberger 2010; Haugaard 1997; 2003; 2010a; Clegg & Haugaard 2009; Richardson & Cashmore 2011). Instead of disregarding the concept of power as an important analytic concept, what is rather needed is a conceptual re-working compared to strategic misrepresentation.

Secondly, another weakness repeated in all of the aforementioned theoretical perspectives on causes of bias and uncertainty is that they all are rooted in either social or technical perspectives, that is, in either one or the other. None of the above perspectives considered the mutual interaction between both social and technical dimensions. An exception is Næss (2011) who traversed the individual perspectives rather than treating them individually. He discusses how technical, organizational and political-economic factors can intermingle and highlights how certain values and interests corresponding with organizational affiliation and political motives can be embedded in the technical structures of road transport models. I will argue that following the line of Næss (2011) by applying a multi-perspective conceptual approach which reaches across the boundaries of different types of theoretical perspectives seems to offer a promising path for opening up the empirical field of enquiry in new and productive manners. However, we need to go further than Næss (2011) and not only focus on how the intermingling of various social dimensions can influence the shape of transport models' technological content. We also need to conceptualize the inverse relationship, namely how technological dimensions can influence the social dimensions by facilitating some relations while constraining others.

4 Re-conceptualization - a multi-perspective framework

In the above chapter, it was argued that in order to better grasp the multiple, diverse and complex mechanisms potentially shaping transport model based knowledge production there is a need to rework existing theoretical perspectives. In this chapter a multi-perspective theoretical framework will be drawn up, creating a conceptual link between my research questions and my empirical research. The first section addresses the first requirement for the re-conceptualization. Here, the concept of power will be approached based on a multi-perspective framework of power developed by Mark Haugaard. This framework integrates seven different types of power in a commensurable manner, constituting a field of power dynamics. However, despite the conceptual richness of Haugaard's framework with respect to the social dimension of power, it does not have much to offer with regards to the fulfilment of the second requirement for re-conceptualization, namely, the co-production of social order and technology. In order to make Haugaard's framework relevant for addressing the research questions, the second section attempts to integrate other perspectives into the framework, engaging more explicitly with the socio-technological dimensions of power.

4.1 Expanding the conceptualization of power

The centrality of power as a concept for understanding society has been recognized since the time of the ancient Greeks (Saar 2010). However, just as there is no conception of society which has gained universal acceptance, neither is there a universally agreed definition of power. In fact, Steven Lukes has famously argued that:

"... the concept of power is ... an 'essentially contested concept' - one of those concepts which 'inevitably involves endless disputes about their proper uses on the part of their users.'" (Lukes 1974, p. 26)

The contested character of power is also reflected in the literature which is rich in opposing views on what defines the nature of power. The lines of separation between the different theoretical perspectives is concerned with whether power should be conceptualized as repressive or productive; conflictual or consensual; agent- or systemic based; coercive or authoritarian; illegitimate or legitimate; power as distortion of knowledge or power as embedded in knowledge (Haugaard 2002). Power is hence a highly diverse and complex phenomenon and to date it has not been captured within a single conceptual definition. However, I will argue that instead of situating a definition of power within an entrenched debate taking place between different theoretical positions, it is more fruitful to acknowledge that different schools each have conceptualized important aspects of power, but none has captured the concept exhaustively. Robert Dahl, in one of his early, but still relevant contributions to the conceptualization of coercive power expresses it as follows:

"... we are not likely to produce - certainly not for some considerable time to come - anything like a single, consistent, coherent "Theory of Power." We are much more likely to produce a variety of theories of limited scope, each of which employs some definition of power that is useful in the context of the particular

piece of research or theory but different in important respects from the definitions of other studies.” (Dahl 1957, p. 202)

The prediction made by Dahl has been fulfilled. More than fifty years after his study we do still not have a universally accepted concept, which captures the complex, diverse and multiple mechanisms known as power. On the contrary, in accordance with Dahl’s prediction, new theories have been developed during the last fifty years, which have increasingly diversified the conceptualization of power. In the quote Dahl also articulates another word of wisdom. Different perspectives each articulate important aspects of power, but none captures the essence of power. Because power is so diverse in its working, the nature of power cannot be settled upon through conceptual debates alone. Rather, the best definition of power must be defined with respect to the problem at hand. If we agree with Dahl (1957), (and I personally do), this implies that in order to justify why a particular concept of power has been chosen as a frame of analysis, one should not start by a deep discussion about the nature of power. Instead, one should justify the choice of theoretical framework with respect to the research objective and the empirical field of enquiry. However, as the empirical world is much more diverse and complex than any theory of it, following Dahl’s recommendation does not lead to an easy track. Precisely because of the complexity and diversity of the power relations working within the domain of the empirical, it is not obvious which theory is the most suitable to apply. Indeed if one deeply excavates within the empirical field of enquiry, more than one conception of power will almost certainly have something relevant to say about the research problem. One might even realize that different concepts of power are entangled and thereby open the analyses up in a productive manner which none of the concepts in their singular allow for. At this point, you might realize that the concepts of power you find relevant for your research objective and empirical field of enquiry, in the texts where they were originally developed, are articulated as mutually exclusive - so what do you do then? Do you reduce your analytical framework to a single concept and shy away from analysing the dynamics of power multiplicities, or do you choose to apply a framework which is internally inconsistent? Neither of these two situations is satisfactory. Mark Haugaard (1997; 2010a) has recently made an argument similar to Dahl (1957), concerning the fact that there is no essential ‘best’ definition of power, but good and bad must be defined with relation to the usability of concepts for the problem at hand. Haugaard’s (2010a) argument, however, goes further than Dahl’s (1957) and offers a way out of this quandary. According to him, the concept of power is certainly contested, but contrary to Lukes he argues that it is not essentially contested. Power consists of interactions between multiple relations and this complexity cannot be captured within a single concept. Because power is multi-dimensional in its working, so must the conceptualizations be so. Based on Wittgenstein, Haugaard (2010a) argues that power cannot be reduced to a single entity but rather qualifies as a ‘family resemblance concept’. This implies that different theories of power share a number of common characteristics, by which they can be grouped, but there is not a single characteristic which is shared by all the group members. Hence, there is not a single essence which defines the concept of power, but power is rather defined by a number of overlapping characteristics.

Haugaard (2003) has developed a framework consisting of seven diverse but inter-related forms of power creation. The type of power creation which Haugaard draws upon crosses the

conceptual boundaries which have traditionally characterised the power debate. Haugaard's framework thus allows for a conceptualization of power which both is conflictual and consensual, constraining and enabling, intentional and unintentional, agent and systemic based. Haugaard's (2003) framework, however, takes its point of departure from a consensual perspective on power. Haugaard (2003) argues that in complex societies, with a high degree of institutional stability, power that stems from a (re)production of social order exercises a stronger influence than coercive power. Despite coercion being a significant aspect of power it will often not be forceful enough to sustain institutional stability over long periods of time. In contrast, within institutionally stabilized societies the exercise of coercive power is rarely needed in order to obtain compliance with social order. Instead, the rules of the game are accepted, not only by the triumphant, but also by those who suffer defeat (e.g. opposition parties). Thereby, social order is reproduced routinely through the acceptance of various relations of power. Haugaard (2012a) argues that the more repeatedly that structures, institutions or practices are reproduced through acceptance, the more they will be taken for granted and perceived as natural. The aspect of acceptance is hence an important dimension of power, playing a part in reproducing social order and contributing to institutional stability.

By relating practices of acceptance and non-acceptance to other forms of power creation, Haugaard's framework enables conceptualization of how diverse forms of power can unfold in concert, thus embracing the dynamics created in the face of power multiplicities. Haugaard builds his framework of power from a considerable number of prominent power theorists, comprising the range from consensual to conflictual perspectives. The seven forms of power creation which Haugaard's framework revolves around are as follows:

1. Social order (Parsons, Luhmann, Barnes, Haugaard, Clegg and Giddens);
2. Bias (Bachrach and Baratz);
3. Systems of thought (Foucault);
4. 'False consciousness' (Lukes);
5. Power/knowledge, obligatory passage points (Foucault and Clegg);
6. Discipline (Foucault);
7. Coercion (Weber, Dahl, Bahcrach and Baratz, Mann and Poggi).

Some of these theoretical perspectives are originally formulated in incommensurable manners (e.g. Lukes and Foucault). Haugaard, however, avoids the pitfall of internal inconsistency by re-conceptualizing some of the concepts of power, which he draws upon while still being loyal to the type of empirical phenomena the form of power creation was originally intended to describe. The fruitfulness of applying the framework to explore how various forms of power can influence the design and use of Environmental Assessment instruments has already been demonstrated elsewhere by Cashmore et al. (2010) and Richardson & Cashmore (2011). In the following, each of Haugaard's seven forms of power creation will be elaborated on.

4.1.1 Social order

Haugaard's framework of the seven forms of power creation takes its point of departure from a consensual perspective on power. Here, power is understood as a capacity, enabling members of societies to do things which they would otherwise not be able to do. According to Haugaard,

the capacity for action is derived from two sources: nature and society. Despite social and natural power being dissimilar, they share an important feature. Both are dependent on predictability as a pre-condition for being harnessed for social ends. Haugaard puts it as follows:

“To turn to the analogy with physical power, our knowledge of the physical world involves a knowledge of predictability which facilitates physical power: so, similarly, the fact that we all have a tacit knowledge that others will structure their behavior in a relatively predictable way gives us the capacity to engage in collaborative endeavors with them.” (Haugaard et al. 2012, p. 20)

If social behaviour and meaning was entirely fluid and random, the actions of others would be unpredictable. Unpredictable randomness implies that A will neither be able to act meaningfully in concert with B, nor to exercise power over B except in the form of using physical violence. In such a case, the scope for meaningful social interaction would cease, resulting in a state of powerlessness, absurdity and ontological insecurity. According to Haugaard, the condition of possibility for predictability and hence meaningful social interaction is the existence of social order. The presence of social order implies that members of society share structured systems of meaningful production, which order their actions. In that sense, social structures are constitutive to social order. Haugaard puts it as follows:

“As the basic unit of social order, structures exist through social practices. Social structures are available to social actors both as facilitators of social action and as constrainters of social action. Just as discourses do, structures constitute part of the conditions of possibility of social practices.” (Haugaard 2012c, p. 37)

A situation, characterized by social order entails the presence of social structures, ordering the meaning of actions. This implies that the meaning an actor ascribes to a structured action is perceived as the same as correspondingly structured actions performed by other actors across time and space. This enables them to make sense of the world in a similar manner and thereby to act upon it collectively. In fact, it is internalization of social structures by members of the social order which orders their behaviour and thereby renders the conditions of predictability and concerted actions possible. While Haugaard argues that the basic unit of social order is social structures, he argues that at the overall level of society, social order is constituted by an assembly of intersecting social systems. Haugaard puts it as follows:

“A social system is an assembled set of social structures which define each other. Voting and government formation are both structured acts which gain meaning from each other. However, the political system does not exist in a vacuum. It exists together with an economic system, a linguistic system, a cultural system and a virtual infinity of small micro-systems such as schools, churches and families. Some of these systems intersect so there is no neat way of separating them from each other. Social order as a whole is the totality of untidy overlapping systems.” (Haugaard 1997, p. 124)

The concept of social order is hence a multi-levelled concept, ranging from micro structures embedded in everyday practices, to complex assemblies of social systems at national and global scales. When individuals act in accordance with conducts defined by social practices, institutions

and structures, at one level or another, they take part in reproducing these social practices, institutions and structures.

In accordance with Giddens, Haugaard argues that structuration of behaviour is a prerequisite for structural reproduction, but unlike Giddens he argues that it is not sufficient. In order for structural reproduction to occur, the meaning ascribed to a structured action also has to be accepted as correspondingly meaningful by other actors. This implies that if the exercise of power by A, is to have an effect (either in the power to act, or as power over another), it is conditional upon B accepting the relations of power. One cannot, hence, understand structural and institutional reproduction without the concept of acceptance.⁷ This corresponds with Barnes' theory of power, presupposing circles of validating knowledge. Haugaard (2010b; p. 58) argues that:

“Authority, as the legitimate institutionalization of power, is based upon a shared ring of reference that creates the positions of power that individuals occupy”

Contrary to the notion of power being possessed by actors, found in all of the three dimensional power perspectives, power within this perspective is conferred upon actors through their structural positions. Structural positions certify persons who hold them with authoritarian powers which others accept as legitimate. The mayor of a city is only the political leader because others are willing to accept his/her structural position as authoritative, even those who did not vote for the elected governing party. Haugaard uses the concept of social capital to refer to the certified authority of structural positions which define the conditions of possibility for legitimate agency. He defines social capital as follows:

“Social capital refers to the legitimate structuring practices associated with positions of authority that empower a social agent and are recognized as valid either by the rest of society or, in the case of a smaller group, by relevant interacting others.” (Haugaard 2012a, p. 81)

To hold a structural position does not only mean that legitimate authority is conferred upon the person, the person also has to submit to a particular conduct attached to the structural position. If a person who holds a structural position attempts to exercise authority beyond the legitimate conditions of possibility of the held structural position, the act will not be accepted by others in most cases (Haugaard 2012a, p. 79). For instance, the structural position of transport planners licences them authority to act as transport policy expert advisers, and who can legitimately produce authoritative knowledge claims about how to govern traffic effectively. However, the structural position of transport planners does not authorise them to direct police traffic. If a transport planner stops a motorist and attempts to fine the person for speeding, this exercise of authority would be considered beyond what is accepted as the legitimate agency of transport planners and the fine would most likely not be accepted as valid. Likewise, the act of strategic misrepresenting transport models is illegitimate because it is inconsistent with the legitimate capacity of the agency assigned to the structural position of transport planners and consultancies.

⁷ Haugaard terms acceptance of a particular act of structuration as valid and meaningful as confirming-structuration. In this thesis the term acceptance will however be used instead.

The above example concerning the acceptance of a mayor's structural position as authoritative, even by those who did not vote for the person, illustrates an important point. It was argued previously that power created as an outcome of social order is conditional on consensus. However, contrary to Parson, but in accordance with Barnes, Haugaard argues that the locus of consensus within social order is not the level of goals. This would preclude the conceptual scope for significant levels of conflict. Rather, the locus of consensus is at a much deeper structural level, almost squaring with the level of ontology (Haugaard 2003). This allows for conflicts both at the level of goals and various structural levels. Haugaard puts it as follows:

"..., if I put a tick in a box next to a person's name in an election the structuredness of this act is the meaning reproduced, not the goal pursued. I may vote entirely differently from everyone else but this does not alter the fact that I am exercising my vote and, as an unintended consequence, thus contributing to the reproduction of a democratic system." (Haugaard 2002, p. 305)

Structural reproduction is hence not necessarily an intentional effect of actors intentionally pursuing particular goals, but can also occur as an unintended effect of an assembled set of intentional actions. Even though actors may intentionally pursue conflictual ends, they can, as an unintended consequence reproduce consensus at the systemic level, as long as the conflictual ends are pursued by means which are in compliance with rules of the game defined by prevailing institutions, structures or practices.

From the above it can be concluded that predictability is a precondition for social power and it is social structures which render predictability possible through the ordering of meaning and actions. However, despite social power being conditional upon the predictability of behaviour, I will argue that social power neither requires nor implies that behaviour is structurally determined. This is not implied by Haugaard, but he is not specific about conditions of possibility for predictability. Nevertheless, Haugaard conceptualizes social structures as facilitating and constraining particular actions. This implies that structures render some form of actions more likely than others and this is substantially different from structural determination of behaviour. If structures determined behaviour this would imply that deterministic predictability was possible and hence social power would potentially be omnipotent and deterministic in its working. However, in accordance with Næss & Strand (2012) I will argue that social systems are inherently partially-closed/open systems, implying that they are structured but in a non-deterministic manner. This does not rule out the possibility of predictability in general, but it renders deterministic predictions impossible. In fact I will assert that the impossibility of deterministic behavioural predictions constitutes an important constraint on the effectiveness and omnipotence of social power. The impossibility of predicting social behaviour in a deterministic manner is not only due to structural indeterminism of behaviour. Although social structures are reproduced due to others' acceptance, they are in some cases not reproduced because they are no longer accepted by others. Non-acceptance hence constitutes another impossibility of deterministic social predictability. Below, this will be enlarged on.

4.1.2 System bias

While power derived from the creation of social order is a capacity for action, utilization of this capacity is conditioned on the inverse relationship - a capacity to make inaction occur. In other words, while the reproduction of social structures, institutions and practices are conditioned on predictability and acceptance, this is not a sufficiency for the reproduction of social order. The conditions of possibility for social predictability are also dependent on structural exclusion or non-acceptance of competing structuration practices incommensurable with the dominating social order. In accordance with Bachrach and Baratz, Haugaard argues that structural constraints or system bias imply that some issues are organized into politics while others are organized out. Haugaard put it as follows:

“In complex administrations some issues are deliberately made areas of non-decision-making so that power cannot be created with regard to certain controversial issues. When a non-issue is raised and directed at those in power, they will claim an inability to confirm-structure because that is not ‘how things are done’. It will be argued that this is not how the existing social order is reproduced. It may be desirable to deal with a certain issue but dealing with the issue will entail changing the ‘rules of the game’, hence destabilizing existing structural relations.” (Haugaard 2003, p. 94-95)

System bias can be used to marginalize, but contrary to Bachrach and Baratz, Haugaard does not equate structural constraint with domination. Social order presumes structural constraints and these can, through the same empirical processes of inclusion and exclusion, be mobilized both as power over and power to (Haugaard 2012b). Despite the fact that social order and hence social power is conditional on structural constraints, Haugaard does not explain structural constraints with reference to a functional need for social order. Haugaard opposes this type of explanation because it implies that agency is ascribed to social structures, and that actors are simultaneously rendered rubber stamp substantive of these structures. On the contrary, Haugaard argues that it is actors who produce and reproduce structural constraints, but they do this within conditions of possibility which are imposed on them. Haugaard puts it as follows.

“While struggles for power can be found everywhere, power is not some kind of metaphysical force which is everywhere. Power does nothing, wills nothing and, as a thing in itself, is nowhere. It is agents who are and who will, it is agents who struggle, it is agents who create truth claims and use them to empower themselves to positions of authority. Yet, these agents are not free to do so as they wish. They are constrained, but not by structure as a metaphysical force, or by systems. Rather, they are constrained by the necessity to make their structuration practices count as valid in the eyes of others.” (Haugaard 2012a, p. 78)

Haugaard explains structural constraints in terms of the capacity of other agents not to accept new practices of structuration, or de-structure them as he terms it. According to Haugaard the desire to sustain the status quo constitutes a significant reason for actors not to accept innovative acts of structuration which challenge the establishment. He puts it as follows:

“The motivations for de-structuration are complex and varied. One of the most obvious reasons for de-structuring is the desire to maintain existing power relations.” (Haugaard 2003, p. 94)

In order to raise new issues on the “agenda” and thereby change existing system biases of social order, it is necessary to create acceptance around new meanings and practices. New meanings or practices are often initially accepted only within marginal segments of society which suffer from a disadvantage of prevailing structural constraints. Haugaard (2003) puts it as follows:

“In a contemporary context, new social movements attempt to create rival arenas where certain issues are confirm-structured as ‘relevant’ or ‘appropriate’ and over time systemic change is forced upon those who try and maintain the status quo.” (Haugaard 2003, p. 95)

Within different segments of society there are different practices of acceptance and non-acceptance that can prevail and it is from these marginalized arenas that the struggles for gaining wider acceptance are fought out. Practices of acceptance and non-acceptance are vital for understanding, not only the sustention of status-quo, but they are also fundamental for understanding systemic change. Radical social changes occur not only because new practices of structuration have gained wide acceptance but are, to some extent, also conditioned on non-acceptance of former practices. Practices of acceptance and non-acceptance are hence relational and mutually constitutive. Because structuration needs acceptance in order to have a structural effect, innovative acts of structuration will hence often be framed in a manner that increases the likelihood of gaining acceptance from a particular audience. Likewise if a social practice is increasingly being met with non-acceptance to an extent where it losses legitimacy, competent social actors will in many cases also stop reproducing this practice because they know that acceptance of this practice is socially inappropriate (Haugaard 2003).

4.1.3 System of thought

The third form of power creation concerns systems of thought. Haugaard claims that non-acceptance of structuration does not only occur on the basis of actors’ desire to maintain the conditions of possibility of social order (system bias) and hence relations of power and powerlessness. Non-acceptance can also take place because acts of structuration are incompatible with prevailing systems of thought or interpretation horizons. Haugaard puts it as follows:

“While every system of thought has its facilitative aspect it also precludes certain forms of action, which fall outside the “conditions of possibility” of that system of thought. Structural constraint is often thought of as some invisible force determining behaviour or in terms of a lack of resources that preclude certain options, much as poverty imposes constraints. While structural constraint can have these aspects, on a cognitive level it is more frequently the case that certain meanings will be rendered infelicitous [non-accepted] within that system of thought, thus will fail to empower.” (Haugaard 2010b, p. 60)

Systems of thought sustain conditions of possibility of social order by facilitating acceptance of certain types of structuration practices while impeding the acceptance of others. Systems of thought are thereby functional in the stabilization of social order. Interpretation horizons constitute the creation of systems of meaning, a shift from the prevalence of one system of thought to another, where the newer system is incommensurable with the former. This implies that the order of things as defined within the conditions of possibility of the previous system of thought come to be seen as arbitrary and non-causal, while the order of things within the new system of thought come to be regarded as causal or natural. Despite practices of acceptance being dependent on commensurability between structuration and systems of thought, there is not a deterministic relationship between structure and system of thought. Competing acts of structuration can be commensurable with the same system of thought. This implies that the existence of a commonly shared system of thought within social order does not exclude the scope of conflicts about meaning.

“Systems of thought do not necessarily presuppose agreement upon particular outcomes although they do indeed presuppose overall interpretative horizons which converge.” (Haugaard 2003, p. 99)

Haugaard distinguishes between deep and shallow conflicts. Deep conflicts are those where hegemonic systems of thought are contested by counter-hegemonic systems of thought. These unfold *between* incommensurable systems of thought and conflicts *over* meaning are at stake. On the other hand, shallow conflicts unfold *within* system a of thought and the sticking point is *about* meaning, but as an unintended effect it contributes to the reproduction of hegemonic structures (Haugaard 2010b, 62; Haugaard 2012a, 82).

Despite systems of thought being vital for making sense of our being in the world, one should be careful not to conceptualize systems of thought as totalizing and escape-proof systems. Meaning which is incommensurable with a system of thought held by an actor is not necessarily completely meaningless nor is it incomprehensible to that actor, rather, it is inconsistent with what that actor regards as reasonable (Haugaard 2003, p. 98). Neither is it impossible for an actor to internalize diverged systems of thought. According to Haugaard:

“... social actors have multiple interpretative horizons available to them as part of their everyday social practices. Thus, they are not caught in a preconstituted web of meaning from which there is no escape...” (Haugaard 2010b, p. 51)

At one and the same time, an actor can consent to scientific, religious and nationalist interpretation horizons. Actors do not have different interpretation horizons simply because they hold different structural positions from each other, rather, multiple and even conflicting interpretation horizons can also be tied to one particular structural position. Sager and Ravlum (2005) argue that the structural position of transport politicians can have different and conflicting roles ascribed to it. Firstly, transport politicians are political leaders responsible for the management of the transport sector. Secondly, they are party members and have to act loyally to the party programme and politics. Thirdly, they are representatives and advocates for their home constituency. One of these roles or interpretation horizons cannot completely predominate over the others; instead, they need to be enacted in a balanced and simultaneous

manner. Which of the interpretation horizons is of most significance depends on the situated context and as Haugaard argues, being a socially competent actor means one can slip in and out of different interpretation horizons depending on its appropriateness within the particular social context. For instance, close to an upcoming election, the roles of party members and representative of their home constituencies will most likely be more significant than the interpretation horizon as professional transport politician. Moreover, how politicians make use of results from decision support tools is very likely to depend on which interpretation horizon they primarily undertake in a given context. For instance, when the role of professional transport politicians is salient, it is more likely that the politicians make use of results from decision support tools in an instrumental-rational manner, than it is when they primarily act as party politicians or representatives of their home constituencies (Sager and Ravlum 2005).

4.1.4 Tacit knowledge

Haugaard's fourth form of power creation concerns the relationship between tacit and discursive knowledge and is theorized as a source of both domination and emancipation. Following Giddens, Haugaard argues that social consciousness consists of two related dimensions: practical consciousness and discursive consciousness. Practical consciousness knowledge consists of tacit knowledge embedded in peoples' habitués and is hence knowledge which people draw upon unreflectively but as a matter of routine. Most knowledge held by actors about the social practices, structures and institutions, which their actions are structured by is embedded in their practical consciousness. This does not mean that practical consciousness knowledge is entirely unconscious knowledge, rather, it consists of taken-for-granted knowledge, which is only critically reflected upon if it is explicitly called into questioning. Discursive consciousness on the other hand consists of knowledge which actors can articulate and critically reflect upon (Haugaard 2003; 2012b).

Haugaard argues that because the knowledge actors use to reproduce practices, structures and institutions is largely tacit, they implicitly accept and reproduce these practices, structures and institutions as a matter of routine, even in cases where the structural relations which they take part in reproducing, are disadvantageous to them. In that sense, the empirical phenomenon which Haugaard's fourth type of power creation concerns also corresponds to Lukes' concept of power as false consciousness. However, despite the similarities between Lukes' and Haugaard's theorization, there are also differences. First of all, even though Haugaard argues that the idea of 'true consciousness' can be defended in situations where deliberated misinformation occurs, he leaves out the concept of true/false consciousness in favour of practical consciousness, thereby avoiding the pitfall of connoting a form of conspiracy theory or ethnocentric perspective associated with the idea of 'true consciousness'. Haugaard's fourth type of power creation does, hence, provide conceptual space for integrating strategic misrepresentation within the overall theoretical frame. In fact, it can be argued, in accordance with Lukes' third dimension of power that strategically misrepresented transport models are producers of false consciousness, which decision-makers potentially consent to despite being imbued with partisan politics.

Haugaard's theorization of the relationship between tacit and discursive knowledge also differs significantly from Lukes' in another respect. Contrary to Lukes, Haugaard argues that the relationship between tacit knowledge and structural reproduction is not one of pure

domination. Converting practical knowledge into discursive knowledge can also empower actors. Haugaard puts it as follows:

“Actors do not have the option of moving entirely beyond practical consciousness, which constitutes the essence of their being-in-the-world – they cannot escape from ideology. However, they are not entirely trapped in their practical consciousness. They can move practical consciousness into discursive consciousness, which gives them the capacity to reflect upon what they may previously have considered the natural order of things. In essence, this constitutes a form of consciousness raising whereby actors reflect discursively upon the implications of structuration practices. They suspend their natural attitude with the consequence that what may have appeared reasonable relative to their taken-for-granted knowledge of the order of things becomes problematized as discursive knowledge.” (Haugaard 2012b, p. 45f)

Social critique can be used to disclose the relations of power embedded in taken-for-granted practices, structures and institutions and thereby raise discursive consciousness as to how reproduction of these practices, structures and institutions is incommensurable with other discursively held systems of meaning and norms, or to disclose that they maintain disfavoured relations of domination. In that sense, social critique is a matter of converting practical knowledge into discursive knowledge, as this facilitates actors to critically reflect on the structural practices which they previously reproduced as a matter of routine. This type of social critique corresponds with Foucault’s genealogy. A central element in Foucault’s social critique is deconstruction of taken-for-granted truth claims. By ‘rolling back’ a discourse and showing that the claims to truth taken for granted in contemporary society do not rest upon a universal order, but are a product of struggles in the past, it becomes clear that the order of things could have been different. This type of critique is exactly what this thesis aims to exercise. By calling the taken-for-granted utilization of oversimplified transport models into question the aim is to raise consciousness about the fact that these models are based on a foundation which is inconsistent with contemporary transport political objectives, and hopefully to create a moment of opportunity for re-politicization and future change.

I will argue that Haugaard’s fourth type of power creation points towards an important dimension of power, namely, power as a capacity to create moments of opportunity for re-politicization of taken-for-granted practices. In other words, Haugaard’s fourth type of power creation draws attention to how power can be mobilized as a capacity to open up the black box and disclose relations of power embedded in the taken-for-granted of everyday practice and thereby create opportunities for upheaval within parts of social order which otherwise have been marked by stability and routine acceptance of structural reproduction.

This type of power creation enables a conceptualization of processes in which the black-boxed content of transport models is opened up for re-inscriptions. However, it is questionable whether theorization of this capacity to create moments of opportunity for re-politicization of the taken-for-granted is fully captured by the concept of converting practical knowledge into discursive knowledge. This conceptualization implicitly means that the knowledge which is raised to consciousness and used to create moments of re-politicization is, either tacitly or discursively, already part of actors’ social consciousness. In other words, it is implied that actors

in their consciousness possess all relevant knowledge about the structuration practices which they take part in reproducing. Nevertheless, it can be argued that re-politicization can also occur as a result of actors being confronted with new discursive knowledge, which problematizes the taken for granted based on a foundation which previously was not part of the actors' either practical or discursive consciousness. To give an example, the advancement of the scientific theory on anthropological global warming meant that a link between contemporary motorized patterns of mobility and climate change were raised to discursive consciousness, and the environmental un-sustainability of contemporary mobility practices and the car-based society started to be problematized in a new manner. In this case, the knowledge, used to question the taken-for-granted notion of car-based mobility practices was not practical knowledge, converted into discursive knowledge, but rather the creation of new signifiers, which reframed the taken-for-granted, and thereby problematized it in a new and innovative manner. In the controversy on anthropological global warming both opponents and proponents use science to argue respectively for the truthfulness of their own claims and against that of their adversaries' knowledge claims. This form of power will be elaborated on in the following sub-section.

4.1.5 Reification

Haugaard's fifth form of power creation concerns the relationship between power, knowledge and truth and is theorized as reification. While the fourth type of power creation contains a capacity to disintegrate social order by opening up the black box of the taken-for-granted and disclose that routinely reproduced power relationships are no more than social conventions, the fifth form of power creation contains a capacity to stabilize social order by reifying structural practices and thereby make them appear as more than arbitrary conventions. Haugaard states:

"Truth reinforces structural relations by ensuring that confirming-structuration takes place, even when this entails collaboration in the reproduction of structures which disadvantage the confirm structurer, through a process where de-structuration is the denial of truth." (Haugaard 2003, p. 104)

Truth reinforces structural stability, because non-acceptance of structuration practices, reified by truth, is contrary to reason or the natural order of things. Non-acceptance thereby becomes much more "costly" for actors than it is for them not to accept conventional structuration practices. Traditionally, reification of truth has been made with reference to nature or God, but, as observed by Foucault, from about the 18th century onwards, science also came to serve an important reifying function. As Haugaard puts it:

"If something is scientifically true then it is not 'merely' a convention." (Haugaard 2003, p. 103)

Around this period of time a new type of government started to emerge, where the population were made a substance of scientific enquiry. The shift in governmentality was based on a starting recognition by rulers that the population could not simply be governed by law. Instead, it was acknowledged that the population as a whole was regulated by overall processes independent of government (e.g. birth and mortality rates), but they were processes in which government could intervene for governmental ends. Distinct from sovereign modes of government, governing various forms of domains or artefacts meant that these domains or

artefacts had to be made objects of knowledge, and in order to govern properly, government had to be conducted in accordance with this knowledge and it is here that science came to serve a reifying function (Miller and Rose 1990). In contemporary politics, this form of governing is very apparent. The expertise of scientific and technological advice often holds an authoritative position in speaking truth about policy issues. As Haugaard notes:

“Sociologically, one of the functional reasons for success is that modern democracy is based on argumentation and increasingly upon expert opinion. Politicians debate in parliament, and, more significantly, receive their advice from bodies of ‘experts’. The modern democratic state has taken control of education and, in so doing, has taken control of socialization. The state issues certificates of competency in the shared final vocabulary or, what in everyday speech are called, ‘educational qualifications’. All state and corporate bodies are staffed by people who have authority based upon qualifications and, at the apex of the pyramid, elected politicians justify their decisions with reference to the advice of these holders of certificates. Consequently, non-compliance and disagreement become equivalent to irrationality.” (Haugaard 2012a, p. 88)

Even though truth serves an important function in stabilizing social order, reification can, according to Haugaard’s functionalistic approach, not be explained by structural needs. Rather, the durable effect of truth on social systems is an unintended effect of agents intentionally pursuing the use of truth to expand the authoritative capacity attached to the structural positions they hold. As discussed in section 4.1.1, actors are conferred a capacity for legitimate agency through their structural positions. Despite the fact that the boundary of social capital assigned to a structural position is defined by what other actors accept as legitimate authority, the social capital assigned to structural positions is not fixed. According to Haugaard (2012a), actors holding a structural position can expand their social capital either by keeping just inside the boundary of accepted authority or by expanding the boundary of accepted authority. However, the latter cannot be done solely at the will of the individual – it is conditional upon acceptance by others. Since expansion of social capital assigned to a structural position involves an innovative act of structuration which lies beyond the conditions of possibility for agency defined by the structural position, there is a high likelihood that the innovative act of structuration appears arbitrary and is hence not accepted. In order to increase the likelihood of acceptance, the innovative structuration practice, associated with the desire to expand social capital, has to appear as non-arbitrary. Hence, strategically, actors can use truth to expand the social capital of their structural positions by making innovative acts of structuration appear as reified, and to this purpose science can serve effectively (Haugaard 2012a). Haugaard puts it as follows:

“... the use of truth creates the conditions of possibility for power by reifying convention. In terms of functional arguments, at the micro-level of the agent, the pursuit of truth, the expansion of truth to new realms, is tied to an interest in empowerment through either the expansion of the social capital of existing positions of authority, or the creation of new authority positions. As these expansions of authority entail the introduction of new structuration practices, there is a high probability that they will be perceived as infelicitous. However, if

these authority positions are expanded, or created, based upon truth claims, these novel structuration practices have a greater chance of being considered felicitous and will meet with confirming structuration, by the responding other. (Haugaard 2012a, p. 86)

Haugaard draws attention to how actors can use truth as part of a progressive strategy to increase the social capital of their structural positions. To make this strategy more effective, the use of truth to expand the social capital can be combined with attempts to de-reify opponents' claim to truth. Haugaard puts it as follows:

"In moments of systemic change, the strategy for those who wish to discredit the social capital of others, while investing their own social capital with value, is to argue that the social capital of alter is arbitrary while the social capital of ego is made to appear structured and rational." (Haugaard 2012a, p. 86)

It can be argued that attempts to de-reify others' claim to truth can take place both between opponents who share a common system of thought and between opponents who hold counter-hegemonic systems of thought. With respect to the latter, the strategy is to de-construct the basis of the opponents' truth claims and thereby render them arbitrary, while simultaneously self-proclaiming truth. However, with respect to the former (opponents who share a common system of thought) this strategy cannot be used, because it implies that the basis of one's own claim to truth is simultaneously rendered arbitrary. In such case, de-reification can be exercised in at least two different manners. First of all, de-reification can be attempted by claiming that opponents' truth claims do not conform to strict criteria of truth prevailing within the system of thought in question. For instance, within contemporary societies where scientific systems of thought prevail, de-reification can take place by making divergent knowledge claims appear as non-valid or associated with large uncertainties. This can be done by assessing the credibility of the critical scientific knowledge by such high standards for validity and reliability that almost no scientific knowledge passes the test (Hellesnes 2008). Another strategy to de-reify opponents' truth claims within a shared system of thought is to underpin one's own claim to truth by increasingly advanced scientific methods. Thereby it can be argued that the knowledge base of the opponents is based on a simplistic and incomplete foundation.

While Haugaard theorizes upon agents' use of truth as part of a pro-active strategy for expanding social capital, I will add that actors can also use truth as a defensive strategy to protect the social capital of their structural positions against attempts of others to confine it. In modernity, science has obtained the status of being a final language (Haugaard 2012a), and the only reason which appears reasonable enough to contest the truthfulness of scientific facts is science itself. The only effective means of defence towards opponents' use of scientific truth is to call upon even harder scientific facts. In other words, if others use truth to de-reify the social capital of the structural position an actor holds, truth can be applied as a defensive countermeasure. For instance if others criticize one's knowledge claims for being based on insufficient scientific standards, the use of more advanced scientific techniques can be applied in defence of these knowledge claims. This will be elaborated further in section 4.2.6.

As a final remark to this section, it is important to note that despite the fact that reification of social order by the power/knowledge relation can have distortive effects which sustain relations of power and powerlessness, reification of truth is necessary for ontological security. Moreover, according to Haugaard, reification does not imply that everything claimed to be truth is entirely false. In other words, the essence of truth is not an undercover for false consciousness. Haugaard puts it as follows

“... the fact that truth is functional to power does not entail that what is being claimed as true is inherently false. We must not confuse sociology and epistemology. The claim that power is created by linking meanings to truth or nature does not entail the conclusion that this linkage is always fraudulent, although it does mean that it is difficult to divorce from power and interests.” (Haugaard 2003, p. 105)

4.1.6 Discipline

Haugaard's sixth form of power creation concerns how predictability is ensured through the inculcation of routines and is theorized as discipline. Disciplinary power concerns processes of socialization in which actors internalize structural constraints into the practical consciousness of their interpretation horizons. The internalization of these self-constraints makes actors' actions more predictable, because actors tacitly accept these structural constraints as part of the natural order of things. Structural constraints thereby become part of actors' self-perception of what is acceptable and non-acceptable behaviour. As Haugaard argues, this form of power creation is closely linked to the fourth type of power creation. He puts it as follows:

“In some sense, this form of power can be seen as a reversal of the flow of the fourth form of power creation: in the latter, predictability was ensured through tacit knowledge while here tacit knowledge is created by going through the motions of predictability.” (Haugaard 2003, p. 106)

While the fourth form of power concerned a capacity to open up the black box of the taken-for-granted and create moments of possibility for re-politicization and change to occur, the sixth form of power creation concerns a capacity to de-politicize parts of the social order, by creating black boxes and sealing up within them parts of discursive consciousness, which then over time becomes part of what is taken-for-granted. Disciplinary power is a form of power which, according to Foucault, is particular to modernity and the idea of mass socialization. Foucault's analysis of Jeremy Bentham's panopticon jailhouse is emblematic for disciplinary power. The architecture of the panopticon was deliberately designed to raise the visibility of inmates to a maximum, almost making them transparent to the eye of the watchman, while the observer was simultaneously concealed from the view of the inmate. The inmate was not able to know when he/she was being watched or not. Due to the inmate's feeling of being kept under continuous surveillance, the inmate internalizes a kind of self-policing and becomes his own warder – a warder whose eye there is no escape from. Foucault's analysis of the panopticon also shows how relations of power can be inscribed into spatial-material arrangements, as a means to discipline actors to behave predictably, and thereby sustain social order.

4.1.7 Coercion

The last type of power creation, theorized by Haugaard, is coercion. According to Haugaard (2003; 2012b) coercion is a hybrid form of power. It consists of a mixture of physical power, in the form of violence, and social power. According to Haugaard, coercion is not, hence the ultimate form of power. Rather, coercion indicates that social order is relatively weak, and most often it is drawn upon as a last call, when power derived from other forms of power creation are ineffective in making others accept a process. The effect of physical power is rather limited and its use represents the failure of social power. Haugaard (2003) states:

“In its raw form, physical power, violence, creates only two forms of predictability: mutilation and death. However, in most complex social orders violence is blended with social power and then we get coercion. In that type of relationship the less powerful actors are conscious of not wishing to reproduce the meanings or, alternatively, the outcomes required, but a threat is used to induce them to do so. It is within this context that the modern state strives for a monopoly of physical violence.” (Haugaard 2003, 108)

Despite that coercion can be backed by use of, or simply by the threat of physical power, violence is not inherent to coercion. Dahl’s form of power as direct decision control is not necessarily linked to violence or to legitimate authority. For instance, let us say that an executive commands a subordinate to spy on the subordinate’s immediate superior, because the executive suspects that the immediate superior is having an affair with the partner of the executive. At first the subordinate resists, because the person has an amicable relationship with the immediate superior. However, the executive then says that the subordinate will be fired if he refuses to spy. In this case, the structural position of the executive does not legitimate the person to command the subordinate to spy. Moreover in this case, the executive neither calls upon truth in an attempt to expand the capacity of legitimate action, nor is the threat of violence used as a sanction. Hence coercion is not necessarily tied up with physical power.

4.1.8 Sum up

Haugaard’s seven forms of power creation are summed up in Table 4.1 below.

Table 4.1: Haugaard's seven forms of power creation. Adopted from Haugaard (2003)

	Forms of power	Example	Scholars of inspiration
1	Power created by social order	Power creation stems from production and re-production of social structures, making actors’ actions predictable, but it is conditional upon acceptance.	Parsons, Luhmann, Barnes, Haugaard, Clegg and Giddens
2	Power created by system bias	Structural constraints theorized as actors’ ability not to accept structuration practices. Social order constrains certain actions which deviate from prevalent social structures or rules.	Bachrach & Baratz
3	Power created by system of thought	Certain acts of meaning production are incommensurable with particular interpretive horizons and will therefore be met with non-acceptance.	Foucault

4	Power created by tacit knowledge	'Power over' based upon social knowledge that is not discursive. Empowerment through the transfer of knowledge from practical to discursive consciousness.	Lukes
5	Power created by reification	Social order has to appear as non-arbitrary. In modernity, science performs a significant reifying function by possessing "truth production" capabilities.	Foucault and Clegg
6	Power created by discipline	Routine is used to make actors predictable through the inculcation of practical consciousness knowledge	Foucault
7	Coercion	Natural power as base: violence and coercion as a substitute for the creation of social power	Weber, Dahl, Bahcrach & Baratz, Mann and Poggi

4.2 Creation of order beyond the social

According to Haugaard's theorization, power creation is conditional on predictability, ensured by structures which order behaviour (see section 4.1.1). While Haugaard conceptualizes structures as social systems of meaning production, I will argue that this is too narrow in scope to fully grasp mechanisms ordering the social. Natural and physical structures as well as material and non-material technological objects (e.g. software and data files) all have capacities to structure social practice, organizations and institutions. Technological systems and artefacts are, however, so deeply ingrained in our daily practices that we often take them for granted and accept them tacitly (Pinch 2008). Yet technology is not neutral - it does something - it takes part in structuring social action and interaction. As Law puts it:

"Machines, architectures, clothes, texts all contribute to the patterning of the social. And this is my point - if these materials were to disappear then so too would what we sometimes call the social order." (Law 1992, p. 382)

Due to the structuring effect of technology, it can aid in ensuring predictability and hence in constituting social order. For instance, in order to understand contemporary patterns of urban mobility, in addition to accounting for structures embedded in social systems (e.g. economic, political and cultural), one will also have to account for spatial-material structures and technological artefacts (see Section 1.1).

In order to make Haugaard's framework suitable for overcoming the need to investigate interactions between technological and social dimensions, other theoretical perspectives will be integrated into it, in this section. These other perspectives will engage more explicitly with the mutual shaping between social and non-social structures. These perspectives that will be merged with Haugaard's framework originate from science and technology studies and are mainly inspired by the social shaping of the technology perspective (particular the social construction of technology) and the actor-network theory. The reason why these perspectives are found to be particularly relevant is because both perspectives, in correspondence with one of this thesis' research objectives, aim to question the taken-for-granted nature of technology.

The social shaping of technology is concerned with showing that technologies are not autonomous, but that their development and use are shaped by social processes of meaning production. Moreover, in accordance with my research approach, the social construction of

technology often uses history as a means to question the taken-for-granted nature of contemporary technological practice. It seeks to open up the black box and disclose the contingency of the social choices embedded in technological artefacts and then link these choices to wider societal concerns. By showing how things could have been differently, it seeks to politicize technological design.

Actor-network theory is a conceptual frame for analysing socio-technological processes and interactions. To some extent it can be argued that actor-network theory aims to explain the creation and transformation of social order, but in order to do so, the actor-network theory goes beyond the social. In accordance with the social construction of technology, actor-network theory holds that technology is developed through interaction and negotiation between actors, organization and institutions. However, actor-network theory adds to this that non-humans also play a role in these interactions and negotiation. According to actor-network theory, social order is not only made up of humans but rather of heterogeneous elements, networked together (Law 1992, p. 381). In accordance with Barns' argument, concerning the fact that the creation of social order is an added capacity for action, actor-network theory holds that the capacity to act, is an outcome of the heterogeneous elements' composition in assembled actor-networks. The core of the actor-network theory is to analyse how heterogeneous networks are assembled, held together, organized, expanded, dissolved, resisted and transformed. As Law puts it:

"... the task of sociology is to characterize these networks in their heterogeneity, and explore how it is that they come to be patterned to generate effects like organizations, inequality, and power." (Law 1992, p. 382)

Both social construction of technology and actor-network theory originate from the sociology of scientific knowledge, and the issue of symmetry has been taken up within both perspectives. The issue of symmetry has, however, been given another meaning within both approaches. Within the social construction of technology, symmetry means that successful and unsuccessful technologies should not be explained by reference to their inherent properties. The social construction of technology also adheres to the notion of symmetry by arguing that one should not make any distinction *a priori*, between the social, the technical, the political and the scientific, but treats them as a fabric, patched together in a sociotechnical ensemble (Bijker 1995). Actor-network theory employs the principle of symmetry in a more radical fashion, claiming that no distinction should be made *a priori* between the social and the natural or between human and non-humans.

Despite the two positions having important contributions to make, their total merger of the social and the technical at the ontological level can be problematized. I agree that social and technical can be contained in one another and that they are so entangled in many cases that they can be difficult to unwrap. However, I do not agree that this implies that everything which is technical is social and vice versa. Despite the fact that they can be contained within one another, they cannot be reduced to one or another - ontologically they are not one and the same. Instead of mingling the social and technical together conceptually, this thesis approaches the relationship between the social and the technical as one of reciprocal interaction - they shape each other through facilitating and constraining mechanisms, but are not reducible to one another. Below, it will be elaborated as to how the relationship between technology, structures

and institutions is conceptually approached in this thesis. Despite the ontological status that is assigned to technology in this thesis differing from both actor-network theory and some positions within social construction of technology, I will, nevertheless, argue that some of the fundamental questions which they ask are still relevant for approaching my research questions. One does not need to agree with other positions in order to receive inspiration and learn from them.

4.2.1 Technology, structure and institutions

It was argued above that in order to account for the constitution of social order, it is insufficient to only account for social structures as technological structures are also relevant. This raises questions as to how to conceptualize the relationship between the social and technical structures. Are technological structures determining or determined by social order, or are social and technological structures mutually constituting? I will argue that a mono-causal and deterministic conceptualization of the relationship between social and technical structures is inadequate. Instead, the relationship between the social and the technical is better conceptualized reciprocally. In accordance with several scholars (Cashmore et al. 2010; Jepperson 1992; Lascoumes & Le Gales 2007; Pinch 2008) I suggest that technology can be conceptualized as an institution. Like social institutions, technology is a product of social action, which also structures action, by facilitating some forms of behaviour while constraining others. Moreover, despite the fact that technology is the product of human action, the structuring effect of technology cannot be reduced to intentional effects, but can also have ordering effects, which are the unintended consequences of actor's pursuit of intentional ends. Theorizing technology in this manner squares with Haugaard's functionalistic approach. Let us illustrate this point by a simple example. In Figure 4.1, two benches can be observed. The material structure of both benches facilitates the action of sitting. Let us assume that this structural feature is a result of intentional human action. The benches' material structures, however, do not only facilitate the behaviour of sitting, they also constrain behaviour. For instance, while the bench to the right also facilitates the action of lying down, this action is constrained by the material structure of the left bench. This structural constraint of the left bench is likely to be a deliberated feature, designed to exclude homeless individuals from taking up residence. Hence, the material structure of the left bench contains an intentional system bias. Yet, the political effect of the left bench's material design cannot be reduced to this seemingly intentional effect. For instance, the person sitting on the right bench has taken up position in the middle of the bench and hawks the whole bench with his body language. The material structure of the left bench, however, constrains this type of bench hawking behaviour. On that ground, it can be argued that as an unintended structural effect of the bench's deliberate design, the bench does not only contain a political programme of exclusion, but also a democratic programme of inclusion, not reducible to the intentional design.



Figure 4.1: The political effect of the bench material structure is not reducible to the intention of design. The bench on the left excludes homeless from taking up residence (Henman 2010), but it also constrains the type of bench-hawking behaviour seen at the bench on the right.

In this example, the structuring effect of technology was due to the material form of the benches. Yet, the structuring effect of technology cannot be reduced to material form, but is better conceptualized as a technological structure (Faulkner & Runde 2011). This distinction is important because not all technologies are material, and non-material technologies can also contain structural properties, capable of ordering behaviour. For instance, software is a technology rendered possible by the grammar of particular languages, namely computer programming. The basic unit of software is, therefore, social structures and not material structures. Admittedly, the performance of software programs is conditional upon a material bearer, namely computer hardware, but the material bearer does not determine the structural effect of non-material technologies (Faulkner & Runde 2011). Jepperson gives an example of how software programs can function as an institution. He put it as follows:

“Within any system having multiple levels or orders of organization, primary levels of organization can operate as institutions relative to secondary levels of organization. A microcomputer’s basic operating system appears as an institution relative to its word-processing program (especially to a software engineer).”
(Jepperson 1991, p. 146)

Hence, an operating system can function as an institution, structuring the interaction between different application programs. Software can, however, also function as an institution relative to the software users. A word-processing program allows the user to write in particular ways and not in others. In that sense, software programs are embodiments of structural constraints, facilitating some actions while constraining others. For instance, if the technological structure of a four-step model is based on a fixed-trip matrix, this serves as a structural constraint for including induced traffic into transport models. Likewise, an all or nothing assignment constitutes a structural constraint for calculating time costs due to induced traffic. These non-material technological constraints may be discursive conscious to the model developer but not necessarily intentional. The intentional end of these simplifications might not be aiding an inappropriate evaluation of transport projects, but perhaps, for example, limited computing power, resources, skills, etc. Despite technological structures being a result of human choice (intentionally or unintentionally), the choices embedded in the material or non-material technological structure, are often not visible to the user but accepted tacitly. Pinch puts it as follows:

“It is because social choices appear to have vanished from technologies, or are so deeply embedded within technical structures that they become invisible to all but the technical experts, that technologies are powerful institutions.” (Pinch 2008, p. 467)

This implies that if one wants to account for how technologies can function as institutions, producing ordering effects, one will have to look inside the black-box and investigate the choices which resulted in a given model’s technological structure.

4.2.2 Social order and inscription of meaning into technology

Haugaard defined social order, or segments within social order, as shared structures of meaning production, enabling members of the social order to make sense of the world in a largely similar manner (see Section 4.1.1). Within different segments of social order different structures of meaning production can prevail and this implies that phenomena and objects can be assigned multiple meanings (see Section 4.1.3). In accordance with this, one of the central ideas of the social construction of technology approach is that the meaning of a technology is not fixed, but is constructed within different social groups. In accordance with Haugaard’s definition of social order, a social group is defined with reference to a shared meaning assigned to a technology among the group members. Because different social groups can construct the meaning of a technology differently, the technology does not contain a fixed meaning. The concept of interpretative flexibility refers to how different social groups, engaging with a particular technology can have different understandings of that technology and hence ascribe different meanings to it. When different social groups assign different meanings to an artefact they also assign different purposes to that technology. Thereby different problems which they would like the technology to overcome are also constructed. The social construction of technology holds that the different meanings and problems, assigned to a technology, are essential for understanding its development path. The problems assigned to a technology by different social groups do not themselves determine, however, the response of producers and designers to overcome such problems. This implies that the solutions of technological design to these problems also are interpretatively flexible. According to the social construction of technology, the meaning of technologies is particularly open to different and conflicting interpretations among different social groups during the initial design stages of a technology. Because particular meanings assigned to an artefact can shape and constrain the development of technology designs, interpretative flexibility can lead to the development of different and competing design versions of a technology. Unlike a linear understanding of technological development, this opens up a multi-directional conceptualization of technological development. With respect to transport modelling, interpretative flexibility implies that different social groups can ascribe different meanings to a transport model. Henman (2002) has made a similar argument, pointing out that computer models can simultaneously function as intellectual, scientific, forecasting, governmental, truth production and political technologies. Henman puts it as follows:

“...scientists use computer modeling both as an intellectual and a scientific technology, but it may in turn be invested with truth claims, thereby becoming a truth-production technology. Similarly, when computer models are used as political technologies, they also simultaneously act as truth-production and

forecasting technologies. In short, the way computer modeling is used in one setting may be ambiguous, and it is this very ambiguity that provides fertile grounds for computer modeling as a political technology.” (Henman 2002, p. 163)

Because the meaning of computer models can be assigned through various interpretation horizons, their interpretative flexibility means that they do not contain a fixed and singular identity. Rather, a model can contain several meanings at once. This ambiguity of computer models enables them to be moved between different interpretation horizons and still be accepted within those different horizons. However, despite the ambiguity of technology, one should not equate interpretative flexibility with unbounded interpretative flexibility (Bijker 1995, p. 282). Interpretative flexibility does not mean that a model does not contain any properties beyond the social meaning ascribed to them. Despite model development, and despite subsequent interpretation of results being shaped by social meaning, the technological content of a transport model does not change due to the shifts in meaning attribution attached to it when it has been stored. The intrinsic properties of a model also influence which meanings are likely to be attributed to it as well as which meanings are likely to be sustained by that model. As noted by Faulkner & Runde (2010), this implies that technological objects have a dual identity; one constituted by its structural form and another constituted by its social function. They put it as follows:

“...an object possesses a particular technical identity within the community in which it is used and / or appropriately referenced if: (1) that object has assigned to it the function associated with that technical identity; and (2) the structure of that object is such that it is generally able to perform that function.” (Faulkner & Runde 2010, p. 15)

On the one hand, interpretative flexibility means that technology does not have an essence, and on the other hand, the technological structure of an object constrains the interpretative flexibility of that technology. Hence, technology is neither technologically nor socially determined but mutually constitutive.

The social construction of technology's concepts of relevant social groups and interpretative flexibility and its focus on meaning, is very helpful in constructing a link between Haugaard's concept of social order and the development of technologies. Yet, it cannot be assumed, *a priori*, that meaning and hence social order fully and freely is inscribed into technology. What happens if designers encounter unforeseen problems when developing a technology? What happens if the original meaning and goals are unsuccessfully inscribed into a technology?

Latour (1994) argues that artefacts mediated programmes of action (meanings, interests and goals). This means that the initial meanings, interests and goals of actors can be translated into something else through the mediation of technology. One should therefore be careful not to equate the initial meaning of a dominant social group with the properties embedded in the resulting technology. Latour uses the example of an angry person who wants to “take revenge” on another person, but when a gun is introduced, the person's programme of action becomes translated into “shooting” that person. He puts it as follows:

“You are different with a gun in hand; the gun is different with you holding it. You are another subject because you hold the gun; the gun is another object because it has entered into a relationship with you, the gun is no longer the gun-in-the-armory or the gun-in-the-drawer or the gun-in-the-pocket, but the gun-in-your-hand, aimed at someone who is screaming. What is true of the subject, of the gunman, is as true of the object, of the gun that is held. A good citizen becomes a criminal, a bad guy becomes a worse guy; a silent gun becomes a fired gun, a new gun becomes a used gun, a sporting gun becomes a weapon.” (Latour 1994, p. 33)

The association between the properties of the gun and the intention of the angry man means that both the man and the gun change and become something else. This something else is a hybrid and the new capacity for action which has been created cannot be reduced to the human or the non-human. In other words, the coupling of the angry man with the gun means that the conditions of possibility for action have changed, both for the gun and for the man. Due to the new conditions of possibility, a new act of structuration emerges, previously impossible. The new conditions of possibility for action is neither reducible to the gun nor the man, but is shared between them. If either the gun or the man resigns from the association, this added capacity for action disappears. It is not only the use of technology which can mediate action - so can development of technology. According to Latour (1999) technological development is often not a strait path, but paved with problems, not easily resolved and leading to dead ends. In order to overcome these problems, it is necessary to deviate from the strait path and take a detour in search of a solution. The detour means that other humans or non-humans will have to be made interested and enrolled to work on a solution to the problem. The detour may, however, also mean that one gives up the initial goal, and instead follows a path towards others. A third possibility is that a new goal is invented. No matter which route the detour takes, negotiations are required in order to create alliances. Technology can mediate action, and this means that the initial goal or meaning becomes translated into something else as illustrated at Figure 4.2 (Latour 1994).

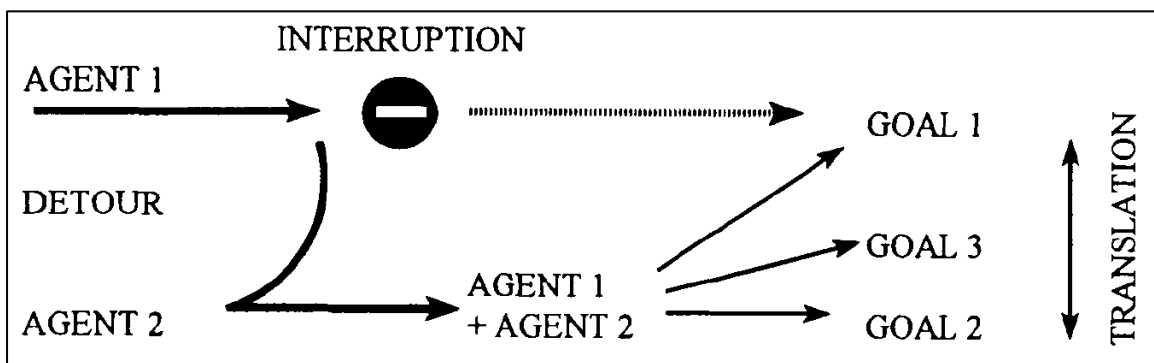


Figure 4.2: Translation of goals and meanings due to unforeseen obstacles. Source (Latour 1999, 187)

This shows that one should be careful not to equate the meaning embedded in the properties of a final developed transport model with the meaning and goals which prevailed among the dominant social groups at the time it was decided to develop the model. Rather than assuming that meaning is either fully inscribed or that it has been translated beyond recognition, the process of inscribing meaning and goals into transport models will be a concern of the empirical investigations, in both of the embedded cases.

4.2.3 Acceptance and non-acceptance of technology

In Haugaard's theorization of power, the concepts of acceptance and non-acceptance are vital for understanding both structural reproduction and structural changes. Hereafter, I will argue that the concepts of acceptance and non-acceptance are also important with respect to understanding socio-technological stability and change. According to Haugaard, the difference between felicitous and infelicitous acts of structuration is that felicity has gained acceptance. Likewise, the social construction of technology does not explain successful and unsuccessful technologies with reference to the superiority or inferiority of their inbuilt properties, but with reference to whether or not they are accepted among relevant social groups (Bijker 1995, p. 270). One cannot *a priori* assume that organizations implement technologies because they are the best of all. In order to understand why a particular technology is institutionalized as opposed to others, the social construction of technology looks towards the social context of the technology's operational environment, and investigates the social criteria for what qualifies as the best technology and why it gained acceptance (MacKenzie & Wacjman 1999, p. 22).

Hereafter, the importance of non-acceptance for understanding technological development and changes will be discussed. Originally, the social construction of technology had a pluralistic conception of relevant social groups, and its focus was primarily confined to producers and users of technology. This focus has, however, been criticized for neglecting, asymmetrically, the relationship of power and structural constraint. Due to structural constraints, some groups are more able to access and influence the design processes than others. Some groups might even be completely excluded from engaging with particular technologies (Klein and Kleinberg 2002). On the other hand, it is important that non-use of technologies is not only conceptualized as a marginalization due to system bias. Wyatt (2003) argues that non-use of a technology also can be a strategic choice, because one opposes the technology, finds it uninteresting or has more suitable alternatives available. Non-use can hence be based on a desire to de-structure a particular technology or the social capital of those whose acts of structuration are tied up to that technology. Non-use is important to account for because technological change is not only shaped by those social groups who produce and accept to use a given technology; it can also be shaped by transformative resistance from social groups who do not accept using a particular technology (Kline 2003). Hence, just like innovative acts of structuration are likely to be framed in a manner that increases the likelihood of being met with acceptance by relevant others, technological change can come about as a reaction towards resistance, non-use and non-acceptance of a technology. In order to increase the likelihood of being accepted among a wider range of social groups, and thereby expand the socio-technological order, it will have to transform in a manner, making it more acceptable to relevant non-users. In accordance, Latour (1991) argues that technological change can be driven by dynamic struggles between programmes and anti-programmes of action. A programme of action can be inscribed into artefacts but this scripted programme of action is not always accepted by users, but is met with non-acceptance from anti-programmes, attempting to overwrite or rewrite these inscriptions. To counter the resistance of the anti-programmes, the programme of action must respond with a counter-strategy, and this will often mean that the initial inscriptions are transformed, made increasingly durable more difficult to resist. Latour (1994) provides an illustrative example, namely, the introduction of speed bump. He argues that the programmes of action (or act of

structuration) “slow down your car” is not often accepted by car drivers if it is inscribed into a sign. If a policeman stands next to the sign, the drivers might accept slowing down, but only when the officer is present. In order to counter these anti-programmes and make car drivers accept the programme of action, namely “slow down your car”, it is inscribed into concrete, in the form of a speed bump, and thereby made durable. Such inscriptions of social order into durable materials can be effective with respect to ensuring structural reproduction. This is because, as in the case of the speed bump, the consequence of not-accepting acts of structuration made durable, can be severe. As Law points out:

“...some materials are more durable than others and so maintain their relational patterns for longer. Imagine a continuum. Thoughts are cheap but they don't last long, and speech lasts very little longer. But when we start to perform relations and in particular when we embody them in inanimate materials such as texts and buildings they may last longer. Thus a good ordering strategy is to embody a set of relations in durable materials. Consequently, a relatively stable network is one embodied in and performed by a range of durable materials.” (Law 1992, p. 387)

It is only when the programme of action has been made durable that most of these anti-programme actors become converted to accept the programme of action, and thus it stabilizes and becomes predictable (Latour 1991). However, the act of structuration associated with the programme of action, which was accepted in the end, is no longer the same as the acts of structuration of the initial programme of action. The delegation of action to the speed bump involves a translation of programme of action from “slow down your car” to “slow down your car or it will be damaged”. The act of structuration has hence transformed both through the enrolment of technology into the programme of action and through the use of technology to counter an anti-programmes. Hence, in order to convert the non-accepters into accepters, the act of structuration will have to be negotiated, transformed and made durable.

In accordance with Haugaard's theorization, this implies that in order to understand transformations in the socio-technical order, it is not enough to include the producers (structuration) and those who accept to use a technology, but it is also necessary to account for those who do not accept its use and those who resist using the technology, namely relevant non-users or anti-programmes.

4.2.4 Closure and stabilization

In Haugaard's framework the concepts of tacit knowledge and disciplinary power was respectively used to describe, firstly, re-politicization, where the taken for granted is opened up, and secondly, de-politicization where taken-for-granted practices are created. Accordingly, the social construction of technology applies the concepts of stabilization and closure to refer to how the interpretative flexibility of an artefact can decrease. The artefact's meaning is fixed and it becomes taken-for-granted. Moreover, in accordance with the third form of power creation, the taken for granted meaning of a technology can also be opened up and re-politicized, thereby become increasingly interpretative flexible anew.

Above it was argued that technological artefacts are interpretative flexible, and particularly in the design stage of a new technology, the meaning of that technology is open to various and

conflicting interpretations. However, the interpretative flexibility of an artefact often diminishes over time as its meaning becomes more fixated and one interpretation tends to become dominant. Thereby, stabilization and closure have been reached. The concept of stabilization refers to the process of creating consensus on the meaning of an artefact within a relevant social group. The degree of stabilization of an artefact can vary between groups. The concept of closure is used to refer to how consensus on the meaning of an artefact emerges among relevant social groups. The process of closure and stabilization of technological artefacts does not only mean that their meaning becomes more unequivocal, but also that the perceived problems of that technology delimit and, therefore, the possible development paths also reduce in number. When closure has been reached, the technological properties and characteristics of an artefact tend to become taken for granted, and it is difficult to imagine that its design ever can or could have been different.

Pinch and Bijker (1984) distinguish between two types of closure mechanisms. The first is rhetoric closure which comes about through the discursive construction of a problem as fixed. This does not necessarily mean that the problem has actually been fixed, only that it is perceived to be so by relevant social groups. The other closure mechanism can come about due to a redefinition of the problems that the relevant social groups assign to a technology. Humphreyes (2005) adds a third closure mechanism, namely, the redefinition of solutions. The concepts and closure is imported from the sociology of scientific knowledge, where it was introduced to analyse how consensus on scientific facts was obtained within scientific controversies. However, Bijker (1995, 264) also links the concept of closure to Foucault's concept of disciplinary power. In fact, in accordance with the concept of disciplinary power, Pinch has recently made an argument concerning the closure and stabilization of technologies, asserting that it can come about through the way technologies can aid in disciplining human behaviour through routine. Pinch states:

“Highly institutionalized processes are ones where humans repeatedly act in the same way, and that is exactly what technologies do to their users.” (Pinch 2008, p. 474)

Accordingly, it can be argued that traffic models, through the inculcation of routines, can have a disciplinary effect on model designers, which leads to rigid ways of thinking about the causal relations which influence the behaviour of the road users. As Clausen (1969, p.30), who is a transport modeller himself, puts it:

“The acquired familiarity with the model during its construction often entails that you discover new and surprising characteristics of the system; but it can also imply that one gets used to the concepts and casual relations embedded in the model. In regard to the latter, the result can be a stereotypical way of thinking, which will be an impediment for both actual and possible subsequent model developments” (Cited in Nielsen 1995; Own translation).

This shows how models can function both as disciplinary technologies, narrowing down the flexibility of technological designs and as consciousness raising technologies, producing outcomes which question the taken for granted.

Rosen (1993), however, criticizes the notion of stabilization and closure for being too rigid. Originally, the social construction of technology approach focused on the development stages of various technologies, and was thereby not capable of showing how the meaning of a technology, which at one point in time has reached closure and stabilization, and at a later point can open up for flexible interpretations anew. Likewise, Kline and Pinch (1996) showed that after the meaning of the car had stabilized within rural America, it was re-opened in the early twentieth century, reinterpreted and put to the additional use of a stationary power station to ease household chores. In their study they showed how the use of the car once again became interpretative flexible due to a reframing of its use. Reframing can hence function both as a mechanism of closure and increased flexibility. In order to avoid the irreversible connotation of closure, Humphreyes (2005) has instead proposed the concept of temporal closure, to highlight that in the long term closure will never be final, particularly not if the closure is only rhetoric.

In accordance with Haugaard's theorization, the social construction of technology theorizes only on social mechanisms taking part in opening up a taken-for-granted practice. However, this theorization might be too narrow to fully grasp the mechanisms that create moments of possibility for re-politicizing to come about. According to actor-network theory, changes in some elements of the network (or changes in the composition of the heterogeneous elements of the network) can generate changes in other parts of the network. This will allow for a conceptualization of processes which can take part in re-opening taken-for-granted practice, which is not restricted to social elements.

4.2.5 Technological frames

According to Haugaard, a shared interpretation horizon among members of social order means that their actions are structured in a similar manner, enabling them to act in concert (see Section 4.1.1 & 4.1.3). Accordingly, in order to explain how interactions between members of a relevant social group are structured, Bijker (1987; 1995) introduces the concept of technological frames. Bijker uses the concept of technological frames to explain why stabilization of an artefact within a social group follows a particular path and not others. According to Bijker it is the technological frame which constitutes the production of the common meaning attributed to an artefact. Moreover, like interpretation horizons, technological frames are both enabling and constraining (Bijker 1995, 264), and they define the rules of the game, including criteria of truth. As Bijker puts it:

"... arguments, criteria and considerations that are valid in one technological frame will not carry much weight in other frames" (Bijker 1987, p. 184)

In accordance with Haugaard's theorization of interpretation horizons, Bijker argues that actors are often part of more than one social group. At one and the same time, actors can thereby, be included in several technological frames. The degree to which an actor is structured by a technological frame is dependent on the degree of inclusion. People with a high degree of inclusion are highly structured by the frame and can find it difficult to imagine that a technology could be designed differently or put to other uses or even that other technologies could be applied for the same purpose (Bijker 1987, 173).

Despite the similarities between technological frames and interpretation horizons, there are also differences. Distinct from both paradigms and interpretation horizons, technological frames are not only cognitive but also social and technological. A technological frame can consist of the following elements: goals, key problems, problem-solving strategies, requirements to be met by problem solutions, current theories, tacit knowledge, testing procedures, design methods, user's practice, perceived substitution function and exemplary artefacts (Bijker 1995, 126). The build-up of a technological frame is often guided by existing socio-technological practices. Technological innovations often emerge as a result of gradual modifications or new combinations of already existing technologies. In other words, existing technologies are part of the conditions of possibility for new technologies to emerge. In that sense, old technologies often shape new ones, as Mackenzie & Wajcman argues:

“New technology, then, typically emerges not from flashes of disembodied inspiration but from existing technology by a process of gradual change to, and new combinations of, that existing technology. [...] Existing technology is thus, ..., an important precondition of new technology. It provides the basis for devices to be modified and is a rich set of intellectual resources available for imaginative use in new settings.” (Mackenzie & Wajcman 1999, p. 9)

This implies that previous socio-technological practices of transport project evaluation constituted part of the conditions of possibility for emergence of computerized transport modelling.

The aforementioned points deal with how a prevailing meaning within a socio-technological frame is (or is attempted to be) inscribed into an artefact during its development phase. However, what happens when an artefact, developed within one socio-technological frame, is moved into another, where other structures of meaning production prevails? Will it then be passively adopted, or will it be reshaped, when situated within another socio-technological context? Scholars working within the domestication of technology approach have highlighted that new technologies are not necessarily passively adopted but rather transformed when moved from one socio-technological context to another (Lie & Sørensen 1996). Sørensen defines the concept of domestication as follows:

“the domestication of artefacts may be understood as the complex movement of objects into and within existing socio-technical arrangements. In contrast to the standard assumptions of diffusion theory, such objects are not immutable; they are - at least in principle - mutable and may change through their movement.” (Sørensen 2006, p. 47)

Hence, when a technology is appropriated within a new domain (e.g. urban transport planning), this often means that this technology is re-shaped in accordance to the existing prevailing practices within that domain. However, domestication of technology into a new domain is not a one-way process. Sørensen (2006) argues that:

“... in the domestication process people and their socio-technical relations may change as well. Domestication therefore has wider implications than a

socialization of technology: it is a co-production of the social and the technical.”
(Sørensen 2006, p. 46)

The domestication of technology is, therefore, neither based on social nor technological determinism, but in accordance with the approach taken in this thesis, it is based on a mutual shaping perspective.

4.2.6 Technology and reification

The social construction of technology does not provide any concepts linking technology to truth. However, I will argue that this dimension is important for understanding how transport model based knowledge production is shaped. According to Haugaard (2012a), actors use truth to expand the social capital tied up to the structural positions which they hold. In section 4.1.5, however, it was argued that actors also use truth to defend their social capital. This sub-section, first elaborates on how transport models can be constituted as truth production technologies serving to reify expansion of social capital. Next, it is discussed how power struggles over truth between different segments of social order (or between programmes and anti-programmes of action) can generate technological change. The focus will be on how technical advancement can come about as a countermove towards relevant others' attempt to de-reify the social capital of particular structural positions.

In contemporary politics, scientific and technological advice often holds an authoritarian poison in speaking truth about a policy issue. Computer models are commonly used to produce certified predictive knowledge about the effects of policy implementation and non-implementation. Within this context, it can be argued that the authority assigned to transport models to a large extent is tied up to the implicit claim of predictability. Making a domain appear as if it has been rendered predictable is a bid for power because it implicitly contains claims to governability. If traffic can be predicted, based on salient parameters, this means that traffic can be controlled and managed, through regulations of these parameters. In that sense, transport modelling can perform a reifying function, by making traffic appear governable. A condition of possibility for governing the future in the present, is however, that the future has actually been rendered knowable. Yet, the knowledge about the future cannot be completely validated in the present, only in the future. This means that planning and decision making is not based on facts about the future, but on perceptions of uncertainty. However, despite computer models, (for example, transport models) being socio-technological constructions of an uncertain future, they might be vested with truth claims, which portray an acceptance of certain policy actions as rational, while unacceptance of these becomes portrayed as unreasonable (Henman, 2002; 2010). According to Andersen & Næss (2010), the three following aspects reinforce transport models' functions as truth production technologies.

1. The technical complexity and low degree of transparency which characterize many traffic models mean that it can be extremely difficult for lay people as well as professionals to grasp the basis on which model calculations are conducted (Nielsen 1995; Osland & Strand, 2010; Tennøy *et al.* 2006). Seen in this perspective, traffic models can be considered as “black boxes” (Hajer (1995, p. 272) with a content that is not considered necessary to take into consideration but treated as taken for granted.

2. By crowding out preparation of other alternatives, the utilization of model calculations in the decision-making process tends to create a monopoly on the knowledge production about an investigated policy issue. This is partly because of the high construction and maintenance costs, which means that fewer resources are available for alternative approaches of assessment, and partly because of the complexity of the calculated model scenarios often means that it is almost impossible for opponents to formulate alternatives which appear equally well underpinned (Tennøy, 2004).
3. In the documents introduced to the decision-makers and the public, uncertainty is often masked by presenting the calculations in exact numbers (Tennøy *et al*, 2006; Nicoliasen 2012)

When perceived as a truth production technology, transport models can be used to expand the social capital of particular structural positions by making innovative acts of structuration appear reified. However, transport models can also be used to produce truth claims, in defence against relevant others' attempts to delimit the social capital of particular structural positions through practices of non-acceptance. In fact, the need for truth generated for this purpose can be facilitative to technological advance. This will be elaborated on below.

Porter (1995) provides an emblematic example of how increased standardization and scientific grounding of decision support tools can come about as a reaction towards non-acceptance among project opponents. Porter (1995) analysed the institutionalization of the cost-benefit framework within the policy domain of water management, in the USA. Originally, the cost-benefit framework was institutionalized in the 1920s as a rudimentary method of analysis, which was developed and executed by engineers and not explicitly grounded in theory. The cost-benefit framework, however, was developed into a uniform and rigorous framework, and in the 1950s and 1960s, it was rationalized in correspondents with economic theory. In order to explain this development, Porter (1995; 2007) points towards the political context of water management projects - a highly contested policy domain. In policy controversies among public and private interests, and especially between rival public agencies affiliated with competing policy domains, the arbitrariness of the inconsistent methodological application of cost-benefit analysis was used by project opponents to de-reify the results and thereby render them unacceptable. The theoretical grounding of the cost-benefit framework and its development into a system of increasingly impersonal and uniform rules provided a solution to the problem of opponents' attempts to de-reify the authority of knowledge claims and thereby to confine social capital. Porter puts it as follows:

"...it (the framework of cost-benefit analysis) is not theory put into practice but a messy, politicized activity that was driven to have recourse to theory." (Porter 2007, p. 338)

In accordance with Latour's notion of programmes and anti-programmes of action, this shows how attempts to counter the anti-programmes, not accepting the initial knowledge claims, meant that increasingly harder and more durable truth claims were produced in order to convert opponents to accept.

Sager and Ravlum (2005) provides another emblematic example of how de-reification and non-acceptance among non-users can shape knowledge produced by decision-support tools over time. Above, it was argued that transport model predictions can take part in producing a knowledge base for rational decision making, which increases the social capital of decision-makers' structural positions because policy actions appear reified by scientific conventions. However, the claims to truth produced by scientific decision support tools are not always politically convenient. Such truth claims can therefore also constrain the social capital of decision-makers. In section 4.1.3 it was argued that transport politicians can undertake multiple roles and not all of these roles encourage them to use scientific decision support in an instrumental rational manner. For instance, in order to be effective as party politicians, or as advocates for their home constituencies, transport politicians will in many cases have to support transport projects which have a low rate of return. In such situations analytic results can constrain politicians' capacity for desired action because the pursuit of these policy-ends appears ineffective. Based on interviews with members of the Norwegian National Assembly's Standing Committee on Transport and Communications, Sager and Ravlum (2005) investigated transport politicians' attitude towards, and direct use of results from scientific decision support tools provided to aid three different rounds of National Transport Plan preparation in the period 1994-2001. During the period of the three rounds of plan preparation the complexity of the scientific decision support tools advanced. Sager and Ravlum (2005) argue that the main forces driving towards increased complexity was neither scientific advance with respect to planning methods nor a demand for instrumental knowledge utilization. Rather, the trend towards increased complexity, was driven by politicians' need to legitimize their non-use of the certified decision support provided to them. In order to justify utilization of alternative knowledge claims more supportive of the desired policies, the transport politicians attempted to de-reify the results of the certified knowledge claims by pointing out shortcomings in the analytic outcomes and by requesting additional and more comprehensive policy aid. The non-acceptance of the certified decision-support generated a spiral of amplified demands towards increased complexity, as the members of the Standing Committee, in the following rounds, on the same ground as previously discussed, made little direct use of the certified knowledge claims. Instead, as a strategy to legitimize use of uncertified but more politically convenient knowledge claims, they once again attempted to de-reify the certified decision support in order to expand the social capital of their structural positions.

Both of the examples show how truth can be used to defend social capital tied up to particular structural positions, as a countermove towards others' attempt to delimit it. In accordance with what was argued above, the two examples also demonstrate that non-use and non-acceptance of technologies are important to account for in order to understand socio-technological change. Non-use of technologies is not necessarily due to marginalization, but it can also be a strategic choice due to active resistance as part of a strategy for expanding the social capital of particular structural positions, while simultaneously delimiting the capital of others' positions.

4.2.7 Sum up

This sub-section has attempted to merge theoretical perspectives on socio-technological relations with Haugaard's framework of power creation. As a starting point, technologies were conceptualized as institutions. They are the product of intentional social actions, but their

ordering effects are not reducible to these intentions. Next, it was argued that the meaning which relevant social groups ascribe to technological artefacts is important in order to understand the path of technological development. Yet not all attempts to inscribe meaning can be expected to be successful and technological constraints can mean that detours have to be made, resulting in translations of the initial meaning. Use and non-use of technological artefacts were also related to practices of acceptance and non-acceptance. It was argued that non-use was not only linked to exclusion, but also to attempts to de-structure a particular technology or the social capital of those whose acts of structuration are tied up to that technology. The concepts of closure and stabilization were also introduced and discussed in relation to tacit knowledge and disciplinary power. While closure and stabilization meant that the interpretive flexibility of an artefact decreased, a re-framing of its application could contribute to opening up its interpretive flexibility anew. The concept of technological frames was introduced in order to explain why stabilization of an artefact within a social group follows a particular path and not others. In that respect it was also discussed how new technologies are not necessarily passively adopted, when moved from one technological frame to another. Rather, both the technological artefact and the frame can be transformed through a process of domestication. Lastly, a conceptual link between technology and reification was made. Here, it was argued that computerized transport models, on the one hand, can serve as truth production technologies, legitimizing expansion of social capital tied to a structural position, and on the other hand, computerized transport models can serve to defend the social capital of a structural position against others' attempts to confine it. In that respect, it was argued that non-use and non-acceptance of knowledge claims produced by scientific decision support tools can create an increased demand for truth in order to gain acceptance in a second round, and thereby facilitate technological advances.

5 Methodology

This chapter presents the thesis' methodological approach and is divided into four sections. The first section presents the research design. Hereafter, the advantages and disadvantages of different empirical sources of evidence are discussed, with respect to how a deep understanding of mechanisms shaping transport model-based knowledge production can be obtained based on each evidence source in turn. In the following section, it is discussed how the individual sub-research questions, drawn up for the respective embedded cases, are approached. The rationales for choosing the particular embedded cases as well as the implications of these choices are also elaborated upon. Lastly, there are some reflections on my journey throughout this PhD, as well as an account as to how and why my approach ended up as it did.

5.1 Research design

This section discusses the thesis' research design. The objects of analysis suitable for analysing transport model-based knowledge production is first discussed. Hereafter it is argued why a single embedded case study has been chosen to address the main research question. This is followed by an argumentation of why temporal and historical dimensions have been included. Lastly, the units of data collection appropriated for investigating the research question are also rationalized.

5.1.1 Object of inquiry

This sub-section elaborates on the object of inquiry investigated in this thesis. It is argued that in order to better comprehend the diverse and multiple mechanisms potentially shaping transport model-based knowledge production, it is necessary to investigate transport model based knowledge production within the context of planning and decision making as the primary object of inquiry, rather than the ex post evaluation of forecast results.

Within the literature on inaccuracy and bias in traffic forecasting, the main methodological approach applied to study inaccuracy and bias in traffic forecasting is statistical ex post evaluation of forecasting results, comparing predicted with observed traffic. By showing rather consistently that predictive inaccuracy should be expected in traffic forecasting, these studies have made important contributions (See Section 2.3 1). Moreover, based on ex post evaluation, valuable hypotheses have been drawn about the causes of predictive inaccuracy and bias (See Chapter 3). Nevertheless, I will argue that an evaluation of transport model outputs as the only object of inquiry is insufficient to account for the complexity of mechanisms that potentially shape transport model-based knowledge production. Most of the theoretical development within the literature has neither been developed from, nor grounded in in-depth empirical investigations into processes of transport model-based knowledge production. This is despite the fact that according to both the technical and social contextual perspectives it is at this stage of the planning process where the mechanisms causing uncertainty and bias unfold (see Chapter 3). Instead, most of the current theory building has been inferred from ex post evaluation studies.⁸ However, bias ex post does however not have to imply bias ex ante, but can be caused by selection bias (see. Section 3.6). Moreover, statistical correlations do not prove a causal

⁸ This is not the case with the organizational/institutional and the ontological perspective.

relation. For instance, an observed pattern of overestimation can be caused by technical, political-economic, psychological, organizational/institutional and ontological factors alike (see section 3.4). By standing at the end of the policy line (see figure 5.1) and evaluating the accuracy of the output, it is limited what can be inferred about the multiple, diverse and subtle technical and social mechanisms which have potentially shaped the model output, as it moved through the planning and decision-making process.

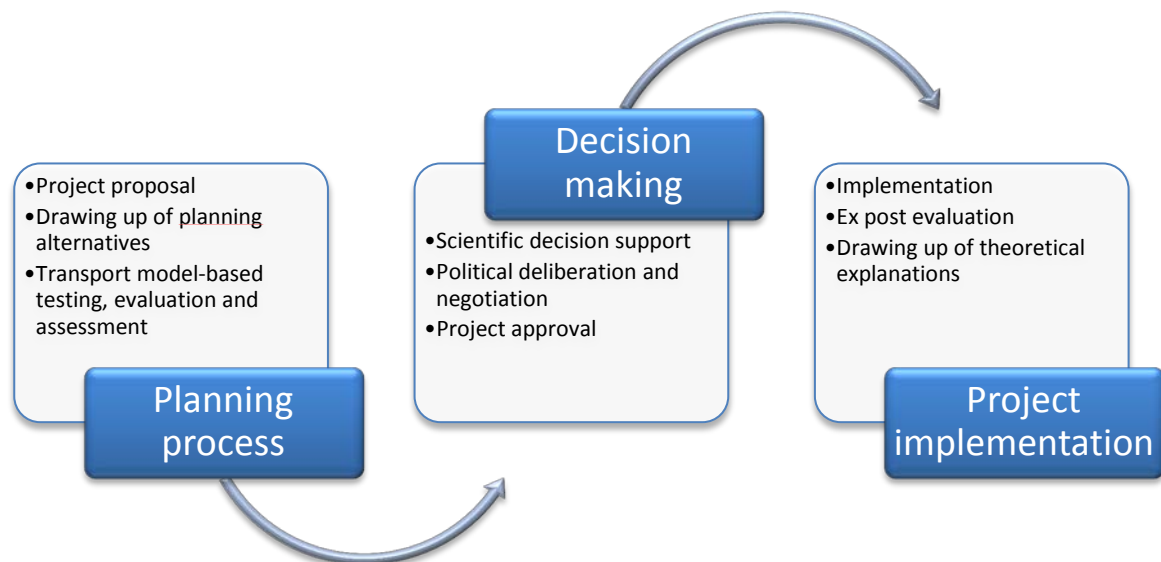


Figure 5.1: Stylish planning sketch of the planning, decision-making and implementation process through which transport model outputs travel before being post evaluated and theoretical explanations inferred.

In order to obtain a better understanding of how transport model based knowledge production is shaped and by which mechanism, it will be necessary to shift the object of analysis from a quantitative comparison between predicted and observed traffic, towards processes of transport model-based knowledge production within the context of transport planning and the decision-making processes. There are, however, only very few previous studies which have actually studied transport model knowledge production. The fact is that we know very little about how processes of transport model-based knowledge production unfold. The existence of this knowledge gap means that the current debate on what the primary cause of the observed predictive inaccuracies and bias is rests on a weak empirical foundation. Shifting the object of analysis towards processes of transport model-based knowledge production also means that a qualitative rather than a quantitative research strategy is followed in this thesis, which enables the author to, for example, investigate the meanings, rationalities, struggles and constraints that shape choices about model design and inputs, etc.

5.1.2 A case study approach

In order to investigate transport model-based knowledge production within the context of the planning and decision-making process, a single embedded case study of transport modelling within Danish planning practice has been chosen. According to Yin (2003) a case study design is particularly relevant when:

- The objective is to answer “how” and “why” questions

- The behaviour of those involved in the study cannot be manipulated through experiments
- One wants to cover contextual conditions, assumed relevant to a contemporary phenomenon under study
- The boundaries are unclear between the phenomenon and context.

On these grounds, the case study methodology seems particularly well suited for this study, which aims to answer precisely how and why and closed experiments are impossible. In my case, the boundaries are also unclear between the phenomenon and context, in the sense that my proposition is that the social and technical can be contained in one another and that a reciprocal relation exists between the social context and the technical content of traffic models (see chapter 4). An additional advantage of the case study is that it enables in-depth empirical investigations on real-life phenomena. Above, it was argued that this is a necessity for comprehending how transport model-based knowledge production is shaped by various mechanisms and hence for also providing a valid answer to the research question. The case study methodology also fits well with my research purpose, due to its potential for detailed empirical enquiry. In addition to building new theory, it is particularly suitable for testing existing perspectives. As Flyvbjerg puts it:

“The advantage of the case study is that it can “close in” on real-life situations and test views directly in relation to phenomena as they unfold in practice.” (Flyvbjerg 2006, p. 235)

The case study methodology has, however, been criticized for containing a bias towards a verification of the researchers’ own propositions. Yet, in accordance with Flyvbjerg, I will argue that this critique is not necessarily valid. In fact, because the case study allows for production of more in-depth knowledge than most other methods, case studies have a large potential for falsifying one’s initial propositions. In fact, Flyvbjerg and other case study experts alike have been faced with such situations during the process of carrying out in-depth case studies. This has generated transformations in their propositions, stimulating the formulation of new hypotheses and the building of new theories (Flyvbjerg 2001). In that sense, it can be argued that the case study methodology has a particular capability to question the taken-for-granted, including the researchers’ own propositions, and on those grounds, it has a productive and transformative capability unrivalled in most other research methodologies. Accordingly, as it will be elaborated upon in section 5.4, many of this study’s original propositions have been rendered insufficient during the process of my PhD project, generating a number of transformations. In addition to being suitable for testing theories and hypothesis, the case study is also particularly suitable for building new theories. Due to these properties of the case study, the method is particularly suitable for fulfilling the research objectives of this thesis. These objectives consist of, one the one hand, testing existing theories on why induced traffic has traditionally been neglected within transport project evaluation practice as well as on the causes of inaccuracy and bias in traffic forecasting and on the other hand, contributing to building a new theory on mechanisms shaping transport model-based knowledge production.

5.1.3 Temporal and historical perspectives

This sub-section argues why it is necessary to include a temporal dimension as a central feature of the case study design in order to comprehend the working of mechanisms shaping transport model-based knowledge production and several reasons are put forward.

The suitability of applying a case study design, including a temporal dimension, to generate in-depth knowledge about dynamic and complex mechanisms unfolding in time during the planning and decision-making processes, has been forcefully demonstrated by Flyvbjerg (1991). In an in-depth case study concerning the implementation of a traffic calming plan for the inner city of Aalborg, Flyvbjerg (1991) followed the planning process from the phase where the plan was initially envisioned to its formalization and from there, on to its approval and implementation. In the case study, Flyvbjerg (1991) showed how multiplicities of complex mechanisms, including the intermingling of planning and politics as well as power and rationality were working throughout the process, shaping and transforming the design of the plan which finally materialized. I will argue that in order to advance understanding of mechanisms shaping transport model-based knowledge production, one will have to follow Flyvbjerg's practice (1991) and use case study designs, including a temporal dimension, to study the planning and decision-making processes in close detail. Otherwise, the dynamic aspects of these mechanisms cannot be accounted for. In fact, one of my propositions is that mechanisms shaping transport model-based knowledge production are not frozen in time, rather they are dynamic and transformative in scope, working through time and space. For instance, in Chapter 4 it was discussed how non-acceptance and attempts to render the base of decision support tools as arbitrary on political ground can facilitate transformations towards increasingly complex and rigid methods of transport model-based knowledge production. These propositions on how non-acceptance can serve as a mechanism shaping transport model-based knowledge production can only be explored if a the temporal dimension is included in the case study design. Second, the temporal dimension is also needed in order to account for how contemporary transport modelling practice is shaped by mechanisms that have unfolded in the past. In Chapter 4.2, it was argued that the development of new technologies can be shaped by existing technologies. Moreover, it was argued that the technological structure of transport models can function as institutions, taking part in structuring actions not reducible to the intentions of the design. This means that if one wants to understand how the use of existing models is influenced by decisions and meaning inscribed into the technical content of a model in the past and if one wants to explain the contingencies of these technical constraints, rather than treating them as given, one will have to go back in time and investigate the choices and meanings inscribed into a model at an earlier point in time. Third, the benefit of including a temporal dimension also goes beyond investigations of individual models' trajectories. History can also be used to open up the black-box of transport modelling practice. The continuous use of oversimplified transport models does not only appear to constitute an established practice, but it also apparently constitutes a more or less taken-for-granted practice. In order to understand how and why this practice emerged within Danish transport planning where it is common not to include induced traffic within the framework of standard transport models, it will be necessary to go back in history and investigate the meaning that induced traffic had when this practice emerged. Based on empirical investigations into the meaning of induced traffic it becomes possible to test existing

perspectives on why induced traffic was neglected from computerized four-step modelling when this practice emerged as well as from building new theory.

The temporal dimension does not only constitute an important element in the design of the single case itself, but also in the design of the each of the embedded cases. It is, however, not all the aspects of the embedded case which, according to Yin (2003), qualifies as a case study. He argues that the case study methodology does not apply to investigations of historical events, for which there are no other sources of evidence than documents and artefacts. On that ground, it can be argued that this thesis qualifies as a combination of case study and historical methodology. I will, however, argue that there are great advantages of combining these methodologies. In fact, it was particularly the integration of the historical dimension into my case study design which contributed to falsifying my original propositions, creating opportunities for change to come about and stimulating the formulation of new hypotheses. This will be elaborated upon in section 5.4.

5.1.4 Objects of data collection

This sub-section elaborates upon the objects of data collection upon which the thesis is based. When investigating transport model-based knowledge production within the context of the planning and decision making processes as the primary object of inquiry, it is particularly relevant to collect data on both the technical content and social context of transport models (see Chapter 4 & Chapter 5). Such data should be collected from the following three spheres: the front-stage, the back-stage and the audience of transport model-based knowledge production. The front-stage is where the model results are presented, the back-stage is where the model results are produced and the audience constitutes the receptors of the model results. This will be elaborated upon below.

Based on data collected in the front-stage, knowledge can be obtained about the problems which a model has been developed for or submitted to, the context of the problem, the solutions which the model has been used to evaluate, the model results, the impacts which have been included in the transport model-based assessment, etc. In some cases data can also be obtained about the causal mechanisms included in the modelling of traffic. Hence, the front-stage allows for the collection of data about what has been included and excluded from the agenda, and how the issues put on the agenda have been framed. However, investigations into the front-stage do not often allow for the collection of data regarding why the agenda was set and framed as it was. Often, information derived solely from the front-stage is insufficient in order to comprehend the mechanisms shaping transport knowledge production.

In order to better comprehend such mechanisms it is necessary to look back-stage and collect data on the processes of transport model-based knowledge production from this unit. The back-stage perspective allows for collection of data on processes and mechanisms that play a part in producing and framing the issues appearing on the front-stage as well as data on issues withheld from the front-stage. By collecting data on the back-stage it also becomes possible to investigate the meaning, interpretation horizons, practices of acceptance and non-acceptance, struggles and constraints, shaping choices about model input, assumptions, structure, etc. Moreover, it allows for an investigation of the meanings assigned to a transport model prior to its

development, the process of inscribing this meaning into the model during its development, and the mechanisms facilitating and constraining this inscription. In other words, data collection from the back-stage is particularly well suited to investigating mechanisms shaping transport model-based knowledge production.

In Section 4.2, it was argued that in order to comprehend technological development, in addition to considering the producers of technology, it was also important to account for users and non-users. Moreover, it was argued that practices of acceptance and non-acceptance can shape transport model-based knowledge production. In order to account for this, it is therefore also necessary to collect data on users and non-users of transport model-based knowledge production. Hereafter these will be denoted as the audience and they consist of both project proponents and opponents. Politicians make up a particularly important social group among the audience, but it is also relevant to collect data on interest groups and the general public.

The back-stage, the front-stage and the audience are all relevant objects of data collection with respect to the content and the context of transport model-based knowledge production. In fact, it will be necessary to triangulate the data collection between these spheres in order to account sufficiently for mechanisms shaping transport model-based knowledge production. However, depending on which of the spheres is more emphasised, we can apprehend the implications for the conclusions on mechanisms shaping transport model-based knowledge production. For instance, if the main emphasis is put on either the front-stage or the audience and data from the other arenas has only been collected superficially, then there is a risk that the conclusions drawn up about mechanisms shaping transport model-based knowledge production will also rest on a shallow foundation. In order to gain a deeper insight into such mechanisms, the back stage of transport model production is vital, but not sufficient. In the two embedded cases, data has been collected from all of the three spheres, but not to an equal extent. This implies that the possibility of apprehending mechanisms shaping transport model-based knowledge production varies between the two embedded cases. This will be elaborated upon further in section 5.3, but before doing so, different empirical sources of data collection, suitable for collecting data from the respective arenas of the back-stage, the front-stage and the audience will be laid out below.

5.2 Sources of empirical evidence

This section elaborates upon the sources of empirical evidence, from which data has been collected on the back-stage, the front-stage and the audience. In Chapter 3 and Chapter 4, it was argued that mechanisms shaping transport model-based knowledge production cannot be sufficiently accounted for based on a mono-causal theoretical framework. Accordingly, data on the aforementioned objects of data collection cannot be investigated sufficiently based on a single source of evidence, but require evidence from different sources to be triangulated. This thesis is based on a combination of qualitative interviews and a range of documentary sources.

The advantages of qualitative interviews are that extensive information can be collected on numerous areas such as, the rationalities of cause and effect that underpin the modelling, technical constraints, how such constraints were attempted to be circumvented, the role of transport models in the planning processes, the perception of predictive accuracy, the grounds on which the transport modelling was accepted or rejected, etc. Through interviews data can

also be collected on the situated as well as the broader context of the transport model-based knowledge production; they contain an explorative potential and are well suited for identifying new relevant mechanisms not previously considered during the study. In summary, qualitative interviews are well suited for collecting information on processes of transport model-based knowledge production and the mechanisms which shaped it. There is also, however, a number of disadvantages associated with this source of empirical evidence. First, there is a concern that respondents detain relevant information in their answers to inconvenient questions. This means that despite interviews having the potential to collect data on the back-stage, it might be that information in fact is restricted to the front-stage perspective. This is, however, not particular to interviews alone but in fact applies to all sources of empirical evidence. Second, interviews contain some limitations with respect to investigations of past events. When investigating processes of transport model-based knowledge production taking place more than 60 years ago, for example, the memory of relevant respondents may be very blurred and/or they may recall events on a selective basis or they might be deceased. The memory bias may also be a concern with respect to events taking place more recently, but nevertheless some years ago. This disadvantage is problematic since the temporal and historical constitute important elements of this study.

Due to the historical dimension of this thesis, data from documentary sources has been collected extensively. An advantage of this source of empirical evidence is that the memory bias is reduced. Moreover, because the documents have not been produced specifically for the research purposes, the risk of a reactive effect is largely reduced (Bryman 2008). However, this also implies that the content of documentary sources is fixed and data collection is therefore restricted to what is contained in documents. It is not as possible to ask questions that are particularly relevant for answering the research question as it is through interviews. The possibility of collecting data in a tailor-made fashion, with respect to answering the research questions, is hence restricted. In any case, data from documentary sources have been collected from the back-stage, the front-stage and the audience of transport model-based knowledge production. Different types of documentary sources have, however, been applied to data collection from the respective spheres. This will be elaborated upon below.

5.2.1 The front-stage

In this thesis, extensive data from the front-stage, both from a contemporary and historical perspective, has been collected from official planning and policy documents. There are several benefits of using this empirical source of evidence. First of all, official documents are rather easily accessible. Second, with respect to some of the historical enquires, planning and policy documents have either been the best source of empirical evidence available due to memory, or they were the only accessible empirical source. However, there are also limitations associated with the use of official planning documents. Most often they are concerned with presenting the results of transport model-based knowledge production, and not with addressing the process of producing transport model-based knowledge outputs in detail. Therefore, official planning documents are often insufficient sources for data on the back-stage. Thirdly, despite planning and decision-making documents addressing a particular audience, it is not possible from these documents to infer how the knowledge claims contained in the reports were received by this audience, for instance whether, and on what grounds they were accepted or not. Due to the

disadvantages of planning and decision-making documents, they do not, on their own, constitute a sufficient base for accounting for how different mechanisms shape transport model-based knowledge production.

5.2.2 The back-stage

Data on the back-stage has been collected from both interviews and documentary sources. While interviews form the main source of empirical evidence with respect to the contemporary investigations, documentary sources are mostly applied in the historical sphere. This will be elaborated upon below.

With respect to the contemporary context, eight qualitative interviews have been conducted with key stakeholders within the transport sector, who produce or use transport model-based knowledge production in their day-to-day work, namely, model developers, consultants and traffic planners involved in policy making at the national or local level. The selection of interviewees was made in order to gain information from respondents representing different roles in the forecasting and planning process as well as to gain information on particular cases in addition to the broader picture.

Three qualitative interviews have also been conducted with respect to the historical parts of the study. One was conducted with the first Dane who obtained a PhD on transport modelling and who also headed a private consultancy firm engaged in transport modelling from the 1960s onwards, and two interviews were done with planners directly involved in the development of the first computerized transport model. However, due to memory biases and problems with finding relevant living persons, documentary sources in the form of archival records have been used extensively in order to collect empirical data on mechanisms shaping transport model-based knowledge production in a historical context. The archival material consists of working papers, draft reports, minutes and internal as well as external correspondence. Distinct from official planning documents, the particular advantage of archival material is that it allows collection of data on from the back-stage (Gidley 2004), the archival material collected has originally been produced during the transport model-based knowledge production processes to which they refer and by persons directly involved in those processes. The archival material hence constitutes a primary source and enables, to a much higher degree than planning documents, collection of information on processes of transport model-based knowledge production and the mechanisms which shaped them. However, despite the obvious advantages of using archival material, this source also has some disadvantages. First, in accordance with planning documents, data collection is restricted to what is contained in the material. Second, the archive may be incomplete or fragmented. Relevant material might have been forgotten to be filed, or material may have been lost subsequently. Moreover, it might also be that material supporting the hypothesis of strategic misrepresentation has deliberately been omitted from the files. Hence, it might be that not all of the material that is relevant for understanding the mechanisms shaping transport model-based knowledge production is available in the archive. Moreover, while it can be argued that the particularity of the data contained in archival records is one of the major advantages of this source it also constitutes a potential disadvantage. The particularity of the data can mean that it is impossible to grasp the meaning of it without

knowing the detailed context to which it relates. It is, therefore, of particular importance that the data from the archival material is triangulated with data on the front-stage and the audience.

5.2.3 The audience

Data from the audience has been collected from the social groups of politicians, planning peers and the general public. Below, the empirical sources of evidence from which data on the respective groups has been collected, will be elaborated upon, both with respect to the contemporary and historical context.

Data based on four qualitative interviews has been collected from contemporary politicians who have transportation policy as a field of responsibility. Two of these represent the national level and the other two work at the local level. With respect to the historical perspective data from politicians, it has mainly been collected from stenotyping of political sittings in the Copenhagen City Council and the National Parliament. These short-hand reports often consist of full transcripts, and they therefore give a detailed account of different political views expressed as part of political debates. However, one disadvantage of this empirical source of evidence is that often there are no short-hand reports from political committee meetings, where political agreements are often reached.

Data from planning peers has mainly been collected from journal articles both with respect to the historical and more contemporary enquires. Journal articles are a particularly relevant documentary source for collecting data on professional peers. As opposed to newspaper articles, journal articles are often considerably detailed in content and based on professional rather than popular views.

Data on the view of the general audience has been collected from newspaper articles with respect to the contemporary and historical contexts. The benefit of using newspaper articles is that they are mostly written during the period to which they relate. However, there are also some draw-backs with respect to using newspaper articles. They often constitute secondary sources and they are also often rather brief. They do not often contain deep elaborations of the issues to which they relate. In addition to the general public data, data from the planning peers and politician have also been collected from newspaper articles.

5.2.4 Summary

Summing up the above information, data have been collected based on the following sources: qualitative interviews, official planning and policy documents, newspaper articles, archival material, short-hand reports of political sittings and journal articles (see figure 5.2).



Figure 5.2: Empirical sources from which data have been collected in order to elaborate the research question.

Despite information from empirical sources of evidence relating to the front-stage, data relating to the back-stage and the audience have been collected for both of the embedded cases; the focus on the back-stage is stronger in the second case.

5.3 Exploring the embedded cases

This section gives an account of how the sub-research questions addressed in the two embedded cases are explored. Both of the embedded cases relate to the overall research question and serve to achieve the research objectives. They contribute to this, however, in different manners and will also make more particular contributions to the individual research objectives. Below, the two embedded case will be elaborated upon, and how the respective sub-research questions are approached will be discussed.

5.3.1 Case 1

The first embedded case focuses on induced traffic and explores the phenomenon with respect to Danish transport project evaluation practice in both a contemporary and historical perspective, placing a special focus on mechanisms related to its inclusion and non-inclusion. The contemporary part of the embedded case aims to fulfil the research objective of contributing to advance the understanding of why the non-inclusion of induced traffic in standard transport models is often accepted within contemporary planning practice. The embedded case also serves to fulfil the research objectives of problematizing the neglect of

induced traffic within Danish planning practice, advancing the understanding of why the practice of neglecting induced traffic emerged and why it has been accepted. In order to fulfil these two research objectives, a critical historical approach is taken where the concept of induced traffic, with respect to Danish transport project evaluation practice, is rolled back in history. History here, is used as a means to raise discursive consciousness about the fact that there is nothing “natural” about the contemporary practice of neglecting induced traffic. The historical enquiries also enable the testing of existing propositions, of why induced traffic has traditionally been neglected, as well as to build new hypotheses. The three sub-questions are explored in the context of a period of around 170 years, from around 1840 to 2011. Each of the sub-questions is, however, explored with respect to a particular period of time (see figure 5.3).

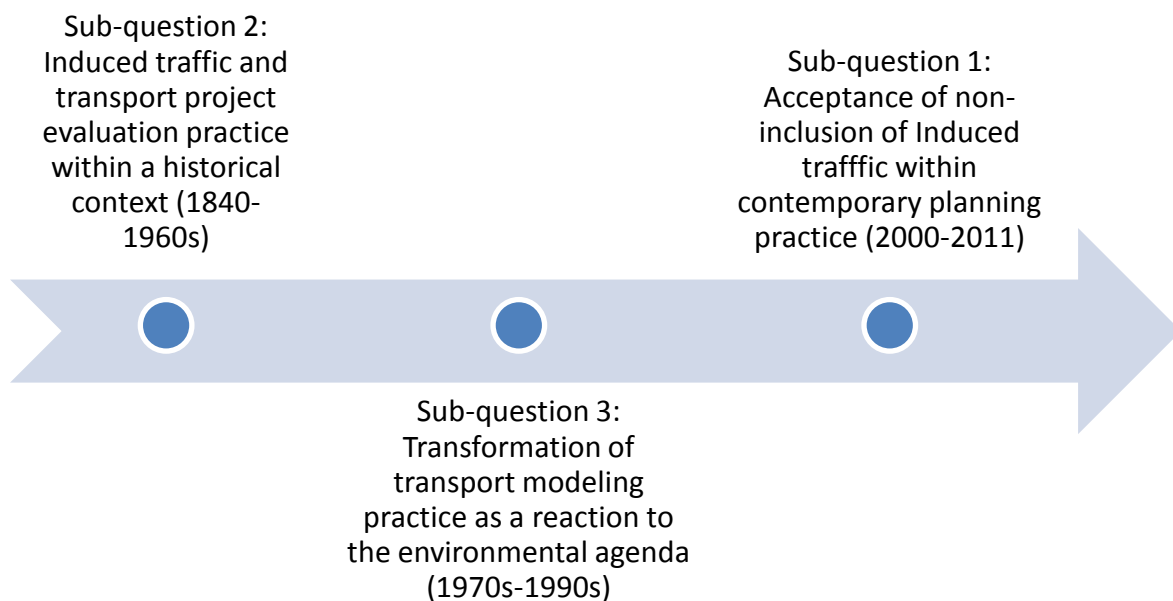


Figure 5.3: timeline with plots of the periods of time explored in the respective sub-research questions addressed in the first embedded case.

Due to the long retrospect on the phenomena of induced traffic, the investigations of the second and third sub-questions are based on a rather broad brush approach. This will be elaborated upon hereafter, where it is discussed how the respective sub-questions are approached and the empirical sources of evidence that form the basis of the explorations are set out.

The first sub-research question “*How is the acceptance of the neglect of induced traffic rationalized within contemporary transport modelling practice?*” will be elaborated upon based on the case of an Environmental Impact Assessment of a proposed Third Limfjord Crossing in the Aalborg area, Denmark. This case has been selected on the grounds that it seemingly constitutes a representative or typical case with respect to Danish transport modelling practice. The model applied in the case is a traditional four-step transport model (see section 2.1). It is by no means a state-of-the-art model, but on the other hand neither does it seem to be much worse than other standard models applied within Danish planning practice outside the Greater Copenhagen Area (see section 2.3.3). The case has also been selected because it seems particularly suited for investigating the sub-question of how the acceptance of non-inclusion of induced traffic is rationalized. This is because neglect of induced traffic has seemingly been taken for granted, and therefore, acceptance of this neglect is often not explicitly rationalized. However, in the Limfjord

case, neglect of induced traffic was problematized by project opponents. As a reaction, acceptance of non-inclusion became explicitly rationalized, and therefore it enables more open exploration of the phenomenon. The case study is based on document analysis of official planning and decision-making reports issued about a third Limfjord crossing in the period investigated. These documents provide a good insight into the front-stage perspective. However, the insight into the back-stage perspective enabled by the document analysis is limited. Therefore two open-ended qualitative interviews have been conducted, one with a planner and one with a politician involved in the case. In order to elaborate on the research questions with a broader basis than only that of the case of the third Limfjord Crossing, the empirical basis also comprises information from qualitative interviews conducted with respondents from a broader spectrum of political and professional areas of the transport infrastructure sector.

The second sub-research question *“Why was induced traffic not included in the structural framework of computerized transport modelling when this practice emerged?”* will be approached by rolling the concept of induced traffic back in planning history to the period prior to, and contemporary with, the emergence and institutionalization of computerized transport models within Danish planning practice. The purpose of this historical inquiry is threefold. First, it serves as a base for investigating mechanisms shaping transport model-based knowledge production. Second, it serves as a base for problematizing the taken-for-granted neglect of induced traffic within contemporary planning practice. Third, the purpose of rolling induced traffic back in history is also to contribute to an enhanced understanding of why the practice to neglect induced traffic from transport project evaluation emerged. With respect to the latter, different perspectives on why induced traffic has traditionally been neglected were presented in Section 3.5. One proposition focused on the fact that that transport planners have traditionally operated within a particular interpretation horizon, namely the so-called predict and provide paradigm, where travel has been framed as inelastic with respect to transport supply. Another proposition holds that induced traffic has, in fact, been part of discursive consciousness, but it signified a benefit with respect to transport project evaluation. In this embedded case these different propositions will be tested and new theoretical explanations will be built. These different propositions will be tested by investigating whether induced traffic has been a part of planners’ discursive consciousness in transport evaluation practice as well as the significance it held with respect to transport project evaluation practice. By investigating whether induced traffic has historically been part of discursive consciousness, it becomes possible to test the hypothesis that transport planners have traditionally perceived the relationship between transport supply and demand as inelastic. If induced traffic is not mentioned in historical transport planning documents, then this lends support to the hypothesis. On the other hand, if induced traffic is included, it will contribute to problematize the hypothesis. In chapter 4.2 an argument was put forward that it cannot from the outset be assumed that there is a total harmony between planners’ interpretation horizons and the content of their evaluation practices. Due to technical constraints, meaning may not be fully inscribed into transport project evaluation methods. In order to test this proposition, it will be necessary, in addition to investigating whether induced traffic was part of planners’ discursive consciousness to also investigate whether induced traffic was part of the evaluation practice. If a discrepancy is observed, then the cause of this must be explained in order to answer the research question. In order to test the two contradictive perspectives concerning whether the meaning of induced

traffic constituted a benefit or a cost with respect to transport project evaluation, it will be investigated which significance, if any, induced traffic held. These issues will be investigated with respect to the three different periods of time that also represent different contexts of transport project evaluation.

The first period is concerned with an evaluation of the rail project around the mid-1800s. This period has partly been selected in order to explore whether the concept of induced traffic can be traced so far back in time, and partly because induced traffic within this context is likely to signify increased revenues, and therefore there is a benefit with respect to transport project evaluation. The particular case which has been selected to serve as a base for investigating induced traffic with respect to this context is a traffic analysis from 1840, prepared as part of a business case for a railway line proposed between the cities of Copenhagen and Roskilde.

The second period concerns an evaluation of a first proposal to a nation-wide intercity expressway system from the 1930s. While induced traffic is likely to mean increased revenues within the context of rail project evaluation, this case has been chosen because it is a toll-free road project, where induced traffic is not related to direct monetary revenues. The meaning that induced traffic holds with respect to transport project evaluation is, therefore, likely to transform in accordance with the shift in context.

The two cases have been selected because they are emblematic with respect to Danish planning practice, not because they are particularly representative for the respective periods they are related to. In fact, I have not looked into a wide range of planning reports from the two periods. Therefore, the extent to which these two cases are in fact representative for their respective periods of time is not fully known to me. However, in order to increase the generalizability of the two cases, I have looked into how they have been received by the audience (peers/opponents) who have evaluated the reports. If it was common practice to include induced traffic but it was omitted from these particular cases, then this neglect would likely have been problematized and vice versa. Hence, by including the audience in the investigations, the possibility of generalizing my findings beyond the respective cases increases.

The third period investigated concerns the period from the 1950s to the early 1970s. It was within this period that computerized transport models emerged within Danish planning practice, and hence, it constitutes a particularly critical movement, with respect to understanding why a practice emerged where induced traffic has commonly been omitted from standard traffic models. The investigations in this period are, compared to the two previous periods, also based on a larger number of cases and project contexts, namely: toll and toll-free projects, fixed links, motorways and highways.

The elaboration of the sub-research question with respect to the first two periods is based on documentary sources, mainly in the form of official planning documents but also on journal articles. This means that my elaboration upon the research question is largely restricted to the front-stage and the audience. However, with respect to the 1950s-1970s period, an open-ended interview has also been conducted with a respondent who undertook a key role in the emergence of computerized transport modelling within Danish planning practice. This means that for this period, the back-stage perspective has, to some extent, been included, but not sufficiently to really get behind the scenes.

The third sub-research question, *“How did transport modelling practice transform as a reaction towards the increased prominence of environmental and health concerns on the transport political agenda?”*, will be explored with respect to the period from around 1970-2000. In the same way as the first case, this sub-research question will also mainly be elaborated upon based on a specific case, namely, the proposed third Limfjord Crossing. Here, how the transport model for Aalborg, initially developed in the early 1970s, with the main objective of supporting a land-reservation for a third Limfjord crossing will be investigated. It is explored how the framework of the transport model transformed in the period leading up to the year 2000 as a reaction towards increasing political, environmental and health concerns about transport projects grew. Due to the shift in the prevailing transport political discourse which occurred during this time, with increased focus on environmental and health, it can be argued that the inclusion of induced traffic became increasingly important in order to avoid biased transport project evaluation. The shift in transport political discourse meant, in addition, that effects of induced traffic were increasingly likely to signify a cost in regard to transport project evaluation practice. The exploration of this sub-research question is solely based on documentary sources. It is primarily based on official planning documents produced about the third Limfjord Crossing, but planning journals and newspaper articles are also applied. The sources of empirical evidence are hence restricted to the front-stage and the audience. The lacking of the back-stage perspectives means that the explorations of this sub-research question is approached from a more shallow perspective than the thesis’ other sub-questions.

5.3.2 Case 2

The second embedded case concerns the emergence, development and use of the first computerized transport model within Danish planning practice. The case is, therefore, historical in scope but it nevertheless aims to make an empirical and theoretical contribution to the contemporary debate on causes of inaccuracy and bias in travel forecasting. Most of the theoretical perspectives put forward in this debate are inferred from a statically generated comparison of forecasted and actual traffic (see chapter 3). This object of inquiry alone is, however, insufficient for exploring mechanisms shaping transport model-based knowledge production (see section 5.1.2). In order to better comprehend these mechanisms and their workings, it is necessary to explore transport model-based knowledge production within the context of the planning and decision-making processes. A knowledge-gap exists on this matter, however, and this has implications for the validity of conclusions about the causes of inaccuracy and bias drawn up in most previous works. In this case, the accuracy of the forecast which the model produced is first evaluated against observed traffic in accordance with the dominant approach. However, instead of inferring the cause of the observed inaccuracy from the ex post evaluation of the model output, the forecast is rolled back in time though the planning and decision-making processes in which it was produced and applied. Based on empirical in-depth investigations of these processes as an object of inquiry, the mechanisms which shaped the forecast result are then inferred.

Despite the fact that the main aim of this case is to make a theoretical and empirical contribution to the contemporary literature on causes of inaccuracy and bias in travel forecasting, it also aims to contribute to a deeper understanding of why the practice of neglecting induced traffic emerged, which aim goes beyond the scope of the first embedded

case. First of all, it is based on much more in-depth investigations than the first case. Moreover, while the contexts investigated in the historical parts of the first embedded case concern induced traffic with regards to the evaluation of inter-city transport projects, the second case investigates induced traffic with regards to an urban context.

The case is based on data collected from the front-stage, the back-stage and the audience. With respect to the front-stage, a large number of official planning documents, supplemented with newspaper articles have been collected. Data on the back-stage has mainly been collected from archival material consisting of working papers, draft reports and minutes, as well as internal and external correspondence. The collected material primarily originates within the Urban Planning Office⁹, under the Department of the City Engineer¹⁰, Copenhagen, where development of the computerized transport model took place. Archival material has also been collected from the so-called Road Data Processing Committee,¹¹ the Regional Planning Council¹² and the Committee for the Technical Review of Preliminary Outlines for Regional Plans.¹³ All of the archival material has either been photocopied or photographed. Access to the back-stage has also been obtained through two open-ended qualitative interviews, with persons directly involved in the development of the traffic model. Each interview lasted around two hours. The recording of one of the interviews, however, failed, and was therefore not subsequently transcribed. With respect to the audience, data has been collected from news-paper articles and transcriptions from sittings in the Copenhagen City Council and the National Parliament. These sources contain information on both project proponents and opponents.

Originally, I came across the case and the back-stage pass to it by chance. The case was chosen at first because it constitutes a unique case (Yin 2003, 40), in the sense that it concerns the development of the first computerized transport model applied within Danish planning practice. It was, therefore, particularly suitable for investigating how and why computerized transport models emerged within Danish planning practice, which was the research question I then opted to explore. In the first place, I did not, select the case based on knowledge about what the case contained other than it was the first computerized transport model. Otherwise, I did not know its broader content and context. In fact, I had been working with the case for some time before I realized that an actual forecast had been produced. However, the more I came to know about the case, the more I dug into it, the more I realized that it also constituted a so-called revelatory case, constituting an opportunity to investigate a phenomenon previously unreachable to scientific inquiry (Yin 2003, 42). Due to the time lag between the transport model-based knowledge production and project implementation, supplementing ex post evaluation of model results as an object of inquiry with an exploration of processes of transport model-based knowledge production is easier said than done. As the forecast horizon is usually 10 years and above, it can be extremely difficult to collect relevant information on the model-based knowledge production. Likewise, if one investigates contemporary processes of transport model-based knowledge production, one will have to wait 10 years or more in order to evaluate the model output. Due to the large amounts of well-preserved archival material existing on the case,

⁹ Byplan Kontoret

¹⁰ Stadsingeniørens Direktorat

¹¹ Vejdatabehandlingsudvalget

¹² Egnspanrådet

¹³ Udvalget til teknisk gennemgang af principkitse til en egnsplan

it constitutes a unique possibility to combine investigations on the processes of transport model-based knowledge production and a retrospective investigation on why the forecast did not materialize.

Despite the case being revelatory for studying mechanisms shaping transport model-based knowledge production, it is not representative with regards to contemporary transport modelling practice. In fact, it is easy to argue that the mechanisms shaping transport model-based knowledge production unfold nowadays differently than they did back then. First of all, computers are much more advanced today than in the 1960s. Second, the issue of data availability was a much larger concern back then than today, where data collection is largely institutionalized (e.g. in the form of the Road Data Bank, and the national travel survey). On the other hand, the institutionalization of data collection within contemporary practice does not mean that data availability is no longer a concern. However, precisely because many of the mechanisms shaping computerized transport model-based knowledge production were not institutionalized when this practice emerged, these mechanisms are likely to be more visible and, therefore, more open to investigation than within the contemporary institutionalized practice. In addition, the case is not representative in another respect. The case was shown to be situated in an extremely politicized context. Despite the generalization that planning and politics are contained in one another, the political stakes in this case seemed to be beyond the normal level. On the other hand, the case does not seem to be representative with respect to the planners' striving for rationalizing planning either. In this regard, the case is apparently also outside normal circumstances. Despite the fact that the case is not representative, it is precisely due to the salience of both technical and political rationalities which makes it well suited for studying how these two rationalities interact and serve as mechanism shaping transport model-based knowledge production.

The first sub-question, "*How and why did computerized transport modelling emerge within Danish planning practice?*", has been investigated by looking at how the conditions of possibility for the emergence of computerized transport modelling were created. In other words, I have looked for transformations in planning practice that took place prior to the decision to develop the first computerized transport model but which facilitated this decision to develop the model. In that respect, I have looked for how methods previously applied on a common basis within transport planning practice started to become problematic as well as the grounds upon which this was so. In other words, I have looked for different mechanisms which took part in opening up practice for change to come about, facilitating the emergence of computerized transport models within planning practice. I have also investigated the particular planning context in which the decision to develop the model was situated. In that respect I have particularly focused on the objective of developing the model, the problems which the computerized transport model were supposed to help overcome, and how it was perceived to be able to overcome these problems. Moreover, I have looked into planning programmes in which the decision of developing the model was situated as well as the spatial politics which surrounded these planning programmes. In other words, in addition to transformations in planning practice, I have also looked for the situated context of the model's emergence as well as the grounds on which the objective of developing the computerized transport model was rationalized.

The second sub-question “*How were the development of the transport model and the making of alternatives shaped by various mechanisms?*” is approached based on detailed investigations on the process of developing the computerized model and the land-use and transport alternatives. Based on these investigations, different mechanisms shaping the processes of developing the model and the subsequent knowledge production are inferred. I have focused on the meaning and objectives related to the development of the transport model and whether meaning and objectives were successfully inscribed into it or not. I then looked at the mechanisms facilitating and constraining the inscription of meaning. I have also looked for how the interpretation horizons prevailing with the operational environment of the model seemingly guided choices about model assumptions and model methodology. Moreover, I looked for constraints faced during the processes of developing the model and collecting the data, and whether these constraints were accepted or not, and if they were not, then how the constraints were attempted to be circumvented as well as what the result of these attempts were.

The third sub-question “*How where the results put to use and did they gain acceptance?*” has been approached based on an analysis of the role of the traffic forecast undertaken in the planning and decision-making processes in which it was applied. The focus is on the knowledge claims that the model results were used to advance, and how they were applied in the planning and decision-making processes, e.g. whether the results were framed as truth claims or uncertain estimates and whether the model result was used in a technical-rational or political manner. Besides the knowledge claims which the forecast results were used to underpin, the counter-claims advanced by project opponents are also investigated. Due to these issues, the deliberations on this sub-question are, to a larger extent than the two previous ones, based on inquiries into the audience. In fact, whether the forecast results gained acceptance will be analysed based on information collected from the national and local political level, the general public as well as planning peers.

5.4 Reflections on the process of the thesis

In this section some reflections on the process of preparing the thesis and why my approach ended up as it did are presented. First, it is discussed how my normative standpoint and understanding of the research problem have transformed throughout the PhD process. The last sub-section elaborates on how an attempt to make a comprehensive PhD thesis meant that I fell into a trap of spending too many resources on collecting a vast amount of empirical material.

5.4.1 My normative standpoint and journey throughout the PhD process

This sub-section discusses my normative standpoint and the process throughout which my approach ended up as it did. These two issues will be discussed jointly because some of the transformations which they both underwent throughout my PhD journey are closely interlinked.

When I started the thesis (and also before that), I had a very critical approach to the research topic of transport modelling. I believed that transport models were promoting the car-based society and thus contributed to environmental harm. In other words, I regarded transport models as promoting values which were against my own normativity. My conceptual approach to the neglect of induced traffic was dominated by the political-economic and organizational

perspectives. On that basis, I had a rather antagonistic perception of transport planners and their models - either they were slippery or extremely narrow minded. Here, at the end of the PhD process, my normative standpoint is largely the same. I still care about the environment, I still have a critical approach to modelling and I still regard transport models, which are based on simplified assumptions, as potentially environmentally harmful. However, my perception of transport planners and models in general has changed. Even though some of my original propositions were somehow confirmed by my empirical material, e.g. with respect to the politically charged contexts of transport modelling and how they are used to advance partisan politics, my simplified prejudices of such processes, which I originally took for granted, were questioned and inconsistencies between my interpretation horizon and my empirical material were raised into my discursive consciousness. This created an opportunity for change to come about. For instance, by conducting qualitative interviews with practitioners, my previous-assumptions about transport modellers and planners were not generally confirmed. Most of the respondents were reflective and passionate about their work. It might be that they conceptualized their work practice within another interpretation horizon than I did/do, but they did not seem narrow-minded and they certainly did not appear slippery. During my interviews, I did not only let the respondents reflect on their work practice, but some of the respondents also questioned my assumptions, implicitly and explicitly, which caused me to reflect upon them. I started to critically re-visit the evidence put forward in the literature which underpinned my approach. I started to realize that the conclusions which my assumptions were based upon did not provide conclusive support, but were based on contestable arguments which I previously had accepted uncritically. I started to realize that perhaps I was the one who was narrow minded. Perhaps I needed to approach the problem differently in order to comprehend the mechanism shaping transport modelling practice.

Reading into historical transport planning documents, as preparation for teaching and due to personal interest, also contributed to my questioning the original propositions, and raised my discursive consciousness. I started out by assuming that induced traffic was a rather new concept and its emergence was more or less related to the British SACTRA committee in the 1990s. I assumed that the reason that induced traffic was not included in standard models was either because it was not accepted as an empirical phenomenon among the profession of transport planners and modellers or that they did not change their practice because it was inconvenient with regards to the objective of promoting road construction. However, by looking into Danish planning documents, first from the 1960s and then in the 1930s, I realized that induced traffic was, in fact, part of planner's discursive consciousness. My pre-assumption was, thereby, falsified and this also contributed to a re-opening of my approach in order for change to come about. I had to formulate a new hypothesis about the neglect of induced traffic and I started to feel convinced about the benefit of taking a historical approach to shed light on the issue.

Another issue which led me on a historical path into the emergence of computerized transport modelling was that I met, in fact, with non-acceptance from my supervisors. I had proposed to carry out an empirical analysis on the historical development of the cost benefit framework within Danish planning practice. My supervisors questioned whether such an analysis was reasonable as part of a thesis concerned with transport modelling. It would be more reasonable to make an empirical analysis about the historical emergence and development of transport

models¹⁴. My supervisors had a good point, and it was not that I had not had the same thought before, but that I had been unable to find any material on the matter. After the supervision meeting, I felt despair - what should I write about in my thesis now? At that time I was also investigating a case concerning the planning of a new rail link between Copenhagen and Ringsted, and I had been trying to trace back the origin of project. That led me to look into regional planning within the Greater Copenhagen Area. I had borrowed a book from the library by Poul Lyager (1996), a planner formerly employed in the Municipality of Copenhagen's Department of the City Engineer and who also participated in the drawing up of the first regional land use and transportation plan for the Greater Copenhagen Area. The book had been lying in my office for some time, but I had not looked at it. Just after the supervision meeting, I opened it for the first time. I did not find anything on the Copenhagen-Ringsted case, but I did find something which turned my frame of mind from despair to excitement. The book disclosed that the development of the first computerized transport model within Danish planning practice was initiated within Copenhagen Municipality's Department of the City Engineering in 1962. This gave me a new clue in my search for empirical material on the emergence of computerized transport models. However, no internet hits occurred based on this subject, but by searching on the Department of the City Engineer site, I ended up by chance at the Copenhagen City Archives' homepage. Here, I discovered that there were considerable amounts of archival material on traffic forecasting within the Municipality of Copenhagen in the 1950s-1960s. This was exciting, and I decided to go there and have a look into the material. I had ordered around twelve archive boxes which was the maximum limit. I do not know what I had expected from this. I had never worked with archival material before, and I was rather overwhelmed by the amount of material which was contained in the boxes. It took me two days just to take photographs of the material. When I came home and started to read through the material I was overwhelmed by the particularity of the material. My knowledge about the context in which this material was situated was very limited, which made it difficult for me to make sense of it. I started to realize that I could not comprehend the particularity of the archive material without taking the wider planning context into account. However one thing which I found interesting was that I could see that in the period 1962-1967 an assignment model including capacity restraint was being developed, but in 1967 where development of a new transport model was initiated, it was accepted to use an assignment model without capacity restraints. I brought this finding to the following supervision meeting. However, once again my supervisors did not accept my proposition. My supervisors asked me the obvious question of why this model was accepted. Again, my supervisors had a good point and it was not because I had not considered this myself, but based on the empirical material I had collected, I was unable to answer it. This made me realize that I had to go back to the City Archives and collect more material in order to better comprehend the mechanisms which shaped the transport model-based knowledge production. In other words, as a reaction towards my supervisors' non-acceptance of my direction, I collected more empirical material in order to make my weak knowledge claims appear solid and more acceptable.

¹⁴ I am not sure that my supervisors actually meant this as a call to investigate the historical content of transport models' emergence within Danish planning practice, but instead were pointing out why my suggestion to investigate an analysis of the historical development of the cost-benefit framework was incomplete.

The more I read into the archival material and the more I read into secondary literature concerning the wider planning context, the more I started to make sense of the particularity of the archive material. However, the more I knew about the case, the more I also started to recognize that in order to comprehend the mechanisms which unfolded within the case, I would need additional vital information. I started to realize that one of the contextual factors of the computerized transport model's emergence was a spatial policy controversy about future land use. However, my material did not contain anything about the preparation of the land use alternatives; rather, it was mostly related to development of the computerized transport model. On that basis, I realized that I had to go back to the city archives once again and search for more material. This time, I brought home some of the missing pieces vital for comprehending the case properly. If I had brought this information home from my first visit to the archive, my interpretation process would have been eased considerably. However, when I was about to finalize my interpretation of the case, I was faced with additional evidence which was problematized by the fact that my empirical material was largely based on the back-stage view, but did not include material about how the knowledge production was being received by the audience. The possibility of including the aspect of acceptance or non-acceptance of the results came about by chance. I had ordered a book from the library, assuming it was a planning report, but when I looked into it I discovered that it was a rather detailed set of minutes from a meeting where, among others, the model results were the topic of discussion. Here, the politicized context of the transport model result became evident in a form not contained in the archival material. The minutes also gave me some ideas for searching in newspaper articles from that period of time. Moreover, I discovered at the very last stage of my writing that there were full short-hand reports from political debates in the Copenhagen City Council. Inclusion of the audience was vital to obtaining an understanding of some of the archival material. The manner in which my interpretation was reopened due to the appearance of new empirical material concerning the political context in which the model results were put to use and non-use made me realise that one cannot comprehend mechanisms shaping transport model-based knowledge production by only investigating the particular. The field of power relations unfolding in the wider context of the transport model-based knowledge production must also be accounted for.

5.4.2 The comprehensive trap

Despite comprehensive planning being regarded as an ideal by many, this ideal has been shown to be very difficult to achieve in practice. Collection of the amounts of data often needed in order to investigate an issue in detail from a comprehensive perspective e.g. by the use of transport models, is very resource demanding. This data quest can imply that too many resources are used at this stage, meaning that the subsequent stages of analysis, interpretation and reporting will suffer. Besides the risk that deadlines pass by unmet, the comprehensive approach also implies a risk of collecting more data than there are resources available for subsequently processing. This can be called the comprehensive trap. In the second embedded case study, the comprehensive trap will be shown to unfold in practice. However, as a reflection on the process of my thesis, I have also fallen into the comprehensive trap. I wanted to include almost everything into my investigations. I created a survey, conducted qualitative interviews, carried out document studies, ferreted out archival material, etc. I aimed to investigate the present, the past and the interim. However, as the deadline came close, I realized that this aim

was unachievable, and I had to delimit myself. This I did several times, but nevertheless, I was not able to meet my deadline. I have, therefore, collected a large amount of data, which I started processing, but in the end, I did not make use of in my thesis. For instance, I took part in preparing a survey, but did not end up using it in the thesis¹⁵. I also conducted a number of qualitative interviews, not fully utilized either. Moreover, I collected a considerable amount of archival material on the development of the second Danish computerized transport model. This model was developed by the Regional Planning Council in the period 1967-1973, and the case is a continuation of the story line drawn up in the second embedded case study. Yet I also had to cut this one out. I have, therefore, collected much of empirical material which I did not manage to put into this thesis, but I spent a considerable amount of time on collecting and processing. However, despite the fact that I have spent significant resources on collecting data which I have not make use of, it has not been a complete waste of time. If I had not collected and looked into all this empirical material, I would not have ended up utilising this rather explorative approach which I believe characterises the thesis. In fact, as discussed above, it was, in fact, due to this data quest that several of my original propositions transformed throughout the process of the PhD. Therefore, despite the fact that that I did not make use of all the collect data in the thesis, much of it did influence my understanding of the research problem. Moreover, despite not using all my data in this work, it will hopefully be taken up in future work. Despite the comprehensive trap having its benefits, I fell deeply into it and it was not easy to get out of it again.

¹⁵ This survey was prepared in collaboration with Morten Nicolaisen, who was part of the same research project as I. Although the survey results are not made use of in this this thesis, they are reported in Nicolisen (2012) and Næss et al. (2013).

Embedded case 1

This embedded case analyses induced traffic in regard to Danish transport project evaluation practice in both a contemporary and historical perspective. It is concerned with problematizing the practice of neglecting induced traffic as well as understanding why such a practice emerged and has been continued. The embedded case is structured into three chapters. Each chapter elaborates upon a particular sub-research question and explores induced traffic in regard to different periods of time.

The first chapter of the embedded case concerns the period from the early 2000s until now and using the transport model applied to prepare two Environmental Impact Assessments for a Third Limfjord Crossing as a case, the chapter explores how the acceptance of not including induced traffic is rationalized by key stakeholders. It is shown that despite the fact that non-inclusion of induced traffic in transport project evaluations is likely to cause bias, this simplification is, among others, rationalized as a practice that has become taken for granted.

In the second chapter, induced traffic in regard to transport project evaluation practice will be explored based on material from the 1830s-1970. History is used here to problematize the acceptance of the contemporary practice of omitting induced traffic. The concept of induced traffic and the meaning it holds within Danish transport project evaluation practice will also be explored. As a result, new knowledge is produced of why the practice of omitting induced traffic has emerged.

The third chapter of the embedded case concerns the period 1970-2000. While transport model results during the period investigated in the second chapter of the case, were primarily used as the basis for infrastructure designs and as inputs to financial and socio-economic feasibility studies, transport model results from this period were also increasingly used as input to evaluate transport-related environmental and health impacts, reflecting the increasing concern within transport political discourses and policy agendas. This chapter explores how transport modelling practice transformed as a reaction towards the increased prominence of environmental and health concerns, during the period scrutinized. The chapter is primarily based on the case of the third Limfjord Crossing, also explored in the first chapter of the case.

6 Neglect of induced traffic and acceptance within contemporary practise

Based on the case of the transport modelling conducted in regard to the preparation of two EIAs for a third Limfjord crossing in the Aalborg area, Denmark, this chapter explores the research question *“How is the acceptance of the neglect of induced traffic rationalized within contemporary transport modelling practice?”*

Aalborg is the regional capital of North Jutland and the third largest municipality in Denmark. In the Aalborg area there are presently one rail and two road crossings over the Limfjord which divides the city, a city-bridge where pedestrians and bike users can cross and a motorway tunnel. The possibility of constructing a third road connection across the Limfjord has been discussed since the second road crossing began to be considered in the 1950s (Komite af embedsingeniører i Aalborg-området 1958; Stadsarkitekten i Aalborg 1950). It was during the preparatory work on the tunnel in the early 1960s that the idea emerged. In 1962 the Committee working on the planning of the tunnel gave its final recommendation regarding the tunnel system to the Minister of Public Works. At the same time it was agreed that the Committee should investigate the possibility of a western crossing, with a view to ensuring a land reservation. The Technical Subcommittee investigated the issue until 1965. As a result, the Committee pointed at either the so-called “Lindholm Line” or the “Rail Bridge Line” as possibilities of relieving the existing fjord crossings sufficiently, but it was not possible to recommend one of the alternatives based on the available traffic calculations.^{16, 17} After 1965 the work stood idle for some years but in 1971 it was resumed thanks to local initiative. It is at this point in time that the analysis of the third sub-research question begins. In this chapter we will, however, move forward in time and start the analysis around the year 2000. This year an Infrastructure Committee was established jointly by the Municipality of Aalborg, the County of North Jutland and the Ministry of Traffic. In order to avoid future congestion problems on the road network, the Committee recommended that a 3rd Limfjord road crossing be built. An Environmental Impact Assessment of three different schemes for this crossing was presented in the spring of 2003, namely, the Egholm Line, the Lindholm Line and the Parallel Tunnel (see figure 6.1). After a public hearing, the County of North Jutland adopted an amendment to the County Plan in the autumn of 2003, including a land reservation for a motorway link to the Egholm line.

¹⁶ *Udkast til teknikkergruppens oplæg til plenarudvalget.* (Trafikministeriet, Udv. 4.9.1972 Ny fast Forbindelse over Limfjorden, Materiale, Original, papir m.m., Box 1)

¹⁷ *Redegørelse fra udvalgsformanden ved pressemøde den 5. august 1977 angående linieføringen for en eventuel 3. vejforbindelse over Limfjorden ved Ålborg,* Udvalget Vedrørende Anlæg af en Ny Forbindelse Over Limfjorden, 04.08.1977 (Trafikministeriet, Udv. 4.9.1972 Ny fast Forbindelse over Limfjorden, Materiale, Original, papir m.m., Box 1)



Figure 6.1: The three alternative solutions for a Third Limfjord Crossing included in the EIAs in 2003 and 2006. (Danish Road Directorate 2010)

The investigations were, however, met with non-acceptance and attempts were made to deify them. Several formal complaints were submitted to the Nature Protection Board of Appeal against the EIA report. Two of these complaints criticized the EIA for an insufficient assessment of the impacts on habitats and species protected by EU legislation; a third complaint criticized the County for having omitted to include in the EIA an alternative aiming to reduce traffic growth through restriction on vehicle usage and substantially improved public transport. The latter complaint was not accepted by the Board of Appeal. The content of the complaint and the premises for rejecting it will be discussed in a more in-depth manner in a later section of the chapter. The two former complaints were, however, accepted by the Board of Appeal. As a

result, in 2006, the Board of Appeal abolished the Region Plan amendment and the associated EIA report on the Third Limfjord Crossing.

The non-acceptance by the Board of Appeal implied that the land reservation for the Egholm motorway was no longer valid. The County of North Jutland decided to initiate a new planning process in cooperation with the Coastal Directorate, the Road Directorate and the Municipality of Aalborg. In the new EIA report (County of North Jutland et al., 2006), more in-depth analyses were made regarding the influence of the proposed road on protected habitats. However, the Danish Forest and Nature Agency considered the EIA report to be insufficient and put forth an objection against the County's proposal for an amendment of the County Plan. This implied that the County did not have the time to adopt the County Plan Amendment before January 1 2007, when the Danish counties were abolished and replaced by a lower number of administrative regions.

In the National Parliament the political parties behind the political agreement 'Better Roads etc.' of December 2nd 2009, agreed to supplement the previous EIAs with additional investigations and assessments of the road systems' environmental impacts during both the construction and subsequent operation phase. The new EIA investigations were initiated in the spring of 2010 and completed in 2011 (Danish Road Directorate 2011). This time the EIA fulfilled the requirements, but it did not receive political approval. Instead, a decision on the project was postponed indefinitely. Hereafter, some of the main results from the two first EIAs will be presented.

6.1 Some main conclusions of the EIA report

The 2003 EIA report included assessments of motorway alternatives as well as highway alternatives for the two western crossings, whereas the report from 2006 only included an assessment of motorway alternatives. The latter report also included an extended chapter on both the terrestrial and marine environment, compared to the 2003 report. Apart from that factor, the 2003 and 2006 EIA reports are fairly similar. Below, we shall concentrate on the environmental consequences that depend on the volume, speed and composition of the future traffic on the new road links and on other affected parts of the transport infrastructure: energy consumption, air pollution, traffic noise and traffic accidents.

In the environmental assessments, the three motorway alternatives were compared to a baseline alternative. According to the calculations, traffic growth would cause the average speed on the two existing crossings of the Limfjord in the peak period to drop to 15 km/h and 20 km/h in 2015 if the road capacity across the fjord was not increased. With the proposed motorway, congestion would instead be diminished.

The motorway alternatives were forecasted to reduce energy use, air pollution, general exposition to noise and the number of traffic accidents involving personal injury, compared to the baseline alternative. Greenhouse gas emissions were only mentioned in the section of the EIAs where the results of a cost-benefit analysis were presented (see table 6.1).

Table 6.1: Predicted energy use, air pollution and noise in the baseline alternative and in the three motorway alternatives (Danish Road Directorate, County of North Jutland and Municipality of Aalborg 2006, pp. 28-29 and 60).

	Baseline	Motorway, Egholm Line	Motorway, Lindholm Line	New parallel motorway tunnel
Energy use (TJ annually)	4083	3973	3936	4020
Hydrocarbon (tons annually)	559	514	509	541
Nitrogen oxides (tons annually)	1352	1336	1323	1333
Carbon monoxide (tons annually)	10990	10455	10217	10565
Particles (tons annually)	54	53.1	52.9	53.7
Noise Exposition Index	230	192	181	230
Number of dwellings exposed to noise above 55 dB (A)	971	993	935	971
Traffic accidents causing injuries to persons (annual number)	355.5	339	341.7	355.4

A slightly higher number of vehicle kilometres per car were forecasted into the motorway alternatives than in the baseline alternative, as the proposed roads would channel a larger proportion of the traffic along routes deviating somewhat more from the straight line between the majority of origins and destinations, compared to traffic on the existing road network. Apart from this, traffic was predicted to grow at 2 % annually on the motorway alternatives and the baseline alternative alike and the growth rate is not assumed to slow down when the capacity limit is reached (see figure 6.2).

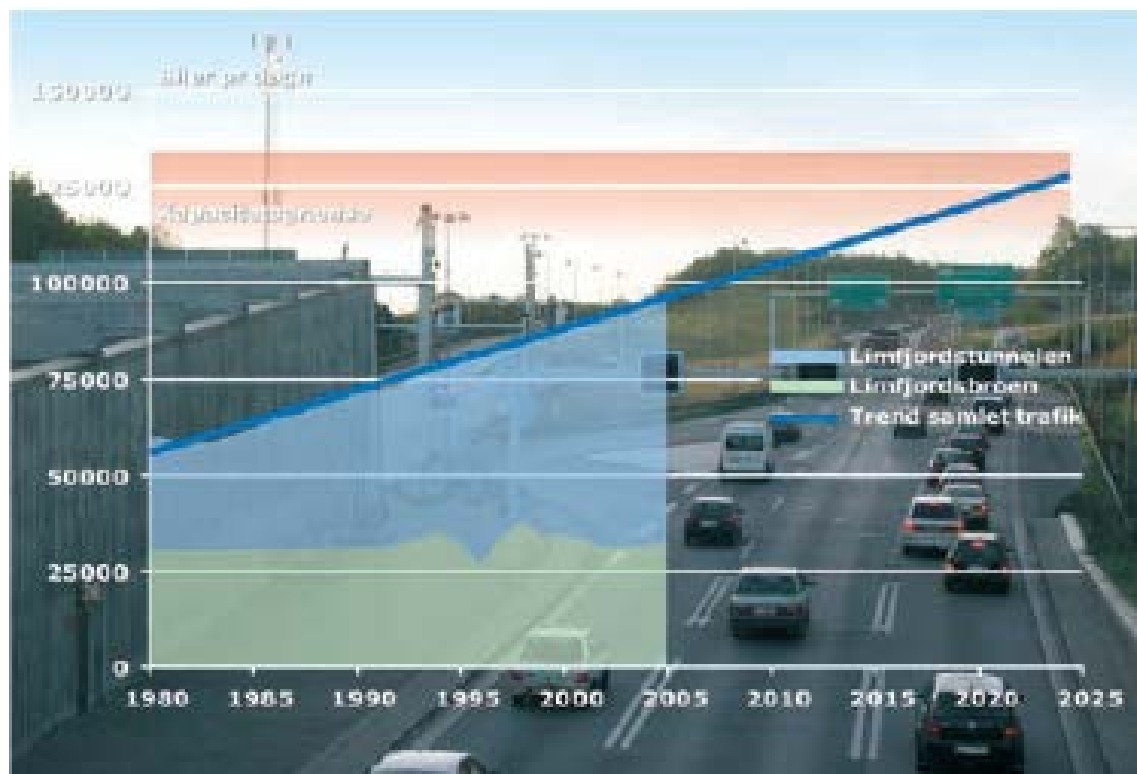


Figure 6.2: Assumed traffic growth in the fjord crossing section, based on a projection of past trends but without accounting for traffic constraining effects of capacity problems (Vejdirektoratet, Nordjyllands Amt and Aalborg Kommune 2006b, p. 12).

6.2 Scrutinizing the assumptions of the traffic model

As the traffic model should serve, not only as the foundation for the assessment of environmental impacts but also as a basis from which to make a decision on establishment of the crossing or not, it was now particularly relevant that the model was capable of reflecting

induced traffic. Hereafter, we will scrutinize the model assumptions and the implications that follow.

The forecasted traffic volumes in 2015 were based 'partly on information about planned residential and commercial development within this horizon, combined with a general assumption about the growth in the traffic crossing the fjord, estimated from the past development' (Road Directorate, County of North Jutland and Municipality of Aalborg, 2006, p. 14). There is no information in the EIA report about the model's assumptions about factors influencing future traffic development. Whether or not the model takes the effect of induced traffic into account is not explicitly stated. The lack of such information is, in itself, a demonstration of the black-boxing character of the model. However, the predicted traffic growth in the motorway alternatives is almost identical to that in the baseline alternative, clearly indicating that induced travel has not been incorporated into the traffic model. This has also been confirmed in an interview in 2010 with a planner from the former County who has worked on the project (Interview with planner, 2010).

The verbal discussion in the EIA report mentions that the new road would accommodate long-term traffic growth. This traffic growth is, however, depicted as unavoidable:

"Even if a Third Limfjord Crossing is not realized, future traffic growth cannot be avoided. If traffic continues its rate of growth without road capacity increases, traffic flows will steadily worsen, with steadily increasing emissions per vehicle kilometre as a result." (Danish Road Directorate, County of North Jutland and Municipality of Aalborg, 2006, p. 28; own translation)

However, when it is assumed that traffic growth will continue along a historically observed trajectory, regardless of whether or not the capacity and standard of the road infrastructure is increased, the fact that the hitherto observed traffic growth is partially a result of road investments having facilitated this growth is ignored.

The increase in road capacity represented by the new motorway and associated access roads is assumed to improve overall travel speeds, reduce emissions per vehicle kilometre and improve traffic safety. However, because the assessment ignores induced traffic, these benefits are likely to be considerably exaggerated, because induced travel implies that the new road capacity will gradually start to fill up again, eventually causing traffic speeds to drop. In addition, due to induced travel, energy use per vehicle kilometre will also show a less marked improvement than has been predicted and the number of vehicle kilometres will be higher than indicated by the model results. It is therefore most likely that total energy use and greenhouse gas emissions, accidents, noise and air pollution will increase instead of being reduced, as indicated by the EIA.

Another deficiency of both the two aforementioned EIAs is that neither of them includes an assessment of uncertainties in the analysis, nor a discussion of the validity of the assumptions on which it is based and how these assumptions influence the model results. Such information is required according to the Ministry of Transport's manual on socio-economic analysis as well as the guidelines from the Ministry of the Environment on the Planning Act (Ministry of Transport, 2003; Ministry of the Environment, 1996). In fact the socio-economic manual also contains recommendations about inclusion of induced traffic. As can be seen above, the underlying

assumptions of the traffic model is not clarified at all. Such neglect is especially problematic in this case, for even though explicit political reduction targets on CO₂ emission within the transport sector had been abandoned by the government at the time, it was still an objective to reduce transport-related impacts and in that respect the results were clearly misleading. We shall return to the implications and possible explanations of this in a later section of this chapter.

6.3 The complaint

After having scrutinized the implications of the simplified transport modelling approach we will now return to the aforementioned complaint submitted to the Nature Protection Board of Appeal which attempted to de-reify the County's rationale for having omitted to include in the EIA an alternative aiming to reduce traffic growth through restrictions on auto usage and substantially improved public transport. The complaint was accompanied by an academic assessment of the validity of the County's arguments for failing to include alternative proposals. The academic assessment was written by a professor in urban planning, who is also a transport researcher, by request (Næss, 2003). The attempt was thus to de-reify the model assumptions on scientific grounds. The paper criticized the underlying premise of the County's claim, namely, that traffic growth would be equally high if this alternative was implemented as it would be with motorway construction with particular prioritization of buses and bikes. The paper also pointed to the fact that the EIA did not include any discussion – or indeed any mention whatsoever – of weaknesses in the information and assessments of environmental impacts, despite the requirement for this as stated in the Ministerial Guidelines. A second paper was later submitted with a more in-depth argument against the claims put forth below by the County in defence of their estimates (Næss, 2004a).

As part of the handling of the complaint, the Nature Protection Board of Appeal asked for comments from the County of North Jutland. The County maintained its standpoint, referring, among other things, to traffic model calculations conducted in 1998 predicting that the replacement of a one car lane in each direction on the existing Limfjord Bridge with bus lanes would only reduce the number of cars crossing the Limfjord by 0.5%, and would result in an increase in the total vehicle kilometres of car traffic by 0.75% (Nordjyllands Amt 2004). We will return to these calculations in Chapter 8, where it will be argued that they rested on problematic assumptions.

In a second reply the county attached a technical paper from the consultant firm COWI, where it was maintained that:

“the method used in the assessment of induced traffic is the method applied generally for new infrastructure schemes in Denmark” (COWI, 2004, p. 2; Own translation)

COWI justifies the neglect of induced traffic by reference to its compliance with the prevailing order within transport project evaluation practice. As it was shown in Chapter 2, COWI's argument that the traffic model used in the Limfjord case is by no means unique in a Danish context is, to some extent, valid. Nevertheless, the fact that induced traffic has traditionally been ignored in most Danish traffic models does not make this less of a bias. From the argument put forward by COWI, the non-inclusion of induced traffic seems not only to be a practice that is

taken for granted and accepted tacitly, but when the bias was raised to discursive conscious in the complaint, omission was nevertheless still perceived to be an acceptable practice.

In 2006, the Nature Protection Board of Appeal decided to reject the complaint about the traffic forecasts and the assessment of traffic-related environmental problems. Concerning the traffic elucidations, the Board of Appeal stated that:

“An assessment of the material content of the traffic analyses lies beyond the legal control of the EIA report to which the Board of Appeal is entitled. The requirements ... must be considered to be met as regards this issue, since the County has elucidated the traffic consequences of a Third Limfjord Crossing and given an account of the traffic analyses. There is no basis for rejecting the material as obviously incorrect.” (Naturklagenævnet, 2006, p. 12; Own translation)

It is both worrying and a democratic deficit that the Board of Appeal was not legally entitled to assess the material content of the traffic model, but accepted the simplified foundation of the model-based knowledge production and the resulting misleading assessment of environmental impacts. The fact that the foundation of these knowledge claims could not be contested constitutes a system bias which positions the technical content of transport models outside the domain of political scrutiny, and within the domain of certified truth.

6.4 Rationalizing acceptance of not including induced traffic

Previously it was shown that non-inclusion of induced traffic was accepted by several key stakeholders. In this section, different rationalities underlying the acceptance of non-inclusion will be analysed both with respect to the Limfjord case and the wider context.

There are certainly technical reasons why induced traffic was not included in the transport model. A planner from the former County of North Jutland informed the author in an interview that the fundamental structure of the model made it impossible to adjust the elasticities in the model to reflect the effect of induced traffic. In order to account for induced traffic in the model, the elasticity would have to be corrected manually for each alternative (Interview with planner, 2010). Here we see how the technical design of the model acted as a structural constraint for the inclusion of induced traffic. Structural constraint also appears to be of significance for understanding the non-inclusion of induced traffic beyond the case of the Third Limfjord Crossing. As an employee in the Road Directorate puts it:

“...if we have not been able to calculate it [induced traffic], then it has obviously not been included.” (Planner/modeller in the Road Directorate; Own translation)

Hence, structural constraints contained in the technical design of transport models seem to be a relevant explanation for non-inclusion of induced traffic. However, the structural constraints themselves do not explain why they are accepted. As it is technically possible to manually overcome these structural constraints, acceptance is not purely a technical issue. One explanation may be that a culture has prevailed where simplification and insufficiencies in

general were accepted. In an interview with an employee within the Road Directorate, he suggests that such a culture has previously prevailed. He states:

“When I got my first project the consultants were very surprised because I was on their neck all the time. There were simply too many mistakes. They have told me a couple of times that this is not the way it used to be. Ergo it was OK if there was a mistake here and there.” (Modeller 2010; Own translation)

Thus we see that technical insufficiencies seem, to some extent, to have been accepted within Danish transport project evaluation practice. However, acceptance of mistakes does not in itself explain the systematic neglect of induced traffic. In the Limfjord case budget constraints constituted a rationale for the simplified approach. A planner who formerly worked in the Municipality of Aalborg stated it as follows:

“I know that the problem generally has been that the civil servants and the consultants have said or had a wish about adjusting the model. And they have never been allowed to adjust the things that they wanted, because it was simply too expensive.” (Planner 2010; Own translation)

The prevalence of economic constraints does not, however, rule out the importance of social biases. In fact, economic constraints mean that resources have to be prioritized more strictly, and because not everything can be included, the selection processes about what to include is more likely to be shaped by organizational, political and psychological rationalities. These perspectives will be discussed in turn, hereafter.

From an organizational perspective, and in accordance with Haugaard’s concept of social order and the social construction of technology’s focus on meaning within social groups, it can be argued that structural constraints can be accepted because they mirror biases prevailing within their social organizational environment. Such a perspective seems to have some relevance with respect to understanding the acceptance of simplified transport models. For instance, in answer to the question of whether multi-modal traffic models were in demand by their clients, a consultant replied as follows:

“Our clients are often marked by a strong sectorial belonging. Road planning agencies often don’t care about issues other than car traffic. Other times, a department in a municipality wants us to assess some public transport initiatives, but does not care about how it affects the car traffic... then we have some borderline cases for larger projects... In these cases you are interested in the modal split.” (Consultant 2010; Own translation)

This shows how system biases born of organization affiliation can be inscribed into the structure of traffic models, resulting in reductionist approaches to transport project evaluation. Such a lack of cross-sectorial integration might be one of the reasons why so many Danish transport models are mono-modal.

Accordingly, part of the reason why induced traffic has often been neglected within Danish transport project evaluation practice may be that the model results tend to fit well with the “predict and provide” interpretation horizon, where according to some scholars, travel demand

has been perceived to be inelastic in regard to travel conditions (see section 3.5). In regard to the Limfjord case, in Chapter 8 it will be shown that in accordance with a “predict and provide” interpretation horizon, the problem of fjord crossing capacity has, throughout the history of the case been framed rather narrowly, offering road capacity enlargement as a solution to the predicted capacity problems. This framing is also reflected in the name of the project, the third Limfjord crossing. Including the rail bridge, there are already three Limfjord crossings. This shows that it has seemingly been taken for granted that the forecasted capacity problems in the fjord crossing section was to be solved by provision of additional road capacity. However, in the Limfjord case there does not seem to be total consistency between the neglect of induced traffic and the interpretation horizons among the planners who have worked with the case in a more contemporary perspective. From interviews it appears that the planners and consultants accept induced traffic and its effect as an empirical phenomenon, and this has in fact been discussed in relation to the case. As a consultant who has worked on the project states:

“Induced traffic has been discussed in relation to the case. ... It is, however, difficult to estimate how great the effect of induced traffic would be ... Based on that, we think that it just as good to say, we have this amount of traffic and we have these forecasts, then the traffic will be distributed in this manner in 2015 ... And because of the annual growth rate for the fjord crossing traffic is about 2-3% and let’s say that the effect on induced traffic would generate 5000-10000 extra cars in the first years, then the annual growth rate would level out this effect pretty fast.” (Interview with consultant, 2007; Own translation)

Despite the fact that the consultant accepted induced traffic as an empirical phenomenon, he regarded the effect to be of minor significance, and therefore he concluded that it was legitimate to exclude it. This lends some support to the hypothesis concerning that induced traffic often are omitted because planners working within a “predict and provide” interpretation horizon, perceive the elastic of travel demand, in regard to travel conditions, as negligible. However, this was not how acceptance of omitting induced traffic was rationalized among the respondents in general. Another respondent who also accepted the non-inclusion of induced traffic, despite accepting it as a real phenomenon rationalized his acceptance differently, stating that:

“The last couple of times we have been working on the third Limfjord Crossing, we have been discussing if we should build up a new model. But as I have said – in Aalborg is it a matter of selecting one alternative over another. So it is ok to use a traffic mode which is not as finely tuned as it ought to be. But when it is the same conditions that are used to analyse all four alternatives, then some of the possible errors will be eliminated when a cross comparison is made” (Planner 2010; Own translation)

Despite the fact that some errors might be reduced in a cross-comparison among build alternatives, this is not the case in the comparison with the no-build alternative, which the respondents also recognized. A respondent from the Road Directorate also rationalized acceptance of non-inclusion of induced traffic, in a manner which leans towards bias against the no-build alternative. He states:

“When we make the projection then perhaps we have, in fact, accounted for induced traffic there. Because otherwise, what is being talking about, is in fact the inverse effect of induced traffic, right. If it [capacity] will not be expanded, then there is no room for that traffic to grow. And so it does not grow as much as the forecasts we use, we genuinely suspect it is going to increase. But if it will be expanded then it can rise. And then it hits the growth, which we actually have. (Chief consultant in the Danish Road Directorate, in interview September 2010; Own translation)

Hence, according to this view, because some of the observed traffic increase has been induced by previous capacity enlargements, induced traffic is somehow accounted for in the forecasts which are based on projections of historical traffic trends. Even though this argument seems valid, this rationality leads towards bias against the no-build alternative which will become relatively over-estimated, thereby exaggerating the demand for capacity enlargements. From the two quotes above, it can thus be seen that despite the respondents' acceptance of the phenomenon of induced traffic, they rationalize their acceptance of not including it in a manner which generates bias against the no-build alternatives. This underpins the argument offered by Næss (2011) that the major bias of neglecting induced traffic from transport project evaluation is generated in the form of overestimated no-build alternatives relative to build alternatives. The implication of this bias is a risk of that the benefits of road construction also become overestimated (see section 2.3.2). However, according to one of the respondents, neglect of induced traffic signified the inverse effect. He states:

“One needs to acknowledge that induced traffic exists ... if you leave induced traffic out of the equation in socio-economic analyses, then the benefits will be underestimated, due to the generated time benefits of the new road users. At the same time, there are, of course, also greater environmental impacts, but in the socio-economic analyses it does not pull nearly so much in the other direction. ... if a road is expanded, then the capacity is enlarged by nearly 50%. Traffic has to increase a lot before congestion reaches the same level as before the enhancement... I fear that we have overestimated the effect of induced traffic in some of the more recent projects.” (Planner/Modeller in the Road Directorate 2010; Own translation)

According to this rationality then, inclusion of induced traffic implies a risk of overestimating project benefits, despite the fact that environmental impacts are systematically underestimated. Hence, non-inclusion of induced traffic is perceived to be biased against rather than in favour of road construction. It is interesting to note that the implications of induced traffic with respect to transport project evaluation is given meaning by the respondents within a cost-benefit interpretation horizon, rather within an interpretation horizon where it is the political objectives which determine the meaning of an effect in terms of desirability and undesirability. Within the latter interpretation horizon, induced traffic signifies a cost because it is at odds with the political objectives concerning stagnation in vehicle kilometres travelled and reduction of environmental impacts.

In some cases reported in the literature, forecasters have been exposed to strong pressure from elected officials (Flyvbjerg, 2007). From interviews it is evident that politicians did have an

influence on the assumptions which underpinned the model result. A planner who was involved in the planning of the Third Limfjord Crossing in the early phases of the project stated that:

“One of the reasons why the forecasted congestion levels never realized was due to the population forecasts we made [it was overestimated]. I can remember that we wanted to produce a population forecast based on assumptions about stagnation in population growth, but the politicians didn’t allow this. ... the politicians wanted models of growth.” (Planner 2010; Own translation)

Thus we can see that politicians did not, in fact, accept assumptions which depicted the demand for a third road crossing as less pressing. However, according to the planner, this non-acceptance was not based on a rationale of deliberately overestimating the demand in order to increase the likelihood of project approval. He put it as follows:

“The politicians’ point of departure has not been that that they wanted to construct a third Limfjord Crossing [therefore deliberately exaggerating the demand for it], but rather that they wanted to indicate that they were in a society marked by growth.” (Planner 2010; Own translation)

Hence, rather than strategic misrepresentation, it seems that optimistic bias among the politicians served as the basis for not accepting the zero-population growth alternative. With respect to the more contemporary aspect of the decision-making process, there is still a strong belief in motorway construction among politicians in North Jutland (Langeland, 2008, p. 194), and there is no doubt that the planning process has mainly been framed around the need for motorway construction as the only proper solution to cope with the forecasted congestion problems. As a former local politician who was part of the political steering committee stated in an interview:

“There is nobody who has taken a position on the fact that none of the alternatives have a particularly high rate of return... Instead, the argument is that a gridlock will arise ... and the only way to solve this problem is to construct a western crossing... you find the numbers that best fit into one’s consciousness... The low rate of return indicates that there are other places in the country where road investments are more needed, but when I raise this issue, I am accused of being hostile towards North Jutland because I don’t attempt to attract investments.” (Interview with municipal politician, 2010; Own translation)

Both at the municipal and regional level, investments in infrastructure are regarded as an important condition for generating economic growth. From the point of view of this growth strategy, the Third Limfjord Crossing is regarded as the most important infrastructure investment (Nordjyllands Amt, 2007). In the decision-making process, motorways have surely been favoured in preference to cheaper alternatives. When the County Council in September 2003 was in the process of passing a resolution about one of the alternative crossings, it was first decided to do so without the highway alternatives, despite these alternatives yielding, according

to the cost-benefit analysis, a higher first year rate of return than the motorway alternatives.¹⁸ This was based on the argument that it would be hard to involve the state economically in a smaller road scheme than a motorway (Wormslev, 2003). I have not, however, had any information indicating that politicians have put any explicit pressure on the forecasting process.

From the above, it can be seen that many different rationales for accepting the neglect of induced traffic were put forward. It cannot, however, be clearly seen from the material which of the rationales is the most important in regard to understanding why this neglect was accepted. Pointing out a single explanation as the primary cause would also inevitably lead to a reduction of the complex mechanisms surrounding acceptance of the practice of neglecting induced traffic. As discussed by Næss (2011) technical, political and organizational explanations are not mutually exclusive but may be entangled; determining the effect of one explanation from another can be difficult. This is particularly true in this case because even though it is also based on the back-stage perspective, the information on processes of transport model-based knowledge production is still rather limited. In the second embedded case, which enjoys more empirical depth, the discussion of the different theoretical perspectives and their interworking will be taken up again.

6.5 The role of the model

Based on the above discussion, it can be argued that the different roles undertaken by the traffic model in the Limfjord case underpin an argument put forth by Henman (2002, p. 163) that:

“the way computer modelling is used in one setting may be ambiguous, and it is this very ambiguity that provides fertile ground for computer modelling as a political technology.”

The manifest function that the model was supposed to undertake in the planning process was to act as a forecasting technology predicting future traffic. However, in spite of the long-standing criticism levelled by transportation researchers, induced traffic and the impact of the quality of the public transport services were not included in the model calculations. As a result, the model contained a system bias, implying that environmental impacts were relatively underestimated. In spite of the misleading result, enquiries into the technical content of the transport model were considered to be beyond the legal control of the Nature Protection Board of Appeal and the model calculations thereby became certified as incontestable truths. In that sense, the model ended up being a form of political technology advocating road construction cloaked as environmental improvement. In the Limfjord case, simultaneously with its manifest, role the model thus served as a “political truth-production technology” reifying the astounding and highly controversial claim: that traffic calming methods and improvement of transit increases transport related environmental impacts, and motorway construction reduces environmental impacts. If this is to be believed, it would almost be environmentally irresponsible not to build the new motorway.

¹⁸ This argument does not indicate that the author regards cost-benefit analyses as a proper decision support tool for infrastructure projects. Cost-benefit analyses contain several in-built biases and contain democratic inadequacies. See Næss (2006b) for an elaborate critique.

6.6 Sum up

The purpose of an EIA is to assess the impact on the environment. When new, high-capacity roads are constructed in urban areas, the consequences in terms of local pollution, noise, traffic accidents, energy consumption and greenhouse gas emissions are some of the most important environmental impacts. Because the model neglected the relationship between increased road capacity and increased car traffic, the EIA on the third Limfjord Crossing arrived at the misleading conclusion that the proposed new motorway connection would result in a reduction of all the aforementioned environmental parameters. In this chapter it was shown that, in spite of such biases, non-inclusion of induced traffic was accepted among key stakeholders. Omission was generally not, however, rationalized in regard to a non-acceptance of an elastic relationship between travel demand and infrastructure supply. Even though one respondent perceived this relation to be negligible, most respondents rationalized non-inclusion of induced traffic with reference to structural constraints. Acceptance of these structural constraints was rationalized on the following grounds: the biases of omitting it were eliminated when comparing build alternatives; and that it was indirectly included in trend projections. Non-inclusion of induced traffic seems to be rationalized, then, in a manner which generates bias towards the no-build alternative. Moreover, despite the Read/Green Alliance's and the professor in urban planning's attempt to de-reify the model assumptions and raise their bias to the discursive consciousness, these efforts did not succeed in re-opening the planning process. System bias meant that the material content of the model became non-political sphere in which the Board of Appeal was not entitled to scrutiny. The model simplifications were accepted, and this was rationalized, in part with to the justification of "This is how we are used to doing things." Acceptance of the simplifications was thus rationalized with reference to the practice being taken for granted. In other words, neglect of induced traffic seemingly constituted a practice which was part of practical consciousness and accepted tacitly.

We leave the case of the Aalborg model and the third Limfjord crossing for now, but we will return to it in Chapter 8. In the following chapter, the concept of induced traffic with respect to the practice of transport project evaluation will be rolled back in history and it will be investigated whether it is "natural" to neglect induced traffic in transport project evaluation practice.

7 A genealogy of induced traffic and transport project evaluation practice

This chapter investigates whether induced traffic has been part of planners' discursive consciousness and evaluation practice historically, and if so, it seeks to show the significance held by induced traffic with respect to transport project evaluation practice. The chapter is structured into three sections, each centring on different periods of time. The first section investigates induced traffic with respect to the assessment of a railway between the cities of Copenhagen and Roskilde conducted in 1840. The second section moves on to investigate transport project appraisal practice in the 1930s. Compared to the first section, the focus here shifts from evaluation of rail to road and from fare to non-toll project evaluation. The case that will be analysed is the first proposal for a national Danish intercity expressway system, proposed by three Danish engineering firms. The third part moves on to the post-war period. As it was in this period that computerized transport models emerged within Danish planning practice, this constitutes a particularly critical moment, with respect to understanding why induced traffic was not included in the structural framework of computerized transport modelling when this practice emerged within Danish planning practice, which is the secondary research question addressed in this chapter.

7.1 From Royal decree to business case

Even though transport project evaluation goes a long way back in history, it has not always been part of transport planning practice. In 1761 when it was decided to construct the first nationwide main road system within the United Monarchy of Denmark, no traffic analysis was conducted beforehand. Instead, the decision was based on a Royal decree, and it was not until 1793 that an overall plan for the construction work was prepared (Jørgensen 2001). It is unknown to me at which precise point in time transport project evaluation emerged within Danish planning practice. However, when construction of the first railways within the United Monarchy of Denmark started to be considered in the 1830s, transport project evaluation was being practiced. Distinct from the national main road system, the first railways within the United Monarchy of Denmark were both constructed and operated by private enterprises (Thestrup 1997). In order to raise private capital to cover the huge construction costs, it was necessary to conduct business cases documenting the financial profitability and in order to estimate revenues, traffic analyses were conducted. The following section will elaborate upon the context as well as the content of the methods used to assess ridership revenues of the first railway section constructed in the Kingdom of Denmark between the cities of Copenhagen and Roskilde. Even though this railroad was the first one to be appraised and constructed within the Kingdom of Denmark it was not the first within the United Monarchy of Denmark. As early as 1832 a railway was evaluated which would run between the cities of Lübeck and Hamburg through the duchies of Holstein, connecting the Baltic Sea and the North Sea., The evaluation took place on the basis of the assertion, among others, that it would generate 100 % induced traffic (Berg 1896, p. 7). The project was, however, highly politically charged. At first, the government opposed the project because it was assumed to be diverting traffic from competing routes crossing the territory of the United Monarchy. This traffic diversion posed a threat to the Monarchy's customs revenues, particularly in regard to the Sound Dues. In order to foil the

English project, the Monarchy considered building a competing line through Holstein and a commission was set up in 1834 to elaborate possible layouts. In 1840, the commission issued its report which, based on traffic analyses, recommended a layout between Kiel and Altona, running mainly through Holstein. In the evaluation of the project, person travel was assumed to almost triple, while goods traffic was estimated to increase by 65% (Berg 1896, pp. 19-20). Besides national-economic issues, the project was also encumbered with nationalistic political issues. The Liberal-nationalist opposition opposed it, and favoured a more northern routing across the more pro-Danish Schleswig. Nevertheless, the track between Kiel and Altona was commissioned by Royal decree in 1840 (Rallis 1992; Thestrup 1997). This decision was not popular within national-liberal circles and fuelled a heated debate about construction of railways within the Kingdom. The accountant Gustav Schram and the secretary Søren Hjort, who respectively became the first managing and technical director of the Zealand Railway Company in 1844, the same year as the Holstein track was commissioned, issued a pamphlet in 1840 titled "Railroad between Copenhagen and Roskilde." The pamphlet contained estimates of revenues and construction costs. As no statistics made up of goods and passenger volumes transported between the two cities existed back then, the revenues were estimated on a rather rudimentary basis. In order to circumvent the problem of data availability, Schram collected data on current goods trafficked between the two cities based on numbers derived from the Western Gateway's statement of consumption taxes paid on most types of goods that were imported from the market towns to Copenhagen. However, contrary to what is taken for granted within contemporary transport planning practice, Schram did not forecast traffic, but based the revenue estimates on current traffic volumes. Yet, due to the improved travel conditions that construction of the railway entailed, he added 50% to his revenue estimates. Inclusion of the 50% was rationalized in the following manner:

We however admit that the route between Copenhagen and Roskilde is not of such a nature, which allows for a considerable increase in traffic. Here you cannot, as in most other rail projects, calculate haulage to the triple size of what is carried on a high road connecting the same points (this calculation has particularly been necessitated in Holstein, in order to produce a tolerable result). The Danish peasant is slow to adopt to something new if the benefit is not immediately felt in his pocket; but as certainly as the charm of novelty will keep the track indemnified in the first years, due a larger amount of travellers from the higher classes, until the peasant learns to realise the benefit in practice, as sure it is that one must expect an increase in the existing, otherwise this railway would be the only one in the world, where everything went on as before, notwithstanding faster and cheaper conveyance. The steamships, the diligences, the horse cabs and many other arrangements here in the country speak in favour of the opposite and any increase will affect the revenues from the railway, ... [...] Yet, the largest increase which can be expected concerns those who travel with diligence, the number of whom might double. Considering all this, we hold with certainty and without in any way making a sanguine calculation, 50% can be added to the calculations of the existing traffic. (Schram & Hjort 1840, p. 5f; Own translation)

All in all, Schram and Hjort calculated the railway's rate of return to be 6.5%. This, they argued, was a conservative estimate. They put it as follows:

“Nobody who in foreign countries have seen the effect of a railway on trade, travel and life in the whole political body of the state, will doubt that in reality this will be far more.” (Schram & Hjort 1840; Own translation)

It is interesting to note that according to the quote, induced traffic has been part of discursive consciousness as far back as the 1800s, and had been observed previously when new transport technologies were introduced. From the above quote it can also be seen that the causality of induced traffic, in accordance with the contemporary conceptualization, was in fact theorized as a result of improvements in the travel conditions, namely in the form of lowered time and monetary costs (generalized cost). Even so-called tourist and ramp-up effects seem to have been part of the discursive consciousness. It is also interesting to note that, contrary to contemporary Danish transport project evaluation practice, it was apparently common to include induced traffic in the evaluation of rail projects at that time. At least, according to the quote, there existed standardized rules of thumb for how to estimate induced traffic within rail appraisals (tripling in haulage). This could indicate that induced traffic was a rather commonly accepted phenomenon within rail project evaluation at that time. This interpretation is also supported by the fact that even though Schram's and Hjort's revenue estimations in general were roughly handled by peers, inclusion of induced traffic does not seem to have been contested (Ursin 1840).

Distinct from the contemporary controversy of whether induced traffic in general signifies a positive or a negative contribution to the evaluation of non-toll transport projects, it seems that induced traffic within the context of preparing the business case only was associated with increases in revenues and hence seems to signify a benefit without costs (e.g. environmental externalities). Yet even though induced traffic was apparently accepted as an empirical phenomenon, it was contested at a shallower level with regard to how it should be included properly within evaluation practice. Schram & Hjort attempted to render the tripling in haulage assumed in the Holstein project as arbitrary and more or less directly accuses it as being an act of strategic misrepresentation. Schram & Hjort had an interest in rendering the Holstein project's calculations as arbitrary. The project was a competitor to the Copenhagen-Roskilde project and Schram was a nationalist who opposed the project on ideological grounds (Rallis 1992; Thestrup 1997). Thus we see that, just as they are now, traffic analyses back then were also conducted within a highly politicized context.

Despite the above empirical evidence shows that in the mid-1800s induced traffic in general was part of planners' discursive consciousness and rail project evaluation practice, it is beyond the scope of this thesis to investigate whether it actually was common practice to include the effect in evaluations of the rail projects, constructed at rapid pace, all over the country in the following century (Thestrup 1997). However, that the present rather than the future served as the base for transport project evaluation practice does not appear to be unique for evaluation of rail projects. In the 1920s the county road surveyors, also used traffic counts to estimate which roads should be expanded and to prioritize between constructions of new roads (Jørgensen 2001, p. 259). To explore whether induced traffic was included in evaluations of new Danish highroad projects established in during the railway era is also beyond the scope of this thesis. However within America road planning practice in the 1920s, induced traffic was, according to Ladd (2012), a known and accepted phenomenon. Here the existence of induced traffic was

perceived to make road constructing unable of solving congestion problems. Yet despite of this recognition road construction was anyhow prevised the desirable.

7.2 From present to future demand

While the previous section investigates induced traffic with respect to rail project evaluation in the mid-1800s within the context of the drawing up of a business case, in this section we will move on to the 1930s and move the focus onto the context of non-toll road projects. This shift in context also involves a shift in the meaning of induced traffic with respect to transport project evaluation. While induced traffic in the previous case signified an increase in monetary revenue, the situation is different for non-toll infrastructure projects. Such projects do not generate any direct revenue and, consequently, induced traffic is not associated with direct monetary benefits or losses. In the following section it will be discussed whether induced traffic was still part of planners' discursive consciousness and evaluation practice within this context, and if so, how the meaning of induced traffic with respect to transport project evaluation was framed within this context of non-toll road projects. The case that will be analysed in this section concerns the first proposals for a nationwide intercity expressway system in Denmark. It was originally proposed by three private Danish engineering firms in 1936. The following year, a revised proposal was issued containing what appears to be one of the first Danish national road traffic forecasts. Besides serving as a foundation for discussing the concept of induced traffic within road project evaluation in 1930s, the case also serves to consider why the focus apparently moved from the present to the future in this case.

Heavily inspired by the motorway plans in Italy and Germany, three Danish engineering firms¹⁹ issued a joint plan in 1936 for a nationwide intercity expressway system with fixed links across the Great Belt and Oresund. It was an extremely ambitious plan. It suggested that the entire intercity expressway system should be constructed within a 10 year period. Except for an Oresund Fixed Link, the intercity expressway system was proposed as a toll-free system, and in the report, the benefit of the project was not argued based on direct revenues but on indirect economic effects such as growth in employment and tourism (Christiani & Nielsen et al 1936). Estimation of traffic was, as with the above Copenhagen-Roskilde case, based on current, rather than future traffic. However, contrary to 1840, official traffic censuses were now available. The newly established Road Laboratory²⁰ (Dansk Vejlaboratorium) had conducted national traffic censuses in 1929 and 1934 (Jørgensen 2001, p 259), and the layout of the intercity expressway system ran parallel with the busiest intercity routes observed in a national traffic census from 1934 (see figure 7.1).

¹⁹ Christiani & Nielsen, Højgaard & Schultz, Kampmann and Kierulff & Saxild

²⁰ The Road Laboratory was established in 1928 as a technical service organism and road research institute.

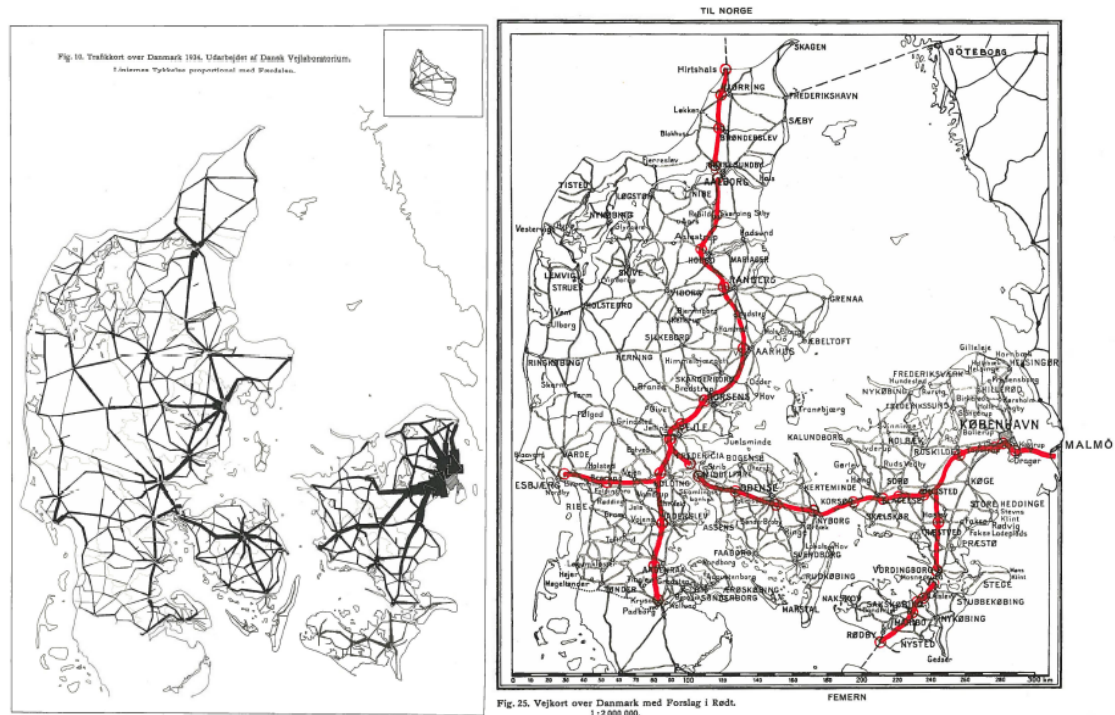


Figure 7.1: On the left: Results from the Road Laboratory’s national traffic census of 1934. On the right: the engineering firms’ proposed layout for a national intercity expressway system (Christiani & Nielsen et al 1936)

The proposal itself actually explicitly argued against forecasting traffic. This was because past experiences with induced traffic resulting from the replacement of ferry services with fixed links had proven it extremely difficult to predict traffic with accuracy. To illustrate the case, the engineering firms referred to the experiences from the opening of the Little Belt Fixed Link in 1935. The traffic analyses prepared for this project grossly underestimated traffic. When the construction bill for a combined road and rail link across Little Belt was approved in 1926, approximately 67,500 motorized vehicles were being shipped across the belt annually. It was then estimated that road traffic would increase to approximately 70,000²¹, in the bridge’s first year of operation. Nevertheless, in the period that followed, traffic grew to unforeseen high rates. In 1934, approximately 200,000 automobiles were being shipped across the belt annually and when the toll-free bridge opened in the following year, the number of motor vehicles crossing the belt increased to approximately 500,000 annually (Christiani & Nielsen et al, 1936, 18-19). In short, in the bridge’s first year of operation, traffic increased by approximately 150%. Adjusted for general traffic growth, induced traffic amounted to approximately 120%²² (Ministeriet for Offentligt Arbejde 1962, p. 92). Induced traffic was, therefore, also part of the discursive consciousness within road planning in the 1930s, and it was also included in a traffic analysis of an Oresund fixed link. This forecast followed a similar pattern as Schram & Hjort’s rail appraisal from 1840, based on current traffic volumes crossing the strait at that time plus an expected amount of induced traffic. However, in contrast to Schram & Hjort’s case, the

²¹ I have not been able to find information about whether this traffic estimation was based on current traffic plus induced traffic, or whether the assumed increase in traffic was due to general traffic growth.

²² The considerable amount of induced traffic generated by the opening of the Little Belt Fixed Link was not unique at this period of time. The Storestrøm Fixed Link opening in 1937 generated induced 210% traffic in its first year of operation. Adjusted for general traffic growth, induced traffic amounted to 150% (Ministeriet for Offentligt Arbejde 1962, p. 92). Just like the Little Belt Fixed Link, the Storestrøm Fixed Link was toll free, whereas a fee had to be paid for the ferry service.

engineering firms' estimation of induced traffic was based on an empirical observation from the opening of the Little Belt Fixed Link as a reference case and not a rudimentary rule of thumb.

In 1937, only a year after the original proposal, the firms issued a revised, less ambitious version of the plan with supplementary comments (Christiani & Nielsen et al. 1937). The revised report contains what appears to be one of the first Danish national traffic forecasts based on a trend projection. A trend projection is conditioned on at least two measurements taken at different moments in time. Unlike the time when the railway between Copenhagen-Roskilde was evaluated, such measurements were now available and the trend projection made by the consultancy firms was based on the traffic censuses of 1929 and 1934. With respect to the overall research question of this thesis, this transformation in transport project evaluation practice is particularly interesting. Accordingly, it will be elaborated upon hereafter as to why the basis of the transport project evaluation evolved from the focus on the present into a focus on the future when the original proposal explicitly argued against forecasting future traffic.

It appears that in order to understand the transformation to the basis of evaluation practice from the present to the future, we must look into the audience and explore how the proposal was received by peers. The proposal was evaluated in the journal of the Danish Road Administration "Dansk Vejtidskrift." Here, the plan was met with non-acceptance from the county road surveyors who evaluated it. The county road surveyors' judgment was that the plan represented a fine piece of projection work but it "*had no grounds in reality*" (Dansk Vejtidskrift 1936, p. 162). In 1935 the Danish car fleet only consisted of approximately 120,000 vehicles (Jørgensen 2002) and according to the county road surveyors, the capacity of the existing roads was sufficient. Therefore, implementation of the proposed intercity expressway system would be an unprofitable way to spend such large sums of money (Dansk Vejtidskrift 1936).

Apparently as a counter-move to the County Road Surveyors' non-acceptance of the engineering firms' original proposal, the firms transformed the rationality which underpinned the second report in order to increase the likelihood of gaining acceptance in a second round. Due to non-acceptance of the current demand, it was necessary to reify future demand. This seems to have been the context of the trend projection²³. The forecast was made for 1948 and showed a doubling in volume and tripling in weight of traffic when compared to 1934 (Christiani & Nielsen et al. 1937, p. 20). The preparation of the forecast was, however, not the only transformation which took place to counter the non-acceptance. Apparently, as a reaction to the criticism concerning the proposal's financial unprofitability, the revised proposal argued that a high quality intercity expressway system, despite the considerable construction costs, would yield such large societal benefits that its implementation would be justified from a socio-economic point of view. In order to reify this claim, a transport economic analysis was presented, and here, the forecast serves as the basis for estimating future socio-economic benefits. Thus we see

²³ This trend projection was drawn up on the following basis. According to the Road Laboratory's national traffic censuses of 1929 and 1934, motorized traffic had increased had in the five period increased by 30%. Based on this trend the average growth rate was estimated to 6% annually. According to the national traffic counting survey from 1934, 200.000.000 vehicle kilometers had been travelled on the main roads, running in parallel to the suggested intercity expressways. This amount of traffic was then projected to 1948 squaring with 330.000.000 vehicle kilometers travelled on the parallel routes. It was then assumed that the intercity expressways would divert approximately one third of this traffic, which equals 110.000.000 vehicle kilometers travelled.

that the non-acceptance of the original proposal on the grounds of monetary unprofitability was countered through a reframing of the concept of benefits in the revised proposal, from growth in employment and tourism to future socio-economic profit. However, as it is stated in the report, calculating the socio-economic profitability was not an easy arithmetical problem to prove. The debit side could, without great difficulty, be calculated in the form of capital investments, but the benefits, which were defined as increased traffic safety, time savings and reduced vehicle operation and maintenance costs, were very difficult to put a monetary value on (Christiani & Nielsen et al, 1937, 10-11). Despite the stated difficulties, an attempt to value future time savings and operation costs was carried out anyway. According to the calculations, the motorway system would reduce maintenance costs by 3 million DKK annually and time savings were estimated at 2.9 million hours per year, amounting to 5.8 million DKK annually. It was stated that the forecasting result was uncertain, but due to the temporary decline in traffic which followed the economic recession around 1932, and the fact that induced traffic was not included in the trend projection, it was more likely to be conservative than optimistic²⁴ (Christiani & Nielsen et al. 1937, pp. 16-20 & 32). Hence, despite induced traffic not signifying monetary revenues, it was, nevertheless, framed as signifying a socio-economic benefit. The transformation from the context of rail project evaluation in the mid-1800s to non-toll road projects in the 1930s did not transform the meaning of induced traffic with respect to transport project evaluation. Within both contexts, underestimation or neglect of induced traffic signified a conservative estimation of benefits.

The revised proposal was also evaluated in the journal "Dansk Vejtidskrift." Despite the engineering firms having framed the benefits in a manner which countered the initial basis for non-acceptance, the attempt to reify the proposal's profitability in the form of future socio-economic benefits did not persuade the County Road Surveyors to accept it in the second round either. The overall judgement of the revised plan was almost identical to the first, namely that:

"Economically, Denmark is unequal to the task of raising capital for superfluous roads which nobody needs" (Dansk Vejtidskrift 1937, p. 262; Own translation).

It does not appear to have been common practice within Danish transport project evaluation practice at the time to assess projects social benefits. In any case, the county road surveyors did not attempt to render the engineering firms' revised framing of benefits as arbitrary. Instead, the assumptions on which the cost-benefit analysis was based were contested. For instance, they problematized the rationale of ascribing monetary values to all forms of time savings (Dansk Vejtidskrift 1937, p. 259).²⁵ However, despite the fact that the county road surveyors did not accept the two proposals' profitability, they did, apparently, accept the engineering firms' inclusion of induced traffic as non-arbitrary. In none of the critical evaluations was induced

²⁴ Traffic did not, however, develop in accordance with the trend projection in the following 10 year period and instead of being conservative as suggested, the forecast turned out to be overestimated. With the outbreak of World War Two, private motoring declined due to the high rise in prices and shortages of gasoline and spares.

²⁵ The engineering firms valued an hour saved in traffic at 2 DKK (Christiani & Nielsen et al. 1937). However, in the 1936 proposal it is stated that an average day wage amount to 10 DKK. The engineering firms hence applied a rather high monetary value of time, which can be interpreted as either optimism bias or strategic misrepresentation.

traffic contested as a casual mechanism or was the magnitude of the estimated effect calculated.

According to Jørgensen (2002) the county road surveyors' motivation to render the engineering firms' proposed intercity expressway system as unacceptable was not only lack of demand. The proposal also constituted an attack on the decentralized organizational structure of the Danish Highway Authority which had prevailed since approval of the road bill of 1867, delegating the authority of the newly completed national highroad system from the state to the counties.²⁶ According to the Road Bill of 1867, the counties would be responsible for the planning, projecting, construction and maintenance of the highroads. The state only maintained a marginal authority and could no longer force through new construction projects (Jørgensen 2001, pp. 159-165). In the engineering firms' revised proposal an explicit attack on the decentralized organizational structure of the Danish Highway Authority was levelled. The report states that in order to ensure coherence in the layout and a uniform technical design standard of the overall motorway network, a centralized State Highway Authority would be needed to head the planning (Christiani & Nielsen et al. 1937, pp. 13-16). The county road surveyors evaluating the plan did not consent to the proposed centralization, delimiting the social capital associated with their structural positions. Instead, they defended the authority tied up to their structural positions within the decentralized organizational structure of the Danish Highway Authority by rendering the motorway proposals non-acceptable (Dansk Vejtidskrift 1937, p. 257). This illustrates Haugaard's argument that non-acceptance of new structuration practices can be related to a desire to maintain the dominating social order (see section 4.1.2). Moreover, as with the studies of Porter (1995) as well as Sager and Ravlum (2005) (see section 4.2.6), this case also shows how non-acceptance generated an amplified need for truth in order to gain acceptance in a second round, resulting in more advanced methods of transport project evaluation being applied. Seemingly, the non-acceptance of the current demand and profitability generated a strategic shift in focus, that is, the consideration of the future demand and the socio-economic benefits, with the object of reifying future demand and the projects profitability in a second round.

7.3 Induced traffic and the large infrastructure schemes of the 1960s

In this section, the focus will be on induced traffic in from the late 1950s to the early 1970s. This is the period where the practice of computerized four-step transport modelling emerged within Danish planning practice. In 1967, the Road Directorate initiated three pilot studies in the cities of Århus, Odense and Kolding²⁷ on the development of urban computerized transportation models. Induced traffic was not included in any of these models, nor in the model initiated the same year, developed by the Regional Planning Council, covering the Greater Copenhagen area.

²⁶ The context of the Road Bill of 1867 was that the parliamentary politicians believed that the railways in the future would become the primary means of long distance travel. In order to free up capital for railway construction, spending cuts with the road sector were desired and the delegation of authority of the highroad system to the counties was a means to do so.

²⁷ To assist in the development of the urban transport models, three consultancy firms were hired. The reason that three different firms were chosen rather than just one was to decentralize the knowhow, in order to facilitate the emergence of a competitive environment between the consultancies (interview Overgaard 2012).

In the second case study, it will be discussed whether induced traffic was included in the first computerized transport model developed within Danish planning practice, which was developed by the Municipality of Copenhagen from 1962-1968. Even though it has been shown previously that induced traffic was part of transport planners' discursive consciousness and evaluation practice in the mid-1800s and the 1930s, this does not mean that it also was at the time, computerized transport models emerged within Danish transport planning practice. This period then, constitutes a particularly critical moment with respect to understanding why a practice emerged where it became accepted not to include induced traffic within the framework of computerized transport models. While the previous case from the 1930s indicated that the competitive balance between road and rail was about to tip, the 1950s-1970s is the period where the transition to a car-based society took place. In general, it was a period marked by great structural transformations both with respect to social and physical spatial structures (Jørgensen 2009).

During the period of time explored in this section, a number of large infrastructure plans were drawn up with the objective of facilitating the transition to the industrial and service-based society. Just after World War Two ended, the Copenhagen Traffic Commission of 1944 was set up with the purpose of preparing an overall traffic plan for the Greater Copenhagen Area. In 1948, a Great Belt Fixed Link Committee was set up (Storebæltskommision 1960a), followed by the establishment of an Oresund Fixed Link Committee in 1954 (Ministeriet for offentlige arbejder 1962). The so-called Traffic Economic Committee was set up in 1955, on the initiative of the Economic Secretariat under the Ministry of Finance. The objective of the Committee was to prepare a coordinated transport infrastructure investment plan for the different transport modes and to fit the following mega projects into the overall plan: a Great Belt fixed link, an Oresund fixed link and the transport infrastructure investments in the Greater Copenhagen Area. In the final report of the committee, it was recommended that 700 km of motorway be constructed during the 20-year investment period and of the three mega projects. The investments in the Copenhagen infrastructure were assigned highest priority (Det Trafikøkonomiske Udvalg 1961). Parallel with the work undertaken by the Traffic Economic Committee, a number of Road Planning Committees were established in 1959, headed by the Road Directorate, with participating top road engineers from the municipalities and counties (Jørgensen 2009). Based on the work of the Road Plan Committees, the Road Directorate issued a report in 1962 and another in 1963 containing proposals for the layout of motorway systems on Jutland and Zealand respectively. In the second embedded case study, it will be shown that the work of these transport committees constituted important contextual factors, which facilitated the emergence of computerized transport modelling within Danish planning. Hereafter, the focus will, however, be on whether induced traffic was still part of the transport planners' discourse consciousness and evaluation practice at the time that computerized transport models emerged within Danish transport planning practice. If this were the case, the meaning which was assigned to the effect of induced traffic will also be discussed. First, it will be investigated whether induced traffic was included in the work of the Great Belt and Oresund Fixed link committees. Next, it will be discussed whether induced traffic was included in a number of non-toll projects from the 1960s. Finally, based on the findings of this chapter, there will be a discussion of different possible explanations for why a practice emerged that had an

inherent discrepancy between discursive consciousness and evaluation with respect to induced traffic.

While induced traffic was estimated in a rudimentary manner in the aforementioned Copenhagen-Roskilde railway case and was estimated based on a reference project in the above motorway case, induced traffic was estimated based on methods of calculation both by the Great Belt and Oresund Fixed Link Committees. In a Danish context, the Great Belt Fixed Link is emblematic with respect to calculating induced traffic. Apparently, the first time that induced traffic was estimated based on computational methods was as part of the work undertaken by the Great Belt Commission which was set up in 1948 and issued its final report in 1960. In the report of the Great Belt Committee, induced traffic is calculated based on the following equation (Storebæltskommision 1960a, p. 28):

$$\text{Induced traffic} = \left(\frac{\text{Travel time before}}{\text{Travel time after}} \right)^2$$

According to calculations presented in these documents, a Great Belt fixed Link would induce 48.5% for road traffic (Storebæltskommision 1960b, p. 39). It is not, however, explained why it can be expected, from a theoretical point of view, that induced traffic should amount to the square (²) of time savings. In that sense, the method appears a bit arbitrary.

The method applied to calculate induced traffic by the Oresund Fixed Link Committee, was more sophisticated than the one used by the Great Belt Committee. In this case, induced traffic was calculated based on a variant of the gravity formula developed in 1955 by the Swedish professor Torsten Åström. The gravity model was based on virtual distance (in the form of time and cost) and also contained the level of car ownership as a parameter influencing trip production (Åström 1955). According to the calculations, a layout between Elsinore and Helsingborg would induce between 50% and 120% traffic, depending on whether the toll fee was assumed to be equal to the price of the ferry ticket or if it was toll-free; a layout between Copenhagen and Malmo was calculated to induce between 100% and 300% traffic (Ministeriet for Offentlig Arbejde 1962, p. 93).

Despite the fact that the work of the Great Belt and the Oresund committees show that induced traffic was still part of discursive consciousness in the 1960s, they are both extreme cases. Whether induced traffic was also considered relevant to include in the evaluation of ordinary non-toll highways and motorway projects will be discussed in the following sections. In fact, induced traffic was not only included in the two large fixed link projects, but also in a number of key motorway and highway reports from the 1960s. For instance, induced traffic was included in the section of the Traffic Economic Committee's final report prepared for the Road Directorate (Det Trafikøkonomiske Udvalg 1961). Here, it is stated that the construction of motorways was assumed to induce 25% traffic due to the resulting increase in travel speed (Det Trafikøkonomiske Udvalg 1961, p. 28). This rule of thumb was apparently accepted within the Road Directorate at that period of time; certainly, it was reproduced in a number of infrastructure plans issued in the 1960s. Based on the work of the Road Plan Committees, the Road Directorate issued a proposal for a nationwide motorway system (the so-called "Big H") in two reports. The first report was issued in 1962 and concerned the layout in Jutland; the second

report from 1963 contained a proposal for a layout in North Zealand. In both of these motorway reports, the rule of thumb of 25% induced traffic was included (Vejdirektoratet 1962a, p. 33 & 39; Vejdirektoratet 1963, p. 18). In the Jutland report, it is also argued that the construction of highways would induce 10% new traffic (Vejdirektoratet 1962a, p. 33 & 39). This rule of thumb of 25% induced traffic was also repeated in an assessment of a new Little Belt Fixed Link (Vejdirektoratet 1961, p. 2) and a new Storstrøm Fixed Link (Vejdirektoratet 1969, p. 51). In the 1960s, induced traffic was clearly still part of planners' discursive consciousness and was also considered relevant to non-toll projects being accounted for in the forecasts.

It does not seem to be particular to Danish planning practice that induced traffic has been part of discursive consciousness and evaluation practice. According to Goodwin (1998), induced traffic was also an accepted phenomenon within British planning practice in the 1930s-1960s. Nevertheless, induced traffic was not included in the framework of four-step computerized transport models developed during this period of time. Knud Rask Overgaard, the first Dane who obtained a PhD in transport modelling, reviewed state-of-the-art literature on transport modelling practice in his thesis in 1964. Overgaard knew the effect of induced traffic, and problematized that induced traffic was neglected in state-of-the-art transport modelling. He put it as follows:

"The trip production, which is determined by an analysis, corresponds not to transport needs, but only for the part that can be made with advantage under the prevailing conditions. In the preparation of forecasts it is important to keep this in mind." (Overgaard 1964, p. 21; Own translation)

At this time, feedback between the steps of the sequential framework had already been included in some models, but none included loopback mechanisms to the first step, trip generation - not even the most advanced model with respect to feedback (Overgaard 1964, p. 18). Overgaard states as follows:

"Despite the fact that the program here [the transport model developed in Toronto] is the most advanced as to allowing overload of streets and car parks to impact on the emerging travel pattern, then trip generation for the different zones is however still determined as if the number trips is independent of traffic conditions. In other words, it is "only" the choice of destinations, traffic and travel route, which are adjusted through iterations ..." (Overgaard 1964, p. 180f; Own translation)

But why was induced traffic not included within computerized four-step transport models developed in this period of time? A possible reason could be that induced traffic was not part of planners' discursive consciousness or at least it was not an accepted phenomenon in the USA, where the framework of the four-step transport model originated. This practice of neglecting induced traffic was then copied together with the framework of the four-step models into Danish planning practice, overriding the previous practice of including it. This does not seem to be a likely explanation. In fact, induced traffic was also part of transport planners' discursive consciousness in America in the 1950s and 1960s. In the Eno Foundation for Highway Traffic

Control's report from 1956 *"Highway Traffic Estimation"* reviewing state-of-the-art transport project evaluation methodology, it is stated as follows:

"It is commonly accepted that each new facility or each improved facility may cause this component [induced traffic] to be created in addition to causing diversion." (Schmidt & Campbell 1956, 146)

As early as 1947, an empirical study on induced traffic was conducted indicating that induced traffic may be as great as 20%-25% (Jorgensen 1947). It appears, however, that only a limited number of empirical studies were available. It is stated as follows in the aforementioned *"Highway Traffic Estimation"*:

"Although a common phenomenon, and often of substantial proportions, little quantitative data are available regarding the amount of traffic induced as a result of adding improved facilities in an urban area." (Schmidt & Campbell 1956, 147)

Despite induced traffic being seemingly a widely accepted phenomenon, it was not the main focus of empirical studies. That said, the American primer on motorway construction *"A Policy of Arterial Highways in Urban Areas"* issued in 1957 by the American Association of State Highway Officials (AASHO), included a chart with different components of induced traffic (see figure 7.2). In accordance with Litman's (2009) framework, the AASHO primer differentiates between long and short term effects of induced traffic, though other terms are used.

Together with the so-called *"Highway Capacity Manual"* from 1950, issued jointly by the Transportation Research Board and the Bureau of Public Roads, the AASHO user manual were the *"Bibles"* within highway planning. Just like the framework of the four-step transportation model, the AASHO primer travelled from the USA around the globe. In fact, the motorway plans drawn up by the Road Directorate in this period of time were, according to Jørgensen (2001, p. 375), heavily inspired by these user manuals, which were also applied by the Municipality of Copenhagen (Lyager 1996). AASHO's chart of induced traffic was also included in Overgaard's PhD thesis and, as a result, it must also have been well known among the early community of transport modellers in Denmark. With respect to the emergence of computerized transport modelling and the associated neglect of induced traffic, it appears that there is a discrepancy between planners' discursive consciousness and evaluation practice.

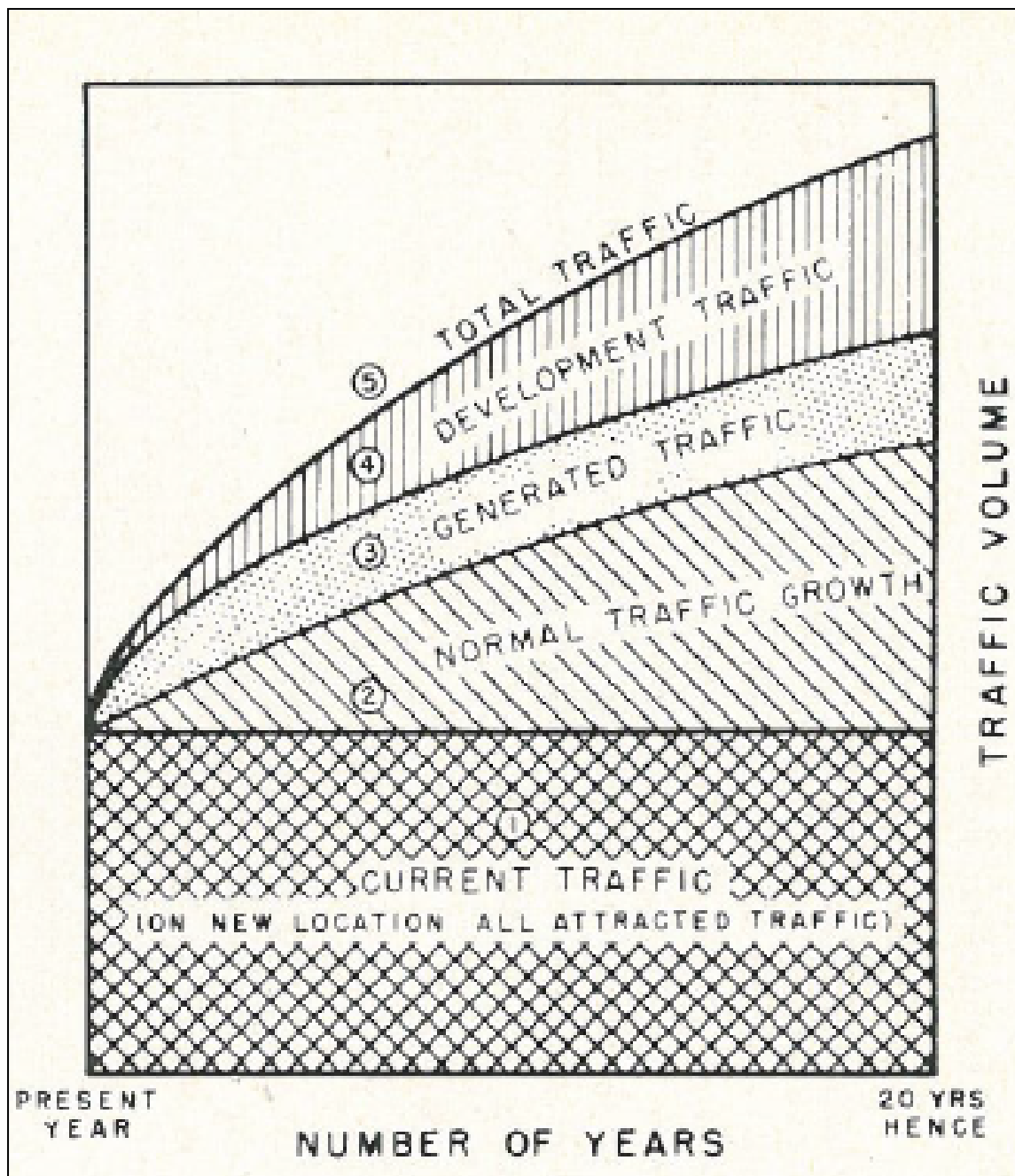


Figure 7.2: Components of future traffic. Current traffic (1) consists of existing and diverted traffic. Normal traffic growth occurs due to increased volume and usages of automobiles. Generated traffic (3) is new traffic which would not have occurred without improved traffic condition. According to the manual, generated traffic develops within 1-2 years and induces between 5%-30% of current traffic. It is, however, stated that in cases where ordinary roads are upgraded to major roads, the short term effect of induced traffic can be weak and may be ignored. On the other hand, if a road serves as a feeder to an expressway with ample capacity, the amount of induced traffic generated on the feeder road may square to the amount of induced traffic generated by the expressway itself. Development traffic (4) results from the development of land which would not have taken place if accessibility had not been improved. Development traffic often constitutes one of the larger components of future traffic after 10-25 years (AASH 1957, pp. 107ff)

When induced traffic, both in the USA and in Demark, was part of discursive consciousness in the period of the 1950s-1970s, why was this meaning not then inscribed into the technical structure of standard computerized four-step models? Was there a discrepancy between discursive consciousness and evaluation practice because induced traffic now signified a cost with respect to transport project evaluation and was neglected as an act of strategic

misrepresentation in order to promote road construction? Or did induced traffic still signify a benefit in accordance with the view held in the mid-1840s and the 1930s?

This will be elaborated upon based on the Road directorate's Jutland reports from 1962 (Vejdirektoratet 1962a; 1962b). In this report, two alternative layouts for a main north-southbound thoroughfare were evaluated against each other. One was proposed by the Road Directorate, and the other was proposed by a Professor in geography at Århus University, Johannes Humlum. The Road Directorate's proposed layout closely resembled the engineering firms' proposal from the 1930s with the main Jutlandic thoroughfare following an eastern line, where the larger cities are located. Hence, despite the engineering firms' intercity expressway proposal not being accepted in the 1930s, it was apparently accepted on a cognitive level within Danish planning practice. Humlum, however, contested this proposal, and proposed an alternative layout running along the Central Jutlandic ridge. Humlum's proposal should be seen within the context of the national planning discussions going on at the time about which the so-called National Planning Committee was elaborating a detailed statement. Humlum advocated a decentralized national planning model, and his proposed layout was supposed to promote the construction of new industrial centres and urban areas in proximity to the motorways, thereby facilitating a more decentralized national development (see figure 7.3).

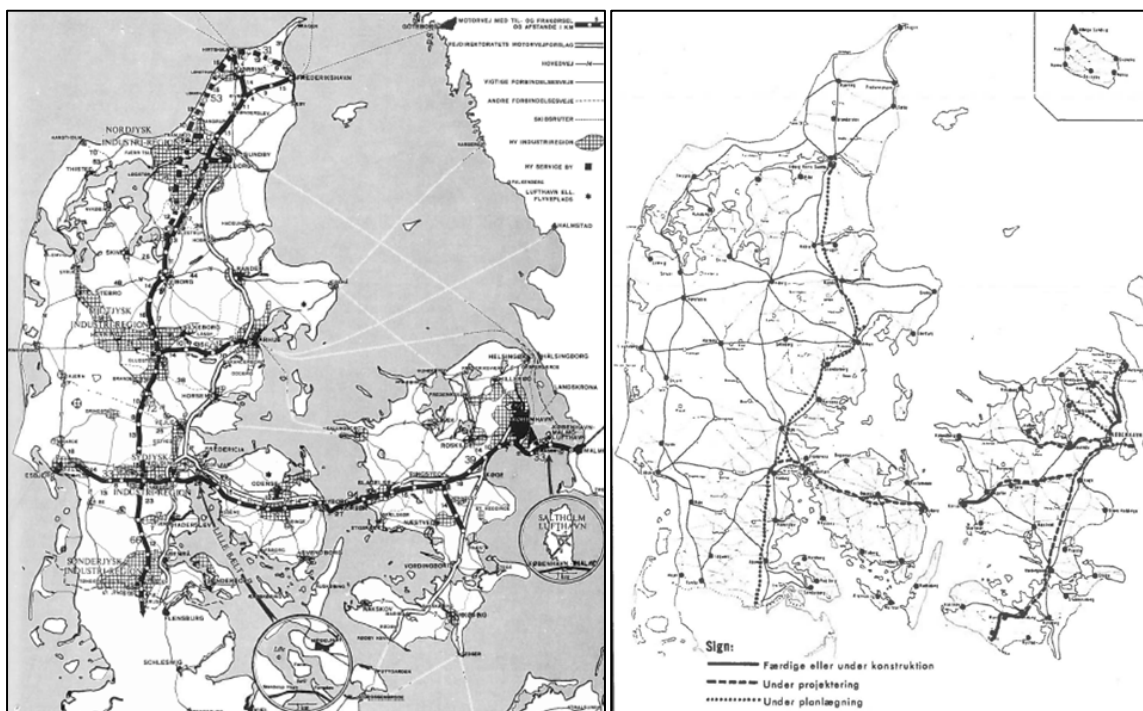


Figure 7.3: On the left: Humlum's motorway proposal (Humlum 1966, p. 191). On the right, the Road Directorate "Big H" proposal (Milner 1962, p. 863)

In the discussion of the Road Directorate's proposal against Humlum's proposal, it becomes evident that induced traffic signified increased economic activity. In the Jutland report it is stated as follows:

"Experience shows that traffic improvements, for example, the reduced travel time, which may result from the construction of larger bridges, create the opportunity for travel and transport which would not have been carried out

under the previous conditions, now to be carried out. This is likely also to apply to traffic improvements as a result of motorway construction. The motorway can thus be said to create ("generate") new traffic. This generated traffic [induced traffic] is, of course, a token that the business or touristic activity in the area increases. It is particularly difficult to say in advance something general about such wider economic effects. When the motorway runs to nearby cities, you may see a growth of industrial and other business enterprises on both sides of the motorway line. Part of this growth can be companies moving out from the city centre, and part, newly established industry. On the other hand, there exists, as far as is known, no examples of a motorway running through sparsely populated areas far from cities, ports or the like, which in itself was sufficient to make the upbringing of new industrial or other areas etc. of greater significance along the line." (Vejdirektoratet 1962a, p. 8; Own translation)

Here we see that even though it is argued that road construction does not in and of itself create economic growth but can only facilitate economic growth (and thereby implicitly de-reifies the theory of Humlum's new industrial and urban development areas), induced traffic was framed as signifying increased economic activity and was hence framed as beneficial.

Moreover, even though the cost-benefit analysis was not yet institutionalized within Danish transport planning practice in the early 1960s, a rough transport economic estimate was prepared. In that respect, the following is stated:

"In the choice [between motorways and four-lane highways] it must also be considered that due to the better and faster road communication that a motorway is, it must be expected to create a not insignificant number of completely new trips, which would not have taken place under worse traffic conditions. The societal value of these trips must be less per vehicle kilometre than the value of the improved travel conditions for the existing traffic, but it must, however, be assumed to be positive and thus to the benefit of the motorway system." (Vejdirektoratet 1962b, bilag 2; Own translation)

From this it can be seen that induced traffic signified a positive socio-economic contribution with respect to the evaluation of intercity expressways. In fact, induced traffic constituted an argument for road construction and not against road construction.

Denmark does not seem to constitute a particular case when it comes to framing induced traffic as a positive effect with respect to transport project evaluation. In fact, despite the fact that induced traffic was not directly included in the first cost-benefit analyses conducted within road planning in Great Britain, the M1 motorway between London and Birmingham was, based on the American experience, estimated to induce a traffic growth of 30%. It is stated as follows:

"This extra traffic, in so far as it is carried on the motorway, will give rise to virtually no extra cost in road congestion but, in so far as it is carried on old roads, there may be some increase in costs to vehicles remaining there. The extra total traffic will affect accident costs adversely, and congestion will be

somewhat increased on roads leading to the motorway.” (Cobum, Beesley & Reynolds 1960, p. 60).

Despite only a half-benefit being assigned to the induced traffic, it was argued that the calculated first year rate of return was a conservative one because the benefits of induced traffic were not included. If it had been included it would have increased the net benefits by 17%-39% depending on the alternatives (Cobum, Beesley & Reynolds 1960, p. 60f). Yet despite induced traffic in this case being framed as beneficial, it does not imply that induced traffic solely signified a benefit in the 1960s - at least not in Britain. Michael Beesley issued a paper in 1963, together with two colleagues, criticizing a number of early American and British transportation studies for not including second round effects as they termed induced traffic. In their critique, the concern was not that the benefits were underestimated due to the neglect, but rather that time benefits were overestimated. They put it as follows:

“New roads, particularly expressways, generate new demands - supply creates demand. Additional traffic slows down predicted traffic, incurring costs and reducing benefits to road users.” (Beesley, Blackburn & Foster 1963, p. 248)

Louis Mumford also problematized induced traffic and used the phenomenon as a case against road construction, as early as 1958. He put it as follows:

“In order to overcome the fatal stagnation of traffic in and around our cities, our highway engineers have come up with a remedy that actually expands the evil it is meant to overcome. They create new expressways to serve cities that are already overcrowded within, thus tempting people who had been using public transportation to reach the urban centres to use these new private facilities. Almost before the first day's tolls on these expressways have been counted, the new roads themselves are overcrowded. So a clamour arises to create other similar arteries and to provide more parking garages in the centre of our metropolises; and the generous provision of these facilities expands the cycle of congestion, without any promise of relief until that terminal point when all the business and industry that originally gave rise to the congestion move out of the city, to escape strangulation, leaving a waste of expressways and garages behind them. This is pyramid building with a vengeance: a tomb of concrete roads and ramps covering the dead corpse of a city.” (Mumford 1964 [1958], p. 180)

Even though Beesley, in contrast to the Road Directorate, conceptualizes the effect of induced traffic as a cost with respect to transport project evaluation, this does not necessarily represent a conflict of meaning. There are, of course, substantial differences in the context to which these two different meanings relate. Beesley and his colleagues refer to the context of central London while the Road Directorate refers to the context of a Danish intercity expressway. We cannot conclude that the meaning of induced traffic was contested even though it was expressed differently within the context of Britain and Denmark. While induced traffic was seen as beneficial with respect to promoting road construction, it does not seem likely that induced traffic was omitted within Danish planning practice because it was inconvenient with respect to an objective of promoting road construction. This statement is, however, premature. Previously,

the meaning of induced traffic has been investigated only in an inter-city context and not an urban one, as referred to by Beesley. The urban context will be analysed in the second embedded case.

But if induced traffic was framed as a benefit, why then was this effect not included within the technical structure of the standard computerized four-step transport models developed in the 1950s and onwards?

An additional cause seems relevant for understanding the neglect of induced traffic within Danish planning practice. According to Knud Rask Overgaard, the reason induced traffic was not included in the early computerized four-step transport models, despite holding a place in discursive consciousness, was due to a lack of knowledge of how to model it. He put it as follows:

“We used an externally defined car ownership, based on the assumed economic development. When we assumed that GDP increased by 3% per year - there are a lot of things contributing to that 3% increase in car traffic. One of the things which cause the 3% increase is that we continuously have improved the roads. There have been a lot of things which meshed, and we did not know the causation well enough to be able to manage it in the model.” [...] “We did not have enough knowledge to be able to make a reasonable assessment of how much induced traffic meant, nor to distinguish it from the other effects. Typically, we made some car ownership forecasts, e.g. showing that car ownership increased from 200 passenger cars per 1000 inhabitants to 275 passenger cars within 10-15 years. How much of the 275 cars were in reality due to increased affluence and how much was due to improvements in the road network? I think that we might have done some double-counting if we had included induced traffic as an individual effect on top of the other effects.”
(interview with Overgaard 2012, Own translation)

In order to include induced traffic within the framework of transport models, it was, according to Overgaard, not enough to know that road improvements induce traffic. A much more detailed knowledge about the causality was needed in order to include it properly. Lack of knowledge hence served as structural constraints for including induced traffic. It is also interesting to note that because induced traffic was perceived to be partly contained in projected traffic growth, acceptance of omitting it, as an individual effect, was rationalized by avoidance of bias due to double counting. The unintended effect of this acceptance is however that a new bias was generated when comparing build alternatives with no-build alternatives. This illustrates the importance of Næss’ (2011) argument about the importance of paying attention to bias in the non-build alternative. It moreover underpins an alternative hypothesis advanced by Næss et al (2013), which links omission of induced traffic with the predict and provide paradigm. This will be elaborated on in section 13.2.3.

7.4 Sum up

In this chapter it has been shown that the reason why induced traffic was not included in the structural framework of computerized transport modelling when this practice emerged was

neither because induced traffic was not part of planners' discursive consciousness nor because it was not an accepted phenomenon. In fact, induced traffic has been part of transport planners' discursive consciousness, dating back to before the mid-1800s and was still evident in the 1960s when computerized transport models emerged within Danish transport planning practice. Moreover, because induced traffic was shown to constitute an argument for road construction and not against road construction, it does not seem likely that induced traffic was neglected from the structural framework of computerized transport models based on a rationale of road advocacy. Based on the above, the most likely explanations for why induced traffic was not included in standard computerized four-step transport models applied within Danish planning practices in the 1960s, seem to be a combination of a lack of knowledge about how to model it, and in addition, that non-inclusion of induced traffic was seen as a conservative practice with respect to the evaluation of project benefits. The contexts investigated in this chapter, however, were all related to an intercity and not an urban situation. In urban contexts where congestion levels are higher, induced traffic is more likely to signify a cost. This then, does not provide a firm ground for generalizing that induced traffic signified a benefit independent of context. In order to gain a more complete picture, the second embedded case directs the focus to the urban context and investigates the meaning of induced traffic here, among other issues.

8 Towards a sustainable transport policy

In the period scrutinized above, transport model results were primarily used as a base for designing infrastructure projects as inputs for financial and socioeconomic feasibility studies. This chapter explores the period from the early 1970s to the late 1990s. During this period, the environmental agenda and the political objectives of limiting car traffic and changing the modal split in urban areas towards public transit and non-motorized travel became much more prominent. This implies that in order to make a valid assessment of the difference in environmental and health impacts between build alternatives and the non-build alternatives, it became increasingly relevant to account for the effect of induced traffic. On that ground, this chapter analyses how transport modelling practice transformed as a reaction to increased prominence of environmental and health concerns on the transport political agenda. In this chapter, we will return to the Aalborg model and the Third Limfjord Crossing, which is used as the main case for exploring the secondary research question, namely: *How did transport modelling practice transform as a reaction towards increased prominence of environmental and health concerns on the transport political agenda?*

The chapter is structured as follows. The objectives of developing a computerized transport model for Aalborg and the process of developing it are explained first. Next, the context in which the model was first put to use is explored. Hereafter, the use of the model to single out a land reservation for a 3rd Limfjord crossing is investigated, followed by the transformations in the transport political discourse which occurred in the late 1980s/early 1990s and an exploration of how these transformations influenced the prevailing transport political objectives and transport project evaluation procedures of that period. At this point, the focus returns to the Aalborg-model and the case of the 3rd Limfjord Crossing to analyse how this transformation in the political objectives shaped the technical content of the Aalborg-model. Next, how the transformation in the transport political discourse shaped transport modelling practice in regard to the wider Danish context is explored. Lastly, an answer to the secondary research question is drawn in the conclusion.

8.1 Development of a computerized transport model for Aalborg

The period analysed in this chapter starts at roughly the same time the second embedded case ends. In the second case study, it will be shown that the large urban road construction schemes of the 1950s and 1960s started to be problematized in the late 1960s, when urban traffic started to be framed as undesirable due to its devastating effects on the urban environment, particularly in respect to noise and safety impacts. It will also be shown that transport model results were increasingly met with non-acceptance by project opponents, particularly because noise effects were not accounted for. In fact, inclusion of noise was facilitated by a reaction towards non-acceptance by project opponents.

It is within the context of this new planning and transport political discourse that the development of Aalborg's first computerized transport model was situated. As mentioned, the idea of ensuring a land reservation for a third Limfjord crossing had emerged during the preparatory work on the tunnel in the early 1960s. After 1965, the work stood idle for some years, but it was resumed based on local initiative in 1971 (see Chapter 6). In order to push work

on the plan forward, the consultancy firm which had conducted the pilot study on urban transport modelling in Odense, Anders Nyvig A/S, was approached and asked if it would undertake the task of preparing a comprehensive transportation study, traffic forecast and a road-plan for the Aalborg area. The purpose of developing the traffic model for Aalborg was, in addition to assessing a Western Limfjord Crossing, to assist in the explanation of a road-plan for Aalborg and the on-going master planning (Nyvig 1972a). The consultancy firm accepted the offer. Although the model was prepared before the first oil crisis broke out in 1973, it was required that the model be capable of reflecting the change in transport political discourse from road construction in the 1960s towards a more balanced transport system in the 1970s. It is stated as follows in a background report:

“With the ever-increasing car traffic ... and the disadvantages it has caused, not least in the central parts of cities, we have now realized that an unlimited use of cars may not be permitted, and that we must choose other transport policy objectives including, inter alia, improvement of the transit network and the restriction of the use of the car in the central urban areas, through parking restrictions, etc. With this change in the attitude towards private cars, a modified perception of which tasks traffic models must solve needs inevitably to follow. Today, they should not simply be used to provide the basis for dimensioning of networks and to the cost-benefit calculations for these, but also to evaluate the implications of the choice of different transport policy objectives. The models should therefore be able to provide answers to questions of the type: what will happen to traffic’s distribution on destinations and means of transport if you invest a certain amount in improving the collective transport network? How should this amount be invested so as to achieve the greatest effectiveness? What will the impact be of prohibiting long-term parking in the inner city? etc. In some cases, the consequences range so far that they have influence on the urban policy that must be pursued.” (Nyvig A/S 1973a, p. 5; Own translation)

Hence, the changes in transport political objectives (a contextual factor) demanded that the technical content of transport models be designed accordingly. As stated in the quote, computerized transport models were assigned a new meaning here in the early 1970s, and in order to provide more relevant decision support, the model was now envisioned to undertake an explorative role in the planning process. In that sense, it can be argued that the model should contribute to raising consciousness about the possible impacts of different means in respect to transport political objectives. In order to reflect the shift in transport political objectives from primarily cars to a more balanced transport system, the modal split model was given a central position within the sequential order of the model structure. As it is stated in the report:

“Although the traffic models to be used for this type of study, in principle, are structured in the same way as those hitherto used, the interest in the model must, of course, be concentrated on other sub-models than in the past. Sub-models, which describe the circumstances for which we want to examine the consequences, should particularly be in focus. With the increased interest in transit, this means, inter alia, that we should try to let the modal split model come

to take a more central position in the modelling complex than hitherto.” (Nyvig A/S 1973a, p. 5; Own translation)

The computerized transport model was structured as a sequential four-step type. However, the model structure which today seems more or less standard, with the individual steps ordered according to trip generation, trip distribution, modal split and assignment, was considered too complex. Instead a trip-end modal-split model was chosen, with modal split composed before trip distribution (see section 2.1.2). This model structure is capable of reflecting how household characteristics influence mode choice, but incapable of reflecting transport facilities' and journey characteristics' influence, which was one of model requirements. An attempt was made to circumvent this limitation by developing an accessibility index for each residential zone, expressing the relationship between the quality of private car and public transport. If the transit system was improved, the index would go up, and vice versa (Nyvig as1973b, p. 13). In this way, characteristics of the transport facilities were captured in the modal split model, but characteristics of the journey were not. The accessibility index did not, however, function as planned, and it was agreed to use a more simplified method and to postpone the investigations necessary for establishing the more advanced model (Nyvig A/S 1973b, p. 23). Also, other elements of the model rested on simplified assumptions. The assignment model was based on the principle of all or nothing, without capacity restraints (Nyvig A/S 1973c, p. 9). The model structure was based on a fixed trip matrix, which was standard practice for four-step models of that time (Bates 2007). Hence, several of the models' characteristics corresponded with a predict-and-provide rationality and were unsuitable for reflecting effects of induced traffic, in spite of these effects being relevant for assessing the new transport political objectives. In that sense, it can be argued that the new transport political discourse was unsuccessfully inscribed into the model structure. We will return to this below. The modified requirements of traffic model capabilities due to changes in the transport political discourse did not only imply that transport model calculations now should be able to answer “what if” questions, but the model output was also to be used as inputs for a number of environmental impact models.

Although there was an emphasis on the modal split model in Aalborg in order to reflect the new transport political objectives in the 1970s, transport planning in this decade was characterized by sectorial rather than cross-sectorial planning. This lack of cross-sectorial planning was also manifested in some of the transport models developed this decade. For instance, both DSB and the Road Directorate developed nationwide uni-modal transport models independently of each other (Transportrådet 1993; Vejdirektoratet & COWI 1974). Also, the regional transport models developed in this decade were uni-modal, only accounting for private motorization. In accordance with the pilot studies on urban transportation models, the Road Directorate also promoted a pilot study on development of regional transport models for the counties of North Jutland, Århus and South Jutland (Vejdirektoratet 1977). Distinctively, the models developed as part of the pilot studies on urban transportation models in the late 1960s were all multi-modal, except for that from Kolding.²⁸ Hence, even though environmental impacts were given more

²⁸In both the urban and regional pilot studies, the Road Directorate contributed the major part of the funding. Also, in Aalborg, the Road Directorate contributed half of the funding and the local authorities the other half. The Road Directorate hence played a large role in and was pushing for the institutionalization of computerized transport models within Danish planning practice.

concern in 1970s, models incapable of reflecting the environmental impacts stemming from mode shift were still commonly used.

In accordance with the computerized transport models developed for Århus, Odense and Kolding, as well as the model developed for the Greater Copenhagen area under the management of the Regional Planning Council in the late 1960s, the Aalborg model did not account for induced traffic. This was not because induced traffic was no longer part of planners' discursive consciousness in the 1970s; in fact, the first Danish computerized transport models which deliberately accounted for induced traffic were developed in this decade in order to assess traffic impacts of the Great Belt Fixed Link in the 1970s (Andersen1976).²⁹ While several environmental impacts were put on the policy agenda, induced traffic still appears to signify mainly socioeconomic benefits. In the Road Directorate's cost-benefit user manual from 1974, the rule of a half is put forward in order to estimate benefits of the new traffic users, but it stated that one should be careful not to double-count benefits related to induced traffic because it is strongly related to other benefits in the form of: 1) Stimulation of economic growth in the area, 2) Greater choice with respect to localization of homes and businesses, 3) Cost changes for private investment, and 4) Income distributive effects (Vejdirektoratet 1974). However, in the end of the second embedded case study, it will be shown that induced traffic was actually starting to be problematized and met with non-acceptance in the late 1960s, not on socioeconomic grounds, but rather because increased car volumes within the inner city areas were found undesirable. I have not, however, come across any mentioning of induced traffic in respect to the Aalborg case from this period of time. It is therefore unknown to me whether induced traffic was primarily perceived to signify a benefit, a cost or both.

8.2 The Dag Hammarskjöld breakthrough street

In this section, we will briefly elaborate on the role of the model with respect to the drawing up of a road plan for Aalborg. Above, it was claimed that the model was assigned meaning as a consciousness-raising technology regarding the implications of different policy means in respect to providing guidance on fulfilment of transport political objectives. The model, however, contained technical properties corresponding with a predict-and-provide rationality, making it ill-suited for providing valid decision support. Yet, the first results the model produced were taken up within a predict-and-prevent approach to planning and used to de-reify the desirability of road construction within the city core.

In the 1960s, Aalborg had drawn up a plan aiming to increase accessibility of the city centre. This plan included a breakthrough street, the so-called Dag Hammarskjöld Street, running through one of the historical parts of the town. The Municipality had obtained subvention from the road reimbursement fund for the southern and northern ends and had submitted an application for the middle part. However, in 1972, the road reimbursement scheme was abolished and the application was declined. Nevertheless, the local politicians still favoured the completion of the breakthrough street, but due to its devastating effects on the urban environment, there was a growing scepticism towards the project among the rank and file planners in the Road

²⁹ Andersen (1976) developed an equilibrium model for a Great Belt Link, which included induced traffic. He tested it against DSB's sequential model, based on a growth factor approach, which could also calculate the effect of induced traffic resulting from the establishment of a Great Belt Fixed Link.

Department (Flyvbjerg 1991). As a result, there was a great interest in using the computerized transport model to test the traffic impacts of Dag Hammarskjöld Street. On that ground, alternative road networks were drawn up for 1977 and 1990 with and without the link. In 1973, the results were available and showed that implementation of the Dag Hammarskjöld Street would only cause small changes in loads on the other parts of the road network (see section 8.1). According to the calculations, the breakthrough street was hence not vital (Nyvig 1973d;e;f).



Figure 8.1: Traffic calculations for the inner city road system, both with (to the left) and without (to the right) the Dag Hammarskjöld Street breakthrough, 1990 (Nyvig A/S 1973e)

These first calculations only concerned traffic, though more detailed calculations were subsequently conducted, including modelling of safety and noise impacts. The new results were presented in a report elaborating the impacts of the Dag Hammarskjöld Street breakthrough, concluding with an advice against its implementation. According to Flyvbjerg (1991), the report was first met with opposition and attempts of de-reification, but managed to gain political acceptance in the end. We can see that in this case, despite the model being based on simplified assumptions biased towards road construction, the model still took part in reifying the advantages of not implementing the breakthrough street. Hence, although the model structure was tied up to predict-and-provide, the model results were taken up within a predict-and-prevent interpretation horizon. In this case, the new planning discourse about protection of the inner city was successful in both its attempt to challenge the prevailing order and in rendering the rationality underpinning the Dag Hammarskjöld breakthrough Street unacceptable. But, despite this new planning discourse gaining victory in the inner city, the conventional approach of the 1960s still stood firm in the urban outskirts, and here, the transport model reinforced the conventional approach. This will be elaborated on in the following, where we return to the role of the transport model in respect to the planning of a third Limfjord crossing.

8.3 Adoption of land reservations for a Lindholm Line

In the period of 1975-78, the transport model was used to make more detailed investigations of the Lindholm and the Rail Bridge alternatives. Based on the model results, the committee issued a report recommending that land reservations be made for a third Limfjord Crossing in the Lindholm Line. This recommendation was subsequently adopted into the Municipal plan. Many citizens residing in the most affected areas, however, perceived the land reservation to be unacceptable, and it was therefore met with vehement protests (Harder 1989). Due to non-

acceptance among the general public, the committee agreed to reopen the case. During the 1980s, additional investigations were carried out, confirming that the Lindholm line was the most optimal (Aalborg Kommune 1986). In 1989, at a public meeting in the Engineer Association, a professor in traffic engineering attempted to de-reify the model assumptions by criticizing the data and the formation of the basis of the model for being outdated (Aalborg Stiftstidende, 1989a). At the meeting, the City Engineer of the Aalborg Municipality declared that due to great uncertainties about the base of the decision material, the Municipal Road Department was willing to start from scratch and reinvestigate all previously considered alternatives. This was also accepted by the Municipality of Aalborg and the County (Aalborg Stiftstidende 1989b). It was a great victory for the opponents of the Lindholm Line. A citizen from the residential area of Aalborg Vestby expressed his view on the case as follows:

“The debate about the third Limfjord crossing has been long and extensive.... We think that it would be insane to destroy our urban environment and our, and for that matter, the whole city’s, recreational areas [...]. In the debate, we have been very critical of numbers and statistics that our opponent in the debate, the Road-department of Aalborg Municipality, has displayed. The officials of Aalborg Municipality have ‘proven’ that a new crossing in any rational manner could not be located other places than behind the church of Vesterkæret. But now, wiser counsels prevail. Our arguments have made an impression. ... Our scepticism towards the ‘experts’ behind traffic forecast has been strongly supported. ... The technical basis for the traffic counts and forecasts was encumbered with a number of shortcomings. The used traffic model was primitive and therefore not suited to giving a realistic picture of future traffic volumes. The model is based on an outdated urban structure. ... Surveys must start afresh in a more comprehensive manner. ... There must be conducted traffic counts, interviews, etc., to provide the material for a new traffic forecast, that this time must be drawn up in a scientifically sound manner.” (Aalborg Stiftstidende 1989c; Own translation)

From this, it appears that the model output had been previously presented as truth claims toward which the opponents were sceptical, but due to the technical character of these truth claims, they did not have the expertise to transform scepticism into de-reification. However, now that the basis of the model was de-reified on technical grounds, the opponents among the general public started to build their objections around this scientific critique and thus argued that the results were unacceptable. As we saw above, the professor’s de-reification of model base and the non-acceptance among the general public were successful in re-politicizing the planning of a third Limfjord Crossing, as well as the technical content of the model. Before elaborating on how the technical content of the transport model was transformed due to the re-politicization of the planning process, we will zoom out again and discuss how a new shift in transport political discourse occurred around this time.

8.4 Towards a sustainable transport policy

It was particularly in respect to in the inner city that the new environmental agenda obtained a more central position within the transport political discourse in the 1970s. In the late 1980s and early 1990s, a new transport political discourse started to emerge, putting more emphasis on

integrating transport and environmental policies (Tengström 1999). During this period, the environmental agenda also expanded compared to the 1970s. The focus was now not only centred around protecting the urban environment, but to an increasing extent, the natural environment. This new transport political discourse also transformed into new transport political objectives.

In 1988, taking a point of departure in the Brundtland Commission's report "A sustainable future," the Danish government issued a plan of action for environment and development, in which targets for CO₂ reductions, among other things, were explicitly announced. The objective was to stabilize the overall level of CO₂ emissions at 2000 at the level of 1988, combined with a 20% decrease before 2005 and a 50% reduction before 2020-2040 (Statsministeriet 1988). In respect to the transport sector, a more specific elucidation was conducted in 1990, namely the so-called Transport Action Plan for Environment and Development. In this plan, quantitative objectives for reduction of the transport sector's environmental impacts were specified for the first time. The following objectives were formulated with 1988 as a base year (Trafikministeriet 1990; p. 31-32).

- Stabilization of energy use and CO₂ emissions before 2005. This objective was combined with a long-term objective, concerning 25% CO₂ reduction by 2030, compared to the level of 1988. The CO₂ reduction target for the transport sector was hence lower than the reduction target for society as a whole.
- Reduction of NO_x by 40% before 2000, with a 60% decrease before 2010.
- Halving of particulate matter emission in urban areas before 2010 and further reduction before 2030
- Reduction of dwellings affected by noise levels above 65 dB to less than 100.000 by 2010

In 1992, a new government came into office. As a follow-up on the transport plan of action for environment and development from 1990, a new traffic plan, "Traffic 2005," was issued in 1993, largely maintaining the reduction targets for traffic-related environmental impact (Trafikministeriet 1993, p. 76). In the report, it is also emphasized that existing transport project evaluation methods had to transform in a manner reflecting the new transport political concerns. It is stated as follows:

"The existing methods for prioritizing traffic projects from socioeconomic and environmental standpoints, as well as safety efficiency criteria, should be further developed and disseminated so as to achieve a general acceptance of the applicability of the methods in the transport political discussion. The intention is that the analyses, in the long-term, should not only be used to prioritize between projects in a sector but also to serve as a basis for assessments across the transport sector" (Trafikministeriet 1993, p. 15; Own translation)

It can hence be seen that the new transport political discourse was transformed into a statement about increased emphasis on multi-modal transport modelling. In addition to a desire to transform transport modelling capabilities, the new transport political discourse also translated into increased emphasis on impact modelling. In order to support the municipalities in drawing up local action plans dealing with traffic and environment as central themes, the Plan

Agency (Planstyrelsen) under the Ministry of Environment issued the report *"Environment and traffic in the municipality planning"* in 1992 (Planstyrelsen 1992), following up on the national transport action plans. This report laid forward calculating procedures for assessing the environmental impacts for which national reduction targets had been set. In the following, it will be analysed how these new requirements for transport and impact modelling, reflecting the transport political discourse, came to influence the transport modelling approach taken on in the Limfjord case.

8.5 Reassessment of a third Limfjord crossing

Due to the reopening of the planning process, the Municipality, the County and the Road Directorate started to prepare an assessment programme for alternative crossings. However, in the fall of 1990, the Ministry of Traffic demanded that the Road Directorate resign from further investigations. The reason was that the project was considered to have too local of a charter; only 7% of the traffic volume was long-distance traffic. Seemingly, there was also another reason why the Ministry of Traffic did not accept a role. At this time, the national planning discourse had transformed from focusing on a balanced regional development to valuing growth centres and centralization. Distinct from the balanced development discourse, the North Jutlandic Motorways, agreed in bargaining of the Great Belt Fixed Link, were within this new competitive planning discourse, increasingly perceived as unprofitable and emblematic of transport political "horse trading" (Simonsen 2004). As a head of department in the Ministry of Traffic stated:

"When we back out now, it is not to create some false hope that we will contribute to financing another crossing.... We already have plenty to do in Northern Jutland with two motorways and New Nibevej. We would like to signal that the State does not have unlimited resources." (Aalborg Stiftstidende 1990; Own translation)

In spite of the withdrawal of the Road Directorate, the County and the Municipality found that there was an urgent need to clarify the issue on a third Limfjord crossing and decided to conduct further investigations on their own. It was further decided that the new investigations should put more emphasis on environmental issues than the studies conducted in 1975-1978. This was one of the reasons why the City Council agreed to reopen the planning process; another reason was the new EIA requirements. The Municipality and the County drew up an assessment programme, dividing the further investigations into two phases. In the first phase, the effort would concentrate on assessing several alternatives in respect to traffic, environment and urban structure, with the ultimate objective of narrowing the alternatives to the most favourable. In the second phase, more detailed investigations of one or more alternatives would be conducted with the objective of recommending a layout. Although the planning process had been opened up anew and the choice of layout was re-politicized, it can be argued that the overall interpretative frame through which the problem of fjord-crossing capacity was approached was not opened up for change to come about. While nine alternatives were being considered for inclusion in Phase 1, all of them were road crossings. A base alternative not assuming a new crossing was included, but only to serve as a base for comparison between the nine road alternatives (figure 8.2).

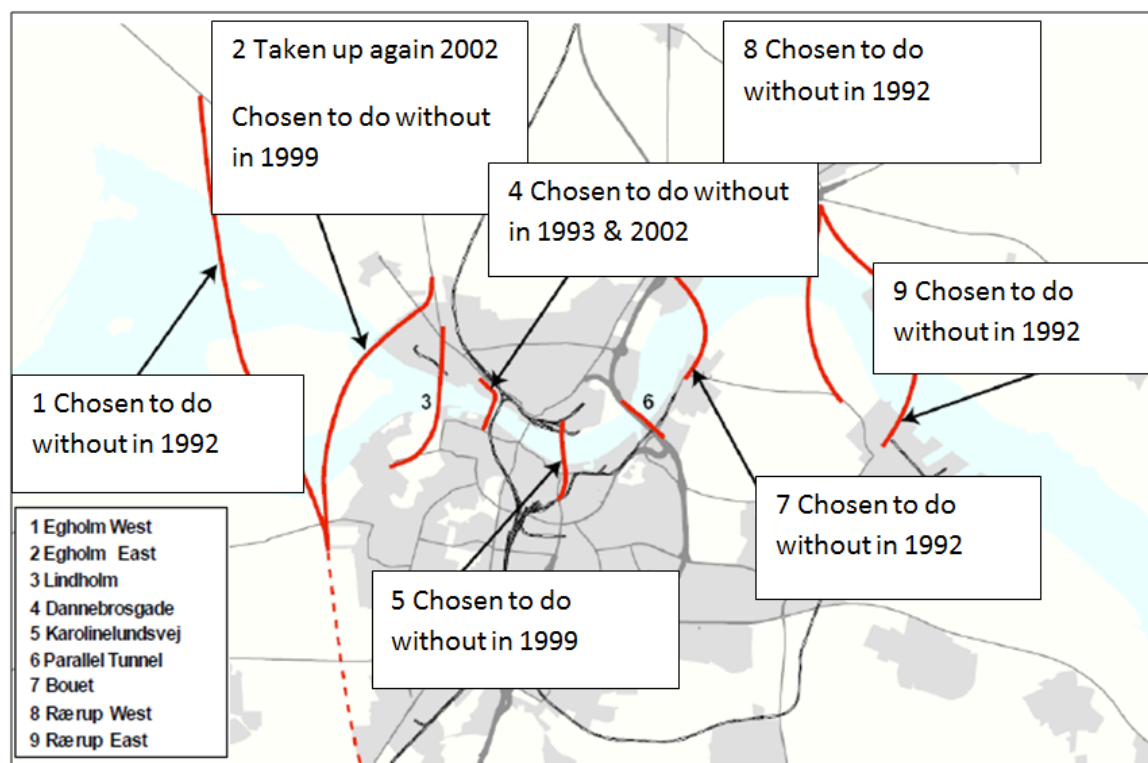


Figure 8.2: Alternatives investigated in Phase 1 (Aalborg Kommune; Nordjyllands Amt & COWI 1993)

In fact, the assessment programme did not contain any considerations for how the forecasted capacity problems could be prevented through implementation of alternative planning means. Hence, the framing of the problem within a predict-and-provide interpretation horizon was not performed. It was only at a shallow level that the planning process had been reopened, and this also turned out to be the case in respect to the technical content of the model. An important element of the first phase was reassessment of the Aalborg traffic model. In this regard, the following three alternatives for updating the model system were considered:

- A. Establishing a new traffic model built on a new data base, which – costs approximately 6-7 million DKK.
- B. Renewing calculations with the existing traffic model, which costs approximately 2-3 million DKK.
- C. Simplifying traffic model formed on the basis of updating the existing model material, and perhaps supplementing it with projections of expected urban growth and transport political development, which costs: approximately 0,3-1 million DKK.

Based on an economical and technical assessment, alternative C was recommended (Aalborg Kommune & Nordjyllands Amt 1991). Hence, while the model was reopened because it was rendered unacceptable on technical ground, it was the same simplified approach which was recommended for the further investments. On that ground, the economic rationale seems more prominent than the technical. If this is the case, then it can be argued that although the model was reopened, financial constraints hampered the opportunities for change to occur. Even though it was business as usual which was recommended, the requirements for fulfilling the EIA standards meant that the model had to be upgraded in a number of respects. First of all, in addition to noise and safety effects, which formed part of the 1975-78 investigations, energy

use, air emissions and barrier effects now had to be assessed as well, both for the average situation and the peak hour. Moreover, in order to fulfil the EIA requirements, it was necessary to assess the alternative crossings' network effects (e.g. in respect to noise) on the other parts of the town. This required fairly in-depth calculations of traffic assignment, making it necessary to upgrade the assignment model with capacity restraints. This upgrade was considered particularly relevant for the investigations in the second phase (Aalborg Kommune & Nordjyllands Amt 1991). It can be argued that due to the implementation of the EIA decree and the new transport political objectives, it was now particularly relevant to include the effects of induced traffic in order to make a valid assessment. Yet, induced traffic was not included. The investigations started in 1992 and the results of the investigations conducted as part of Phase 1 were issued the following year. Although it had been recommended that the group use the existing model to assist the evaluation, a new model system was still somehow applied. The consultancy firm COWI had assisted in the upgrading and calibration of the model, based on data collected by the Municipality of Aalborg. The model was upgraded with new planning data regarding expected development in proximity to the secondary centre, City Syd, and the university area in the east. The model was also implemented in the standard transport modelling software program EMME2, which allowed for inclusion of capacity restraint into the assignment model. Capacity restraint was hence included in the model in Phase 1, but only on critical links. It must be assumed that the model structure was re-revised so that trip distribution was placed before modal split in the sequential order of the model. I am not, however, in possession of particular information on the issue. In Phase 1, the transport model output served as a basis for assessing the impacts of the following variables (Aalborg Kommune; Nordjyllands Amt & COWI 1993)

- Energy consumption and CO₂ emissions
- Air pollution (HC, NO_x, CO and particles)
- Barrier effect
- Noise pollution
- Traffic safety

The calculations of the environmental impacts were conducted on the basis of the procedures instructed by the Plan Agency's report "Environment and traffic in the municipality planning" (see section 8.4). It can be argued that due to the changes in transport political discourse, objective and impact variables, it was now particularly important to include induced traffic in the modelling approach. Unlike in the previous run, there were now specific reduction targets for a range of environmental impacts, and non-inclusion of induced traffic implied a risk of underestimating the negative externalities compared to the zero-alternative, which is misleading in respect to meeting the targets. On that basis, it was reprehensible that the municipality did not upgrade the model with induced traffic now that it had been reopened for possible change. Although the inclusion of capacity restraint made the model more suitable to reflecting induced traffic stemming from route shift due to congestion problems, the model was still based on a fixed trip matrix and was hence not capable of reflecting more significant aspects of induced traffic. In spite of the model's advancement, it was still not qualified to make a proper assessment of the difference in vehicle kilometres travelled between the no-build and build alternatives. Yet, the model did apparently fulfil both the EIA and the local plans of action requirements. It can be argued that it is particularly problematic that induced traffic was not

specified or even mentioned by either the EIA requirements or the Plan Agency's report on procedures to calculate environmental and health impacts. As it was the Ministry of Environment which promoted assessment of new environmental impacts, it should be expected that it also specified the requirements for assessing these new impact variables appropriately. Non-inclusion of induced traffic hence does not only seem to have been accepted within the transport sector but also within environmental agencies.

As an outcome of Phase 1, it was chosen to do without the most remote alternatives because they, according to the model calculations, did not divert sufficient traffic away from the existing crossings (see figure 8.2). Only the alternatives Egholm West, Lindholm, Karolinelundsvej and the Parallel Tunnel were carried through to Phase 2 (Nordjyllands Amt et al 1993). In this phase, the Road Directorate entered into the planning process again. Before further investigations were initiated, it was decided to evaluate the Egholm and the Lindholm alternatives as both highways and as motorway alternatives. For this phase of the assessment, the traffic model was also further upgraded. Capacity restraint was incorporated into the model for larger parts of the network and the model was recalibrated based on new traffic counts from 1993. Phase 2 did not, however, end up with a decision on one of the alternatives. Instead, land reservations were made in the regional and municipality plans for all four layouts.

However, in the following debate, the model results were once again met with non-acceptance. Some participants in this debate problematized the analyses for failing to illuminate the ways in which the need for road development depends on the urban structure and the future urban development, as well as for disregarding alternative traffic measures such as improving the transit system. Hence, this time, it was the framing of the problem within a predict-and-provide interpretation horizon which was contested. In that sense, the struggle now seemed to take place at a deeper level than it had previously. Again, non-acceptance contributed to reopening the planning process and the assessment of alternatives. In 1998, it was decided to investigate alternative means for reducing traffic demand further as part of a general revision of the municipality's "Action Plan on Traffic and Environment." The new investigations were mostly concerned with the effects of building a local railway or introducing light-rail buses, but different land-use alternatives were also included in the analyses. In the light-rail alternative, a lane in each direction of the Limfjord Bridge was reserved. The conclusion on the investigation was that neither of the two initiatives would shift an appreciable amount of people from car to transit and that implementation of traffic calming means could not postpone the demand for a third crossing by more than a couple of years. These are the results referred to by the County as part of handling the complaint submitted to the Nature Board of Appeal about the County's non-acceptance of including the Red/Green Alliance's proposal in the EIA investigations (see Chapter 6). Though the County used these results to legitimize the non-inclusion of the alternative, it is, in fact, stated in the report that these results are rather uncertain. A weakness in the assessment was that the Aalborg Model did not contain a model to calculate mode choice as well as it did not directly include sensitivities toward changes in frequency. Additional investigations were therefore conducted based on travel survey data, but the investigations, especially those concerning the shift in transportation mode from car to bus, did not give fully satisfactory results, according to the planners. It was therefore necessary to make adaptations of the traffic model as well as manual corrections of the model results (Aalborg Kommune 1998, p. 13). Moreover, because the Aalborg model did not account for induced traffic, the inverse

mechanism was also ignored; the fact that reducing road capacity for general traffic and reallocating it for buses, pedestrians, cyclists, etc. can reduce overall traffic (Cairns *et al*, 2002) was thus not accounted for. As a consequence, the number of cars crossing the Limfjord, as well as the number of vehicle kilometres of car traffic, is most likely overestimated in the no-build alternative compared to the build-alternative. Therefore, there are good reasons for questioning the validity of the model results as an argument for rejecting inclusion of the proposal.

From the above, it can be seen that despite the new environmentally-minded transport political discourse leading to more environmental and health impacts being assessed, the framing of the problem of the fjord-crossing capacity did not transform accordingly, and neither did the model structure. In fact, the attempt to reframe the problem was de-reified by the transport model, and this de-reification was accepted by the Municipality and the County even though the model was based on insufficient assumptions.

8.6 The broader picture

Even though the structure of the Aalborg model did not transform radically as a reaction towards increased prominence of environmental and health issues on the transport political agenda, this does not imply that transport modelling practice did not transform at all. According to Overgaard (1996), the desire to estimate vehicle kilometres travelled, energy use, CO₂ emissions and other global pollutants have promoted development of macro-models, while the desire to evaluate traffic, noise, local pollutants, etc. on individual streets have stimulated development of more micro-based modelling approaches. In addition to the aspect of micro and macro modelling, it was also attempted to develop a multi-modal transport modelling approach in accordance with the requirements put forward in "*Traffic 2005*" (see section 8.4). During the 1990s, a new multi-modal national transport model was developed in collaboration between the Road Directorate and DSB. Yet, even though this model was more comprehensive and better suited for reflecting the new transport political concerns than its regional predecessors, it nevertheless turned out to be very inaccurate and was therefore not of use to any significant extent. Hence, in accordance with the development of the computerized transport model for Aalborg, the 1990s National Traffic Model was an example of an unsuccessful attempt to inscribe a new transport political order into the content of the model. The failure of the National Transport Model meant that during the 1990s and 2000s, the uni-modal regional transport models continued to be used as bases for transport project evaluation outside the larger urban areas, in spite of the fact that they were ill-suited for making a valid assessment of the new transport political objectives.

While induced traffic neither was included in the Aalborg model, nor the regional or urban transport models outside the Greater Copenhagen Area, this does not imply that induced traffic no longer was part of planners' discursive consciousness in the 1990s. In fact, the transport models HTM and OTM, both covering the Greater Copenhagen Area, as well as the Copenhagen-Ringsted model covering a larger part of the Zealand, were developed in the 1990s, and all of them were multi-modal, accounting for short-term effects of induced traffic. Nevertheless, inclusion of induced traffic in these three transport models was seemingly not boosted on environmental ground, but rather appeared to be inspired by the innovations in respect to transport modelling taking place within the Danish planning practice, in connection with

developing a transport model for the Great Belt Fixed Link in the late 1980s (Interview with planner within the Ministry of Traffic).

8.7 Sum up

Above, it was shown that during the 1970s-1990s, the objective of transport modelling expanded as a reaction to increased prominence of environmental and health concerns on the transport political agenda. These transformations in the transport political discourse meant that more and more transport-related environmental and health impacts were assessed based on the transport model outputs. As a reaction to these new environmental objectives, transport modelling practice developed towards both macro and micro modelling approaches. Nevertheless, transport modelling practice did not change fundamentally in accordance with the new policy requirements. In fact, during the 1990s and 2000s, it was still prevailing practice outside the Greater Copenhagen Area to use mono-modal transport models not accounting for induced traffic. In the Limfjord case, it was shown that despite the Aalborg model and the layout of the third Limfjord Crossing being re-politicized, creating an opportunity for changes to come about, this neither translated to a radical transformation in the model structure, nor to a solution to the problem framing fjord-crossing capacity. Predict-and-provide continued to prevail. Even though the model was upgraded with an assignment model accounting for capacity restraint, making it more suitable to assess environmental and health impacts, the fundamental model structure did not change in a manner facilitating inclusion of induced traffic. This was not, however, a requirement for either fulfilling the new EIA legislation or for the assessment of the new transport political objectives. Apparently, non-inclusion of induced traffic was not only accepted by road agencies but also by environmental agencies. Acceptance seems to have been largely conditioned on whether environmental impacts were included in the assessments rather than whether the effects were estimated on a valid basis.

As the issue of induced traffic is also explored in the second embedded case, a more comprehensive conclusion will be drawn up in Section 13.2, which is based on a synthesis of the findings from the two embedded cases and elaborates on the contributions to the thesis' research objectives concerned with induced traffic. The section will also discuss, alternative hypotheses on why induced traffic has traditionally been neglected.

Embedded case 2

The second embedded case concerns the emergence, development and use of the first computerized transport model within Danish planning practice. In Chapter 8, it was shortly mentioned that the transport infrastructure plans, drawn up at the national level in the 1950s and 1960s, constituted an important contextual factor for why computerized transport models emerged and were accepted within Danish transport planning practice. Nevertheless, the first Danish computerized four-step transport model was developed by the Municipality of Copenhagen, which established a special working group under the Department of City Engineer in 1962, with the purpose of preparing a traffic forecast for the Greater Copenhagen Area. The forecast was completed in 1968. According to the results of the computerized traffic forecast, traffic crossing the border to the city centre of Copenhagen would increase steadily in the period leading up to 1980. However, the traffic growth that was predicted never came to pass. Instead of growing as forecasted, traffic actually steadily declined from 1970-1980. The forecast, therefore, turned out to be overestimated (see figure b.1). The question here concerns which mechanisms took part in producing this result.

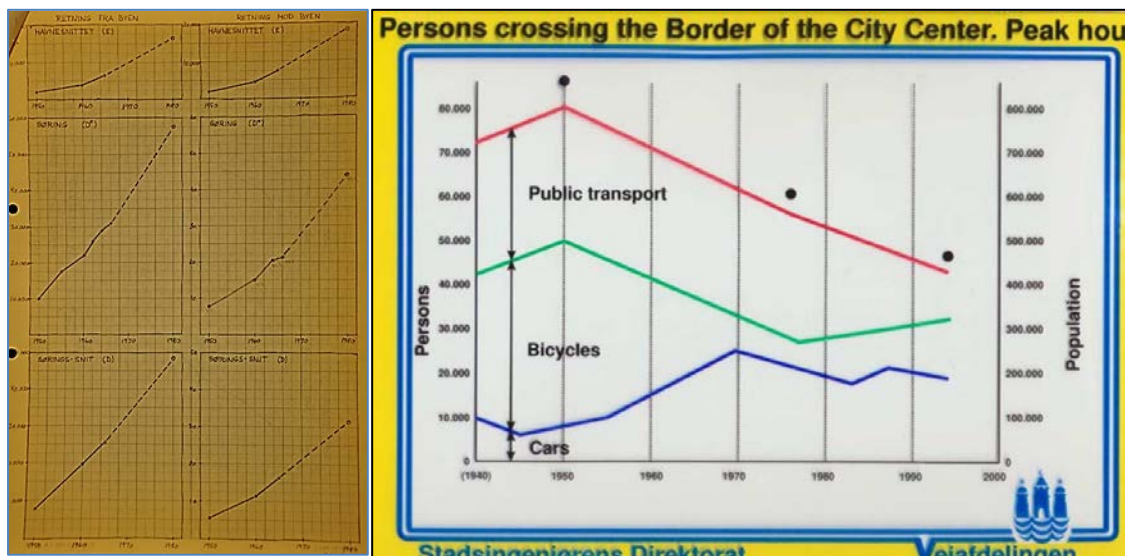


Figure b.1: The figure to the left: forecasted car traffic crossing the border of the city centre in the peak-hour from 1966 until 1980 (dotted line). The graphs in the left column depict traffic in the direction away from the city and vice versa. The top row depicts a screen-line in the harbour crossing section. The middle and lowest rows depict traffic in the screen-line of the Lake-ring.³⁰ The figure to the right: observed development in traffic crossing the border of the city centre in the peak-hour, ranging from 1940-1994 (Rørbech 2011). While car traffic crossing the city centre border in the peak hour was forecasted to increase steadily until 1980, the observed number of cars crossing the border actually steadily declined from 1970-1980.

In Chapter 5, it was argued that one cannot comprehend the cause of inaccuracy and bias in travel forecasting on the basis of ex-post evaluations of transport model outputs alone. In order to understand what affects the forecast, it is necessary to shift the object of inquiry towards processes of transport model-based knowledge production within the context of planning and decision-making processes. This embedded case study will serve to illustrate these claims empirically. It is important to consider whether the observed overestimation of forecast was due to ontological, technical, psychological, political-economic, organizational-institutional, or

³⁰ *Arbejdsrapport 3, kapitel 5, prognose resultater vedr. biltrafikken i maxtiden. 1. udkast. BPD, B.E./H.P., 21.10.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)*

various other reasons. Now, please remember that thought. Write it down to be on the safe side. In this embedded case we will roll this forecast back through its genesis and investigate the diverse and complex mechanisms which shaped the transport model-based knowledge production, and hence, the production of the forecast results. If you only thought of a single cause, then your explanation does not sufficiently comprehend the complexity which is about to be unpacked. We will have to account for both the content and the context, the particular and the broad perspective, and especially, the various mechanisms of power. Indeed, there are so many different influencing mechanisms condensed in the single number which constitutes the forecast that it will take many pages to unwrap them.

This embedded case study is structured into four chapters. The first chapter, Chapter 10, explores how the conditions of possibility for the emergence of computerized transport modelling within Danish planning practice were created. The second part, Chapter 11, investigates in detail the process of developing the transport model, exploring both the methods of data gathering and model development. In addition to the technical content, the focus will also be on the context of the model and how this shaped the content. The third part, Chapter 12, analyses how the first partial results of the computerized forecast framed the agenda concerning the traffic impacts following from urban development on the island of Amager. Particular focus is placed on the mechanisms, which were decisive for what came to be included and excluded from this agenda. The chapter also elaborates whether the model results gained acceptance among planning peers as well as among the local politicians on the Copenhagen City Council. In Chapter 13, the final chapter, there is an analysis of the process of finalizing the computerized forecast, as well as an explanation of how the finalized results were used in the Copenhagen planning. The chapter also explores whether the traffic forecasts gained acceptance at the municipal and the State levels. Lastly, the chapter elaborates some reasons why the computerized forecast did not fulfil as expected.

9 Emergence of computerized transport modelling

While the Municipality of Copenhagen's decision to develop a computerized transport model was made in 1962, it is necessary to account for the processes which preceded this decision in order to comprehend the mechanisms which shaped the transport model-based knowledge production. This chapter, therefore, explores the research question concerning how and why computerized transport modelling emerged within Danish transport planning practice. The decision to develop a computerized transport model was a continuation of an already existing forecasting programme initiated in 1956. The chapter explores the processes and mechanisms which lead to the decision of preparing the 1956 forecasting programme, as well as the processes and mechanisms which transformed this programme into a system allowing for a computer to assist in the forecasting work.

The chapter is divided into three sections. The first section investigates the regional and municipal planning contexts in which the 1956 forecasting programme was situated, and the processes and mechanisms which lead to the establishment of the forecasting programme. Moreover, the focus will be on the logic underpinning the spatial distribution of residents and workplaces in several early comprehensive plans. This is vital for understanding the spatial policy controversy in which the decision to develop a computerized transport model was situated. This policy controversy, which broke out due to a new regional plan proposal contesting the prevailing order of the Greater Copenhagen Area, is investigated in the second section. The focus is on the mechanisms which unfolded during this dispute and how they took part in transforming the forecasting programme. In the third section, the objective of developing the computerized transport model is elaborated on and a second parallel storyline is introduced. This storyline concerns the State's rationale for more broadly accepting computerized transport models and implementation of EDP with transport planning and project design. Despite the fact that the development of the first computerized transport model was initiated in 1962 at a decentralized level by the Municipality of Copenhagen, the State had already set up the so-called Road Data Processing Committee³¹ in 1960. The section also analyses the meanings and objectives of the two respective organizations assigned to computerized transport modelling as well as which of the meanings and objectives came to prevail in the end.

9.1 Towards a comprehensive perspective on planning

The story told in this embedded case mainly unfolds within the Department of the City Engineer. More specifically, it will mainly unfold within the Department's Urban Planning Office, where responsibility for developing the computerized transport model was placed. Prior to World War II, the department's administrative procedure was, to a great extent, based on a case-by-case practice, but during the War, a more comprehensive and scientific-based approach to planning started to emerge as a new system of thought. At first, however, the comprehensive planning approach was met with non-acceptance from the municipal authorities, but in the following period, it became increasingly institutionalized as the base of the department's working practice (Lyager 1992). As it is stated in a report by the Department from 1956:

³¹ Vejdatabehandlingsudvalget

“In the last decades, we have to an increasing degree started to adopt a broader urban planning perspective on the traffic problems, which, among other things, has been reflected in that studies have become more extensive, both in terms of geographical scale and matters-of-fact, and new methods of analysis have been tried alongside the hitherto practiced counting method.” (Stadsingeniørens Direktorat 1956, p. 15; Own translation)

This section explores how the transformation in system of thought towards a comprehensive planning approach generated transformations in the scale planning, transport project evaluation methods, and data processing technologies, and how these transformations facilitated the emergence of computerized transport modelling. The section also explores the spatial distribution of residents and workplaces, as well as the spatial design of the infrastructure systems drawn up in a number of comprehensive municipal and regional plans in the early post-war period. This is vital for understanding the spatial policy controversy, explored in the subsequent section, in which the decision to develop a computerized transport model was situated. The section is structured as follows. The early Copenhagen post-war comprehensive planning initiatives are first explored. The focus is then shifted towards the metropolitan level and the preparation of the first regional land-use and transportation plan for the Greater Copenhagen Area. The focus is hereafter shifted back to the Municipality of Copenhagen, and the preparation of its first comprehensive municipal plans is explored. The follow up on this plan is investigated next, and here the analysis is on how the enlarged planning scale facilitated the decision to initiate the 1956 forecasting programme. The following sub-section investigates how the enlarged planning scale took part in opening up and transforming transport project evaluation practice. Lastly, the programme used to execute the forecast, as originally intended, is discussed.

9.1.1 Early Copenhagen post-war planning

In order to account for the mechanisms which shaped the forecast results, it is necessary to go all the way back to ending of World War II and the period immediately after. This sub-section will elaborate the work of the so called “Traffic Commission of July, 1st 1944,” as well as the first, tentative beginnings to preparing a comprehensive master plan for Copenhagen.

Before the war ended, Copenhagen had already set up the Traffic Commission of July, 1st 1944 under the Department of the City Engineer, with the objective of illuminating future traffic problems within the municipality and reaching an agreement on a solution to these problems. The committee work was based on a wide scale perspective; it was multi-modal in scope and based on detailed technical analyses and subsequent evaluations of project proposals (Kommissionen af 1. juli 1944 angående en trafikplan for hovedstaden 1946). While Copenhagen was, according to the institutional settings of the Danish road administration, in charge of the road planning and implementation, the Danish State Railways (DSB) and the National Parliament were in charge of the rail system. DSB, therefore, also participated in the committee. As part of the committee work, a travel study was conducted in 1945, partly consisting of a range of coordinated traffic counts and partly of a large home-work travel survey. This was the first time since 1911 that a survey of this type had been conducted. The survey was based on a questionnaire about the location of a resident’s home and workplace, respectively, and about

the times of departure and arrival, and was posted to all households as an additional form attached to a census paper (Kommissionen af 1. juli 1944 angående en trafikplan for hovedstaden 1949). Based on the survey, the following version of the gravity model was used to estimate the distance exponent n :

$$T_{1-2} = \frac{B_1 \times A_2}{d^n} \times k$$

In the formula, T_{1-2} is the amount of commuting trips from an area with b_1 residents to an area with A_2 workplaces, d is the distance, n is an exponent, and k a constant. Based on the home-workplace survey, the value of distance exponent (n) was found to increase with the distance to the city centre (Kommissionen af 1. juli 1944 angående en trafikplan for hovedstaden, 1949, p. 15). The model was used to assess future ridership of a proposed subway system. In these calculations, mode shift between the subway and street cars was also accounted for (Kommissionen af 1. juli 1944 angående en trafikplan for hovedstaden, 1951). Below as well as in the subsequent chapter, we will return to the home-work survey and the gravity model and discuss how they later came to shape the knowledge production undertaken by the computerized transport model. It was, however, not possible for the committee to reach a consensus on a layout for the proposed subway system. The Chief City Engineer of Copenhagen at the time, Olaf Forchhammer, and DSB both advanced different alternatives, and a settlement was postponed until a later time (Kommissionen af 1. juli 1944 angående en trafikplan for hovedstaden, 1951).

Although the Commission's work was, to a great extent, based on a comprehensive planning approach, it did not include a land-use plan for Copenhagen. In 1946, the Communist Johannes Hansen took office as new Mayor of Urban Planning, and some planners within the Department of the City Engineer persuaded him to take up preparation of a master plan for Copenhagen as a leading issue. He therefore directed the Chief City Engineer to initiate the work. As pre-work, Forchhammer issued a preliminary master plan delimited to the inner-city, which contained clearance and new breakthrough streets within the historical core, among other things. This plan was, however, met with non-acceptance, from inside and outside the Municipality and particularly by the Architect Steen Eiler Rasmussen. The plan was too small in geographical scope and it was at odds with the emerging discourse on preservation of the historical core. Due to the non-acceptance, further master plan preparations were in a state of inaction throughout the following years. We leave the Copenhagen master planning for now, but will return to it in Section 9.1.3. For the moment, we turn towards the first comprehensive regional plan for the Greater Copenhagen Area.

9.1.2 The Finger Plan and creation of spatial order

Even though the first computerized transport model emerged within the context of Copenhagen comprehensive municipal planning, it is vital to introduce comprehensive planning at the regional level in order to understand how and why computerized transport models emerged and became accepted within Danish planning practice, as well as the mechanisms which shaped the forecast result. In fact, the computerized transport model emerged within a field of tension between the Municipality of Copenhagen and the regional planning authorities, among others, in which the future spatial order of the Greater Copenhagen Area was disputed. In order to

explore this further in the next section and chapters, this sub-section introduces the assumptions and spatial rationales or logics (Olesen & Richardson 2011) structuring the design of the infrastructure systems and the distribution of development drawn up in the first comprehensive regional land-use and transportation plan for the Greater Copenhagen Area from 1947, namely the “Preliminary outline to a Regional Plan for the Greater Copenhagen Area”³² (Egnsplankontoret 1947), affectionately known as the “Finger Plan.” In other words, this sub-section explores the particular spatial order advanced in the Finger Plan.

The idea of preparing a comprehensive regional plan which integrated transportation and land-use for the Greater Copenhagen Area was generated as a reaction to non-acceptance. In 1926, the Association of Engineers of Denmark issued a regional road plan proposing massive expansion of semi-circular and radial roads, but without considering urban development in concert. Professor Steen Eiler Rasmussen did not accept this separation, and launched a special issue of the journal “Arkitekten”, which he edited. Here, the road plan was subjected to review by international planning scholars. The overall judgment was that a road plan was fine, but it was incomplete without a land-use plan. An independent institution, the Danish Town Planning Institute, met the challenge, and it established the “Committee for the planning of the Copenhagen region” in 1928, with Steen Eiler Rasmussen as chairman and financial support by the region’s municipalities and the State. At first, the committee work did not result in a regional transport and land-use plan, but in a report from 1936 on Copenhagen’s green areas, the committee singled out areas prohibited from development. When World War II broke out, further work was brought to a hold. Nevertheless, despite planning activities having declined during the war years, planning obtained increased attention as a tool for managing the post-war redeployment processes. When the War was about to end, the private Danish Town Planning Institute summoned the Committee for the planning of the Copenhagen region with the objective of resuming regional planning in the post-war period. The State supported the initiative, and soon after the War, the technical bureau, called the “Regional Plan Office”³³, was created with the architect Peter Bredsdorff as leader, in order to prepare a regional land-use and transport plan. Steen Eiler Rasmussen chaired the committee, in which all the municipalities within the County of Copenhagen and a few municipalities from Frederiksborg and Roskilde counties contributed to the funding and were represented. (Illeris 2010; Lyager 1992; 2006; Rørbech 2010).

³² Skitseforslag til Egnplan for Storkøbenhavn

³³ Egnsplankontoret

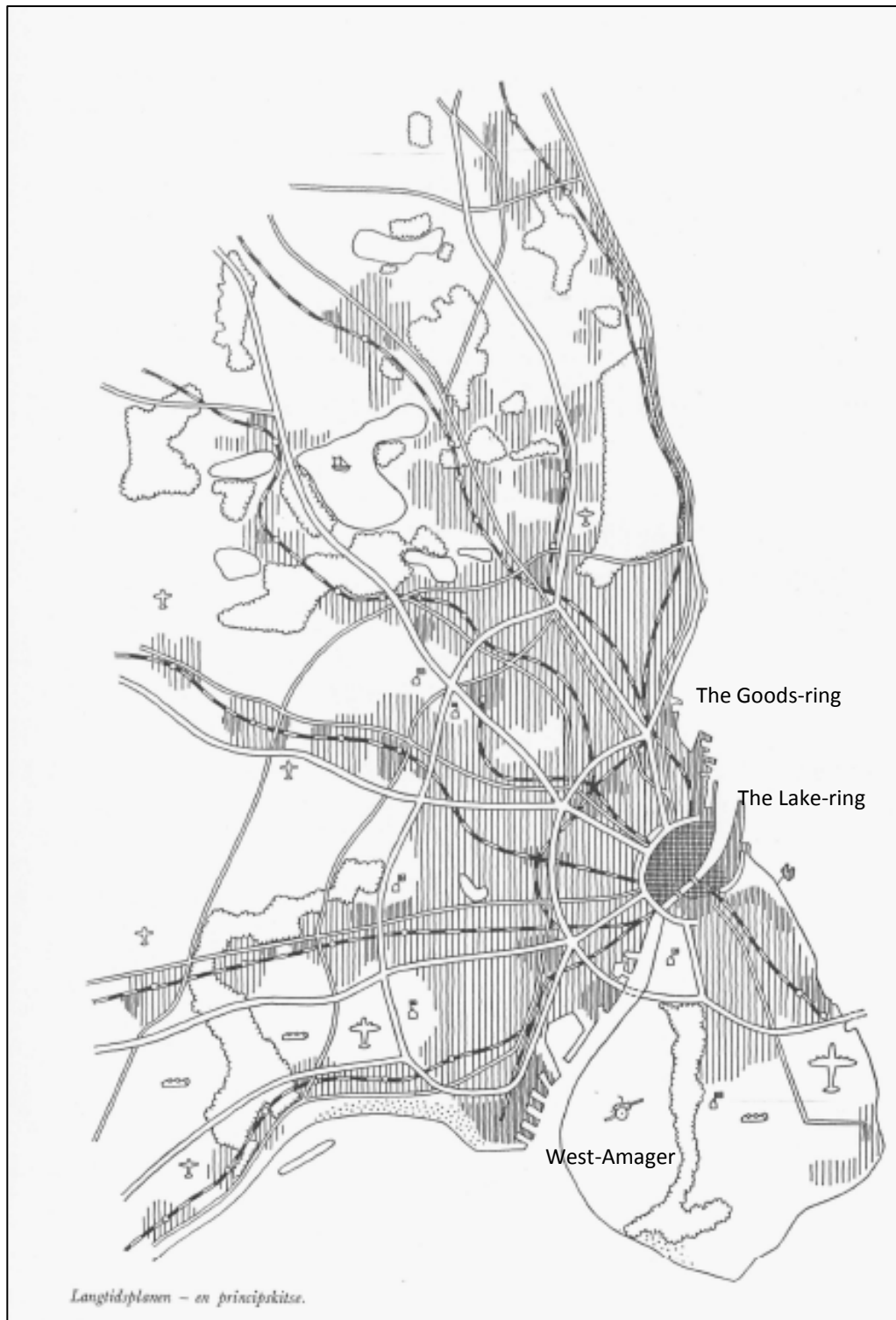


Figure 9.1: The rail and road infrastructure systems proposed in the Finger Plan. The spatial structure of the proposed infrastructure networks radiates from a nodal point in the inner-city of Copenhagen and runs towards the sub-urban municipalities (Egnsplankontoret 1951).

The Finger Plan was drawn up based on assumptions resembling the prevailing conditions of the social order when World War II ended; many of these later turned out to be underestimated. In terms of population, 1.100.000 inhabitants lived within the area contained by the Finger Plan in 1945. Based on the low birth-rates of the 1930s, the future population was forecasted to be

1.300.000 inhabitants around 1960-65 and 1.500.000 around 1980-2000.³⁴ At the end of the war, Copenhagen was a traditionally dense European mono-centric city with the indisputable highest concentrations of workplaces and residents in the city centre. Due to large concentrations of public institutions, business, industry, shopping, and entertainment, there was a surplus of work places in the city centre, and these formed the region's dominant commuting destinations. During the War, private motoring had declined, and when it ended, transit had regained its position as the dominant mode of motorized transport. In the Finger Plan, it was accordingly assumed that transit would continue to prevail in the future. With a point of departure in these assumptions, four prominent logics of spatial order were drawn up in the Finger Plan. The first logic concerns that despite some degree of decentralization being foreseen,³⁵ Copenhagen should continue to be a mono-centric metropolitan area. The second logic addressed minimization of traveling time to the central business district, the third logic concerned the principal of integrated land-use and transportation planning, and the fourth dealt with securing proximity to green areas.

With a point of departure in these four main spatial logics, it was suggested in the Finger Plan that in order to secure proximity to green areas and minimize traveling time to the city centre with transit, successive urban growth should be contained. This is to say that new urban development should be concentrated in proximity to stations on existing and proposed metropolitan and suburban electric train lines, running in radial lines from the city centre to the suburban municipalities and forming the finger structure, with Copenhagen in the centre of the "palm" (see Figure 9.1). However, even though the Finger Plan assumed that transit would continue to be the dominant mode of transportation in the future, an extensive urban expressway system was also sketched out. In accordance with the spatial structure of the metropolitan and suburban electric train lines, the urban expressway system consisted of radial roads connected by semi-circular roads. The radial roads were inserted into the city centre along the fingers, meeting in an inner semi-circular-road at the inner-city border, which was prolonged to the island of Amager (see Figure 9.1). Nevertheless, it was anticipated that the demand for this extensive urban expressway system would not materialize in the near future, but in the long term. Because the radial structure of the infrastructure systems facilitated travel along the fingers while constraining travel between them, Copenhagen came to be positioned as an obligatory passage point within the spatial order of the Finger Plan. The spatial structure of the Finger Plan's infrastructure system and land-use patterns therefore underpinned and reinforced a spatial order where Copenhagen was positioned as the all-dominant business and cultural centre within the metropolitan region. Yet, though the Finger Plan in many ways empowered the "social capital," or in this context, "spatial capital," tied up to Copenhagen's structural position within the spatial order of the metropolitan region, it also posed a structural constraint on Copenhagen's opportunity for expansion. Some of the last larger vacant strips of land within the municipal borders, suitable for development, were located on the island of Amager (Stadsingeniørens Direktorat 1967c). The Municipality therefore had a special interest in further

³⁴ In a follow up report to the Finger Plan, "Status 1950," issued by the Regional Planning Office in 1951, the population forecast was revised upwards. Here, the future size of the population is assumed to be 1.400.000 in 1965 and 1.600.000-1.700.000 in 1980-2000 (Egnsplankontoret 1951, 10-11)

³⁵ The population of the Fredriksberg and Copenhagen municipalities was assumed to grow by 50.000 between 1945-1960 and then decline by 100.000 up to 1980-2000 (Egnsplankontoret 1947, p 51)

development on the island. Amager Fælled, on the western part of the island, received special attention for constituting an important land reserve.³⁶ The areas were, however, owned by the state and a military firing range located in the area, although the State and Copenhagen had entered into a joint ownership agreement on Amager Fælled in 1939. According to the agreement, dwellings amounting to 10.000 people could be developed on the area (Vedel 1963). The agreement was supposed to come into force at some future stage, when the firing range had been relocated and the military had been vacated from the area (Illeris 2010; Lyager 1996). However, as was shown in the preceding chapter, this did not happen until 25 years later. Still, in 1942, the Department of the City Engineer worked out a master plan proposal for West Amager. However, the Finger Plan, which kept the island of Amager free of considerable urban development, overruled the Municipality's master plan proposal. There were several reasons why development on Amager was not accepted in the Finger Plan. First, there was a desire to secure a green wedge curving all the way into the centre of the city. Second, the traffic conditions on the island were unusual. Development on Amager would increase traffic volumes crossing the harbour section and thereby require costly investments in order to prevent congestion problems.

After the Regional Planning Office had released the condensed, revised, and politically smoother version of the Finger Plan, "Status 1950," in 1951 (Egnsplankontoret 1951), the plan was discontinued. The Finger Plan was only a draft and the intention was to prepare a final regional plan, but due to conflicts of interest among the members, the Finger Plan was never accepted by Regional Plan Committee. However, in 1949, the National Parliament adopted a law on regulation of urban development, applying for the four largest cities, which included Copenhagen. According to the law, an urban development committee with local representatives under governmental management should divide the urban areas into inner zones where urban development in general was accepted, outer zones where it was prohibited, and intermediate zones where development was put on hold. In 1951, the Urban Planning Committee's metropolitan division accepted the first Urban Development Plan. This plan was almost identical to the Finger Plan, but it deviated in one regard: After receiving pressure from the Municipality of Copenhagen, the entire Copenhagen part of Amager, with the exception of the reclaimed areas, was put in the inner zone, implying that it could be developed in the future (Illeris 2010; Lyager 1996).

In the following section and chapters, it will be shown that the decision to initiate development of a computerized transport model was situated within a spatial policy controversy where the future spatial order of the Greater Copenhagen Area was at stake, and where the dominance of Copenhagen's structural position within the prevailing spatial order of the Greater Copenhagen Area was challenged.

9.1.3 The Copenhagen preliminary outline to a master plan

We now return to the Copenhagen master planning. Since the criticism of Forchhammer's preliminary master plan for the inner city, further work had been deadlocked (see Section 9.1.1).

³⁶ Particular the western part of the Amager, Amager Fælled, constituted an important land reserve and as part of an employment project in 1939-45 an additional 25 km² larger low watered area was reclaimed at the western part of the island.

Forchhammer, however, retired in 1951, and the head of the Road Section, Poul Vedel, was inaugurated as new Chief City Engineer the following year. This represented the starting signal for the preparation of the first comprehensive Master Plan for Copenhagen, covering the entire municipality. For that purpose, the organization of the Urban Planning Office under the Department of the City Engineer was restructured. Peter Bredsdorff, who also headed the Regional Planning Office, was employed to head the newly created Third Urban Planning Office, which was responsible for working out the municipal Master Plan. After the plan was issued, however, Bredsdorff resigned and became a professor at the Royal Danish Academy of Fine Arts (Lyager 1992; 2006). The work following up on this master plan constitutes a contextual factor, crucial for understanding how and why computerized transport models emerged within Danish planning practice. Indeed, the responsibility for development of the computerized transport model came to be placed within the Third Urban Planning Office, and it is mainly within this organizational milieu that the story told in this embedded case unfolds. Due to their importance for the further story, we next elaborate on the assumptions regarding Copenhagen's first comprehensive master plan.

After only two years of official preparation, the so called "Preliminary Outline to a Master Plan"³⁷, hereinafter referred to as the "Master Plan Draft," was issued (Stadsingeniørens Direktorat 1954). The Master Plan Draft was underpinned by a comprehensive approach to planning (see Chapter 2). It was based on a larger scale of planning than the preceding drafts and was linked to both local and regional planning. As it is stated in the preface to the Master Plan Draft:

"A master plan must, as the name suggests, be a comprehensive plan. It must draw a comprehensive picture of the future city, including, inter alia the various land use, location of public institutions and facilities, the design of the street-and traffic systems, technical facilities etc. Such an overall plan for the municipality's development is necessary not only in respect to the more detailed planning of the city and its individual parts, but also for the further planning of the Greater Copenhagen." (Stadsingeniørens Direktorat 1954, p. 7; Own translation)

In accordance with the Finger Plan, the Master Plan Draft was based on the assumption that Copenhagen would continue to maintain and reinforce its structural position as the dominating centre within the regional spatial order. However, the actual development did not occur as assumed in the Finger Plan. The post-war baby boom and high urban migration rates meant that the population within the Finger Plan area, in general, grew more than assumed. However, this increased growth took place within the suburban municipalities. Within the Municipality of Copenhagen, development was marked by deterioration from approx. 1950 and onwards. Citizens residing within the central municipalities, particularly the more wealthy and young families with children, were increasingly migrating to the suburbs, where more modern and spacious accommodations were available (see Figure 9.2). Also, businesses, particularly industrial workplaces, were relocating to the outskirts of the Finger Plan area.

Copenhagen's Master Plan Draft should be seen as an attempt to govern these structural transformations stemming from the decentralization by adapting to some trends and attempting

³⁷ København Skitse til en General Plan

to reinforce desirable impacts while reversing undesirable ones. For instance, the relocation of industrial workplaces was welcomed, but the outward migration of residents was seen as a threat. In order to revitalize the city centre, the plan suggested that the central business district should be expanded, particularly with respect to office workplaces. Based on the growth in office floor square meters within the central city in the period 1930-45, the need for future floorage was estimated to grow a further 1.000.000 m² (corresponding to a 30% increase) within an unspecified period of time (Stadsingeniørens Direktorat 1954, p. 59-61).

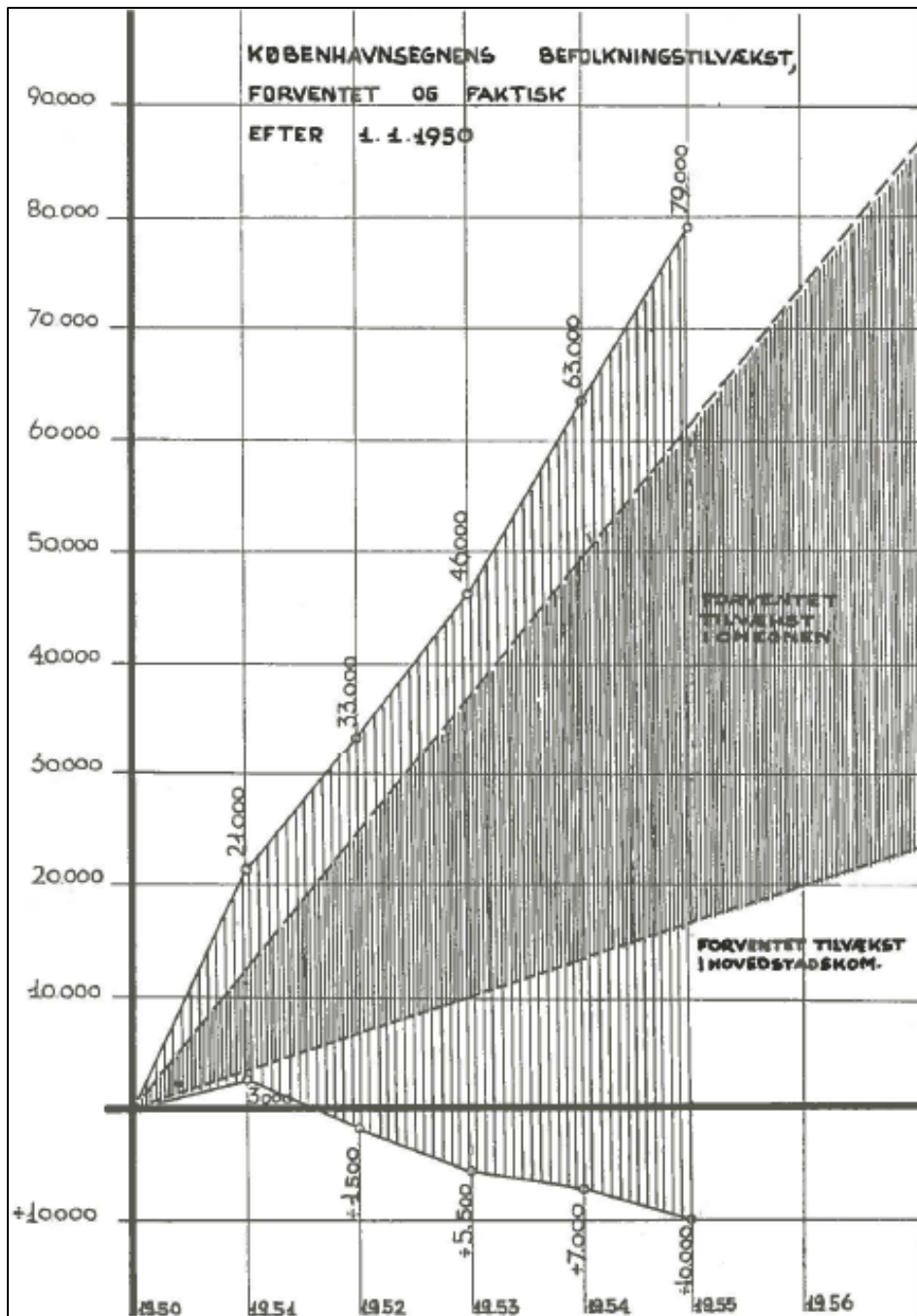


Figure 9.2: Forecasted (narrow hatched area) and actual population trends (wide hatched areas) within the Greater Copenhagen Area 1950-56. At the bottom: forecasted and actual population in the central municipalities. At the top: forecasted and actual population in the suburban municipality. While it was assumed the Copenhagen population would grow by more than 15.000 people 1950-55, the population actually declined by 10.000 (Stadsingeniørens Direktorat 1955a, p. 3)

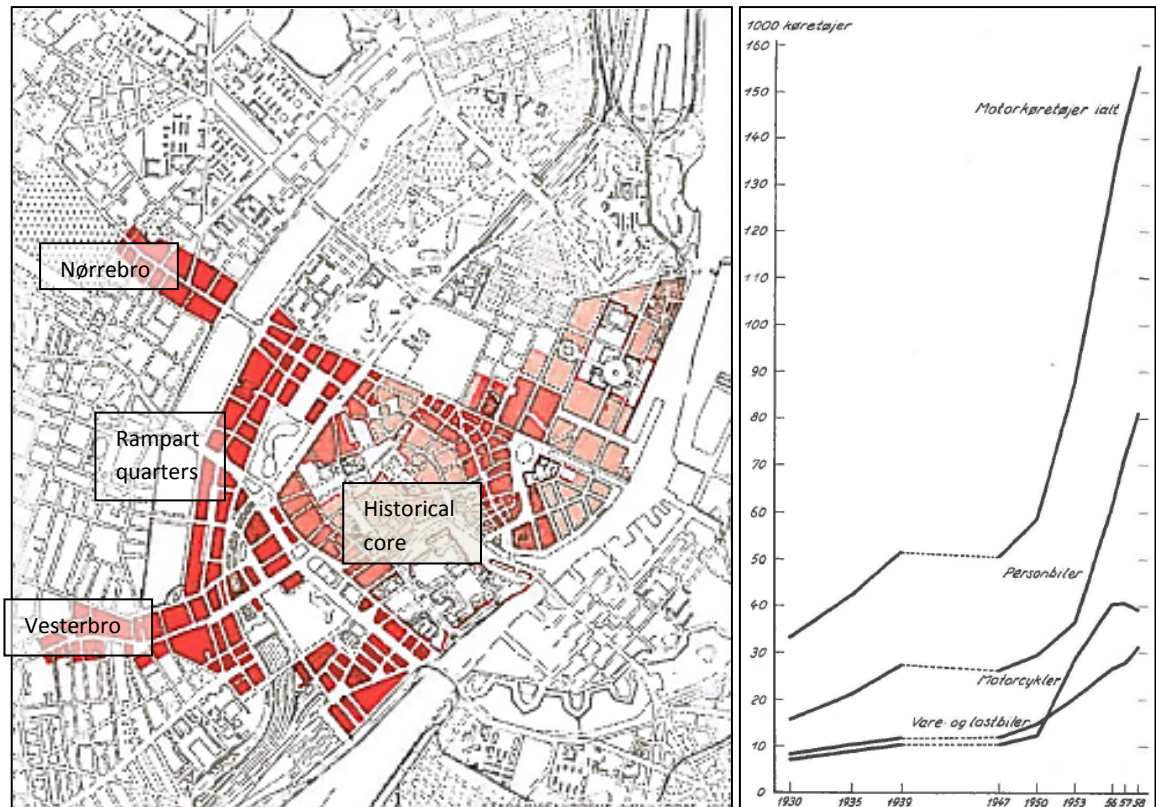


Figure 9.3: On the left: Land-use plan for central business district. The red colour marks development areas, while pink marks preservation areas (Stadsingeniørens Direktorat 1954, 62). On the right: Development of motoring within the Greater Copenhagen Area from 1930-1957 (Det økonomisk sekretariat 1959).

Distinctively, from the former Chief Engineer’s plans for the historical core, the scene within the historical core was in the Master Plan Draft set for traffic calming, high parking fees, and preservation. Instead, the Central Business District was proposed to be expanded in the Rampart quarters, the inner districts of Nørrebro, and Vesterbro, in particular. In these areas, the building plots were to be increased considerably, while they were to be reduced in the core of the city (see Figure 9.3). The Master Plan Draft’s vision of expanding the Central Business district while simultaneously preserving the historical core was in compliance with the spirit of the Finger Plan. Yet, in respect to development on Amager Fælled (which previously had occasioned a policy controversy between the Municipality of Copenhagen and the Regional Planning Office), the Master Plan Draft actually displayed a subtle deviance. While the Finger Plan disapproved of development on Amager, the Master Plan Draft states as follows:

“Amager Fælled constitutes a centrally-located land reserve which may not be fully commandeered for permanent usages in the short term” (Own translation; Stadsingeniørens Direktorat 1954, p. 101).

The Master Plan Draft hence showed some degree of restraint in respect to development on Amager Fælled, but only in the short term; the plans involved further development of the island in the future. As Larsen (2006) points out, due to the fact that preparation of both the Finger Plan and the Master Plan Draft was headed by the same person, Peter Bredsdorff, the deviation between the two plans, in respect to development on Amager, can only be explained by the special interest of the Copenhagen Municipality. Hence, planning and politics do not seem to

have been completely detached within the Department of the City Engineer at this period of time. We will return to this later.

However, the land-use plans for expanding the central business district could not be realized unless accessibility to the city centre was improved. Congestion problems were already occurring in the city centre at peak hours, partly due to increased employment within the central business district, but particularly due to an increase in motoring, which increased dramatically in the early-1950s (see Figure 9.3). The high growth in motoring was therefore seen as a threat to the central business district's vitality. There was potential for reduced accessibility to the city centre due to congestion, which would accelerate the decentralization trends, an outcome considered undesirable by Copenhagen.

To provide the suggested new development areas with high quality transit, a revised version of a proposal originally put forward by DSB was presented, concerning the layout of subways in the inner city (see Figure 9.4).

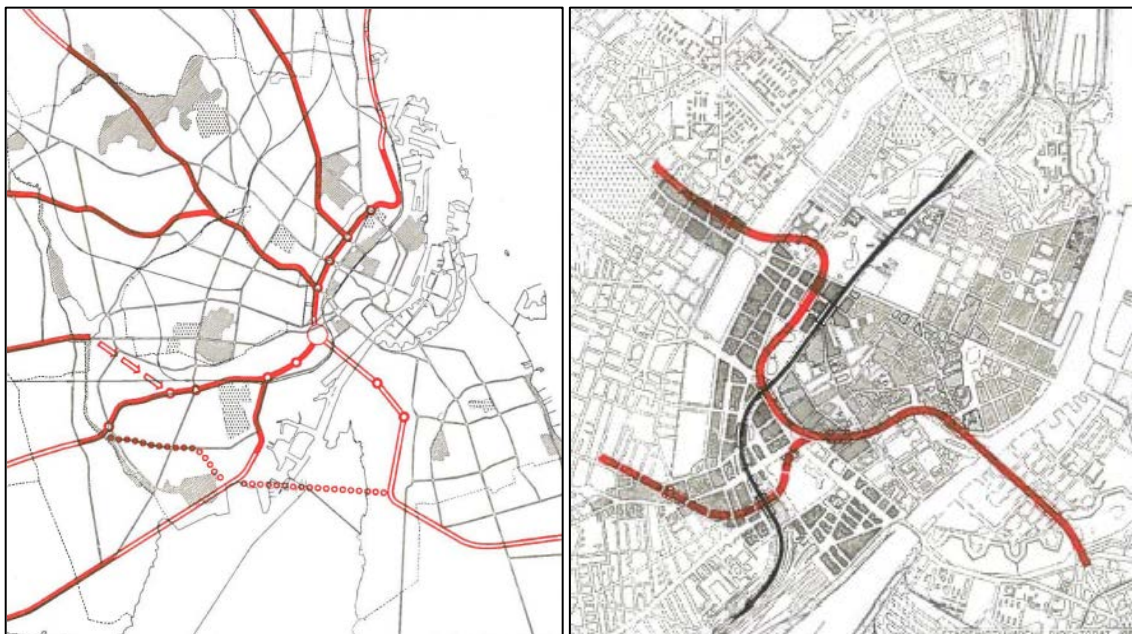


Figure 9.4: On the left: The Master Plan Draft's proposed primary road network. On the right: The Master Plan Draft's proposed subway system (Stadsingeniørens Direktorat 1954)

In respect to the road infrastructure, the Master Plan Draft stressed that improvements for the motorized traffic to and from the centre was urgent. In the plan, a specified and modified sketch of the Finger Plan's stylized urban expressway system was presented. Compared to the Finger Plan's proposal for an urban expressway system, the size of the primary road system was downscaled. Instead of building the urban expressway system in new traces, the Master Plan Draft suggested that apart from the insertion of the West Motorway, the primary road system should be based on an upgrade of the existing radial roads to four lanes, nearly doubling their capacity.³⁸ This was assumed to be a sufficient capacity to accommodate traffic demand at the outer stretches for the foreseeable future, but there was doubt as to whether four lanes would be enough on the inner stretches (Stadsingeniørens Direktorat 1954, p. 149). This was, however,

³⁸ Although the primary road network of the Master Plan Draft was supposed to be based on an upgrade of the existing main radial roads, plans for urban expressways were prepared later on.

an issue which could not be settled then, but required further traffic investigations. In the foreword to the Master Plan Draft, Poul Vedel also specified that:

“With the now conducted work, only the first step is taken. Besides continued investigations, comprehensive deliberations with other parties, both within and outside the municipality, lie ahead. Such deliberations will result in improvements and these improvements will likely be tantamount to considerable modifications of the proposals sketched out here (in the Master Plan Draft)” (Stadsingeniørens Direktorat 1954, p. 7)

This is to say that the Master Plan Draft was to be seen as a draft, not a full-fledged scheme, and further investigations were planned to be executed after its publication. These further investigations will be elaborated on next.

9.1.4 The follow-up in the Joint Committee

After the Master Plan Draft was issued in 1954, a so-called Master Plan Joint Committee was established between the municipal authorities and City Council. From 1955 to 1957, the Chief City Engineer, Poul Vedel, gave a number of speeches to the Joint Committee,³⁹ where he elaborated on the Master Plan Draft, and based on results of additional investigations, specified and suggested some modifications to the original proposal. In the following sections, some of

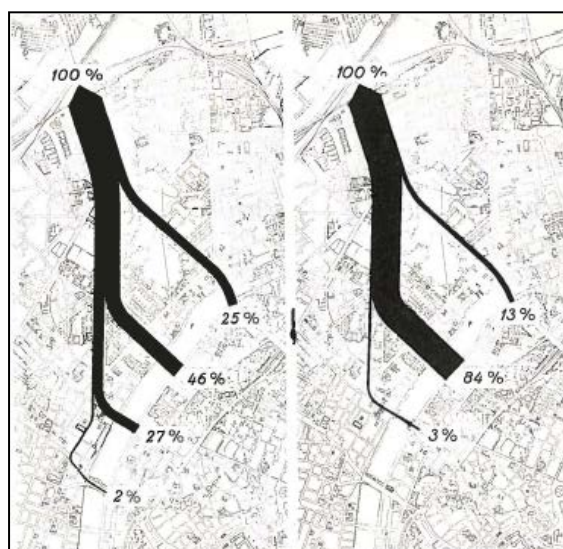


Figure 9.5: On the left: Diagram showing the traffic between the central areas and the catchment area of Lyngbyvjen, before and after the upgrading of Fredensgade to a primary road (Stadsingeniørens Direktorat 1955c, p. 29). On the right: Sketch for a three-levelled junction between Fredensgade and the semi-circular lake-road (Stadsingeniørens Direktorat 1955c, p. 34)

these further analytical investigations and proposed amendments will be elaborated on. We will also explore how the enlarged planning scale facilitated transformations in transport project evaluation practice, resulting in the decision to initiate a comprehensive forecasting programme for the Copenhagen region.

In the speech which Poul Vedel gave about the primary road system, he presented the results of a new peak-hour forecast for the city centre. In the forecast, it was assumed that in the future, inner-city employment would increase by 50%, adding 150.000 new commuters. Therefore, the forecast was based on the assumption that the mono-centric spatial order of the Greater Copenhagen Area would continue to prevail in the future.⁴⁰ The forecast showed that if less than third of these future commuters travelled by private car, the need

³⁹ Fællesudvalget til behandling af Generalplanskiten

⁴⁰ Similar assumptions form the basis for other forecasts prepared during this period of time. See e.g. Det Økonomiske Sekretariat (1959); Lyngbyvej Arbejdsgruppen (1959).

for road and parking space would triple. This scenario signified a cautionary tale both in economic and architectural respects. In the opening of his speech, Vedel therefore stressed the importance of expanding the mass transit system. In fact, he argued that transit improvements were the only sustainable solution to the forecasted traffic problems. Nevertheless, as a supplement to the primary road system presented in the Master Plan Draft, Vedel also introduced a new, outer semi-circular road, namely the so-called Goods-ring, which would follow the trace of a former goods railway (see Figure 9.6). We will return to this outer semi-circular road below and in the subsequent chapters.



Figure 9.6: The proposed Goods-ring, running in the trace of a former goods railway (Stadsingeniørens Direktorat 1955c, p. 10)

were handed out to persons crossing Fredensbro in a direction leading away from the city. The analysis showed that an upgrade of Fredensgade would divert traffic from other routes, amounting to a 40% increase on this stretch (see Figure 9.6).

A forecast for the corridor was then prepared, showing that as long as traffic did not grow by more than a factor of three to four, the junction could be designed in one level, but that a higher factor of traffic, however, would require the junction being designed in two or three levels (see Figure 9.6). This future scenario was discouraging and action was needed in order to prevent it from coming true. In his speech, Vedel argued as follows:

“Consequences in the direction of terrifying junctions and enormous parking needs are so serious that we must consider whether there is an acceptable way to restrict these traffic volumes without at the same time limiting the traffic system and thus the city’s functionality. Perhaps it is a tempting idea, simply to let the traffic choke itself inside the narrow streets, obsolete crossing facilities, and lack of parking possibilities. With the funds, which in the next few years we can to be

expect earmarked for this purpose, it is likely that this cannot entirely be avoided. But it hampers the city's functionality and the business community's, and the individual citizen's transportation costs increases. As a solution to the problem, this is not acceptable. A more reasonable solution, however, it is to try to find the car travel which is necessary for a reasonable development of, and service to, the industry and attempt the other: unnecessary traffic, constrained or completely stopped" (Stadsingeniørens Direktorat 1955c, p. 35f; Own translation).

Uncontrolled growth in car ownership was hence problematized as posing a significant threat to the city's viability, and in order to steer the development clear of undesired consequences, traffic had to be made the subject of government. However, as Vedel stated further:

"On this topic [constraining undesirable traffic], we do not yet have sufficient knowledge, and further studies are necessary, and currently in progress. We are missing a very important piece of knowledge regarding the traffic, namely information about how it moves within the urban area. A study such as the one we have made for Fredensgade may be adequate for examining a locally defined problem, but it does not provide the overview which is necessary when we are facing investments of this magnitude. In the interest of the proper design of the primary road system and out of consideration for the right order of priority of future investment, it is essential to know something more about how traffic behaves within the metropolitan area. The Road Directorate, which will put the bulk of the money on the table, has acknowledged this, and initiated a collaboration, in which the both County of Copenhagen and Frederiksberg Municipality are involved, for conducting a comprehensive traffic analysis for the entire region. It is not cheap, but given the mistakes we could make without the knowledge that such an analysis could provide us, it will still be a good investment." (Stadsingeniørens Direktorat 1955c, p. 35f; Own translation)

The transformation and scaling up of the planning perspective, concordant with the system approach to planning, involved the fact that conventional transport project evaluation methods, designed for local problems, were starting to be problematized and rendered non-acceptable. The corridor perspective was too narrow and did not allow for inclusion of network effects. In order to govern properly, Vedel argued, it was necessary to collect information about how traffic behaved within the entire Greater Copenhagen Area, and a comprehensive travel study was therefore to be executed (Stadsingeniørens Direktorat 1955, pp. 36-37). The knowledge about traffic was needed in order to restrict undesirable traffic, size the capacity of the primary road system, and draw up a rational investment programme. However, as it will be shown in the reminder of this thesis, rendering traffic knowable at a system level was not easy, even if a computer was enrolled in order to ease the task. Below, it will be shown that transformation in the scale of planning came about as a result of other evaluation techniques being problematized, and this will be explored in terms of how it contributed to opening up transport project evaluation practices and allowing for change to occur.

9.1.5 The Greater Copenhagen travel study of 1956

If we should use Latour's terms, then the 1955 decision to prepare a comprehensive forecast based on data collected through the regional travel study is the programme of action which the remainder of this embedded case will follow. Seven years later, that decision translated into a new decision, concerning whether a computer should be used to assist the preparation of the forecast. In fact, the 1962 decision to develop a computerized transport model with the purpose of producing a traffic forecast for the Greater Copenhagen Area was a continuation of the forecasting work initiated in 1955. In the following, it will be explored how the opening up of transport project evaluation practice, facilitated by the transformation in scale, brought about change in transport project evaluation techniques in a manner which facilitated the emergence of computerized transport modelling within Danish planning practice.

After the Road Directorate had approved the proposed travel survey, Karl Arnold Ottesen and Poul Kryger from the Third Urban Planning Office, in collaboration with Hans Sveistrup from the Road Directorate, started to consider how the travel study and subsequent forecast should be designed and organized. From the outset, it was decided that an important objective with the forecast was to examine how changes in land use would impact travel behaviour. It was therefore necessary to consider methods which could be used to collect information about the origin and destination of the traffic. Another objective with the survey was to shed light on how socio-economic characteristics influence travel behaviour and how mode choice was influenced by different rationales. Before a methodological framework was decided upon, pros and cons of different methods were considered. Methods involving stalling the traffic (e.g. roadside interviews) were considered unsuitable for a survey of this scale. This narrowed the choice of methodology to the following three:

1. Postcard surveys among motor owners
2. Home interviews
3. Number plate writing method

In the choice between these different methods, the decision was made to use a rational-comprehensive approach in which the respective methods were made the subject of rational deliberations. A number of pilot studies were conducted in order to estimate the level of uncertainty of the respective methods, as well as the practical implications associated with the data processing (Stadsingeniørens Direktorat 1956b).

The considered postcard surveys among motorists differed from the survey applied in the above-mentioned forecast for Fredensgade. Motorists were to be mailed postcards asking questions about the trips they had carried out on a specified day. The merits of this method were that it allowed for collection of information about origins and destinations, it was cost effective, and it could give an impression of different social groups' travel behaviour. The disadvantages of the method were that it required a high response rate and that it could not be used to detect the actual routing of traffic.

The home interview method was commonly used in America (see Chapter 2) and was considered particularly suitable for collecting general information about actual traffic patterns, but it would be very costly to conduct the required number of interviews in order to obtain a representative

sample. However, the method could also be used to investigate how different rationalities and socio-economic factors influence mode choice. This information was crucial in order to prepare a forecast for the modal split.

The number plate writing method was particularly carefully considered, and like the post-card method, used for the forecast of Fredensgade, though with the large-scale perspective involved, this method was problematized. According to this method, a corridor or urban area is divided into a number of districts based on observation posts on the main roads connecting adjacent districts. When motorists cross the observation posts, their number plates and times of crossing are registered together. On this ground, among others, routing and trip frequencies between districts could be derived. The pro of the number plate writing method, compared to the post card and home interview methods, was that it was perceived to give a more objective picture of the geographical distribution of travel. In conformity with a positivistic conception of science, this is because the data is derived directly from observations. However, a con of the method was that it required a large staff to execute it, meaning the subsequent data processing was extremely labour and time consuming, even if punched cards were used to ease the job. Other cons of the method, relative to the postcard and home interview methods, was that it neither accounted for the origin and destinations of traffic, nor for trips within districts. Moreover, as opposed to the home interviews, the method could not be used for mapping out rationales underpinning travel behaviour. In Denmark, the number plate writing method had previously been applied in a number of studies. In Copenhagen, it was used in 1947 and 1949, in Aalborg in 1949, and in Odense in 1950. All of these studies were, however, of a much narrower scale than the study under preparation in Copenhagen (Stadsingeniørens Direktorat 1956b, p. 38). For large-scale studies, the method had received mixed reviews internationally. In the USA, England, and Germany, the method was deemed unsuited, but in Stockholm and Malmo, it had been applied in large-scale travel studies (Stadsingeniørens Direktorat 1956b, p 37). In order to evaluate the method's applicability, the City Engineer's Department conducted a pilot study, where statistical tests on uncertainties associated with observation errors were conducted. The analyses were published in an internal report and in an article in the Danish town planning journal "Byplan," titled "*Is the number plate writing method practicable?*" (Kryger & Ottensen 1955; Own translation). The tests showed that individual observation errors accumulated to an unacceptable level of uncertainty in the final result, which also tended to be biased. The reliability of the number plate writing method was particularly problematic when the purpose of the analysis was to detect the rate of trips between districts within a large geographical area, and to a lesser extent, when the method was used to detect routing within a limited geographical area. This shows how transformation in scale of study affected the method's applicability. In order to learn from experience with the practical application of the method to large-scale study areas and about how to reduce the level of observation error, delegates from the City Engineer's Department conducted study trips to Odense, Stockholm, and Malmo. Based on the experience from Malmo and Stockholm, it was decided to concentrate the efforts on reducing errors though subsequent control of the observations rather than spending a lot of resources on reducing observation errors. Another objective with the study trips was to collect information about how the survey should be designed in order to ease the subsequent data processing. Both in Odense and in Stockholm, punched cards had been applied. In Copenhagen, the transformation in scale also increased the number of required observations and thereby also

increased the demand for computing power to ease the subsequent data processing. Due to the huge amount of data assumed to be collected, it was considered almost impossible to process it manually. Instead, punched cards had to be used.⁴¹ The transformation in scale and the increased amount of travel data generated by this therefore facilitated a transformation in data-processing technology, first in the form of punch cards and then, later, computers.

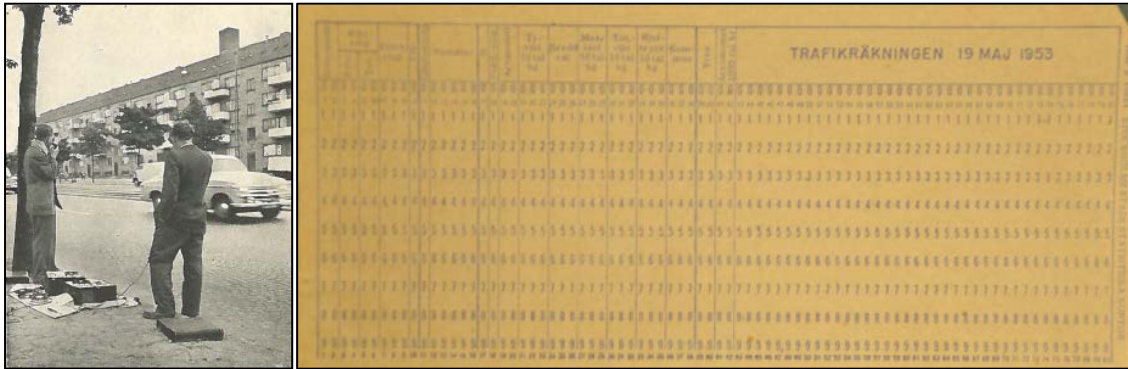


Figure 9.7: To the left: picture from the Copenhagen number plate writing survey of 1956, in which observers record the passing number plates on tape. To the right: Punch card used in travel survey in Stockholm 1953.

Based on the deliberation of the pros and cons of the different methods considered, it was decided that the traffic analysis should not be based on a single process, but rather on a combination of the following survey methods, which supplemented and allowed for control of each other.

1. A traffic counting census, in which traffic to and from the city centre was registered.
2. A number plate writing survey, in which the passing vehicles with registration plates ending at either 1 or 7 were noted at 91 counting stations, placed at four rings around the Greater Copenhagen Area, which was divided into nine districts.
3. A postcard analysis, where postcards were sent to all motor owners with odd registration numbers (60.000 post cards). The postcards contained questions about the trips conducted on a certain day, and the distance of the conducted trips.
4. A parking survey, where the number plates of cars parked in the inner city at the kerbside, car-parks, and multi-storey car-parks were registered every half hour.
5. An interview survey carried out at urban railway stations and tram stops, where 25.000 persons were asked about their origins and destinations.
6. A home interview survey, where 3000 persons aged between 18-70 were asked about which means of transport they owned or desired to purchase, what mode they used for commuting, and the purposes of their trips conducted within the two last days. The purpose of the home interview survey was not only to map out the actual travel habits of the population, but also to ascertain the rationale underpinning choices of transportation mode.

Most of the surveys were conducted in September 1956. In many respects, the Greater Copenhagen compressive travel study broke new ground in Denmark. Firstly, it was innovative

⁴¹ The Municipality of Copenhagen had in 1946, as the first municipality in Denmark, acquired a punch card machine. The punch card machine was originally purchased with the purpose of drawing up income, fortune, and moving statistics, but these tasks did not take up all the capacity of the machine (Heide 1996, pp. 87-89).

that a travel survey was based on a mix of interrelated investigations. Secondly, despite the main focus being on road traffic, this was the first time that private motoring and transit was investigated in concert in Copenhagen. Thirdly, it was the first time that a home interview survey was conducted with the objective of detecting the rationales promoting the population to choose specific means of transportation, the travel impacts of residences' geographical location within the urban structure, and the travel habits of different income groups. Another new element of the home interview survey was that the respondents were asked a number of hypothetical questions, such as whether they would purchase a car if the cost price or running costs were lowered by a specified amount or whether the opening of a new tram or bus line with a stop in proximity to the dwelling would prompt them to use this rather than their current means of transportation. The stated preferences of the respondents were to be used for detecting future travel habits.⁴² The home interview survey aimed to analyse how economic and psychological factors could impact future travel demand, and the interview guide had been prepared in collaboration with Kåre Svalastoga, Professor in sociology at Copenhagen University (Stadsingeniørens Direktorat 1956b).

In addition to the above-mentioned survey methods, which all had a more or less general scope, an experimental special investigation was conducted for the stretch of Lyngbyvej-Fredensgade. All of the above methods allow for assessments of traffic volumes on an individual stretch of road, but none of them could be used to analyse the ability of the road to handle the given traffic volume. The aim of the special investigation was to gain a deeper insight into the relation between traffic volumes, infrastructure capacity, and travel speed, or how capacity constraints influence travel time⁴³. As expected, the results showed that driving speed was lowest on the sub-distances with the most inferior technical design standards. At Fredensgade, where the largest capacity problems existed, the average travel speed varied between 20-25 km/h, and the speed level was clearly dependent on the measured traffic volumes. As opposed to this, the results showed that for the outer stretch of Lyngbyvej, where there was sufficient capacity, the speed level was around the limit of 50 km/h and fluctuated randomly without showing tendencies of being correlated with the traffic volume (see Figure 9.8).

⁴² The use of stated preferences as input to modelling did not become ordinary practices within forecasting before the late 1970's (Ortúzar & Willumsen 2001, p. 22).

⁴³ In order to determine the speed of the traffic flow on the road stretch of Lyngbyvej-Fredensgade, it was traversed in September 1956 with a test vehicle, which contained the driver and two counters. The driver was instructed to drive at the average speed of the traffic flow. In order to do so, the driver had to overtake as many vehicles as the test car was overtaken by. A total of 44 fixed points were marked out in advance on the 4.2 km long road stretch. When the test car passed one of the fixed points, the counters registered the time. During the period of investigation, the stretch was traversed approx. 125 times in each direction between 6.00 am and 8.00 pm. In addition, automatic traffic counters had been set up at four different points in each direction.

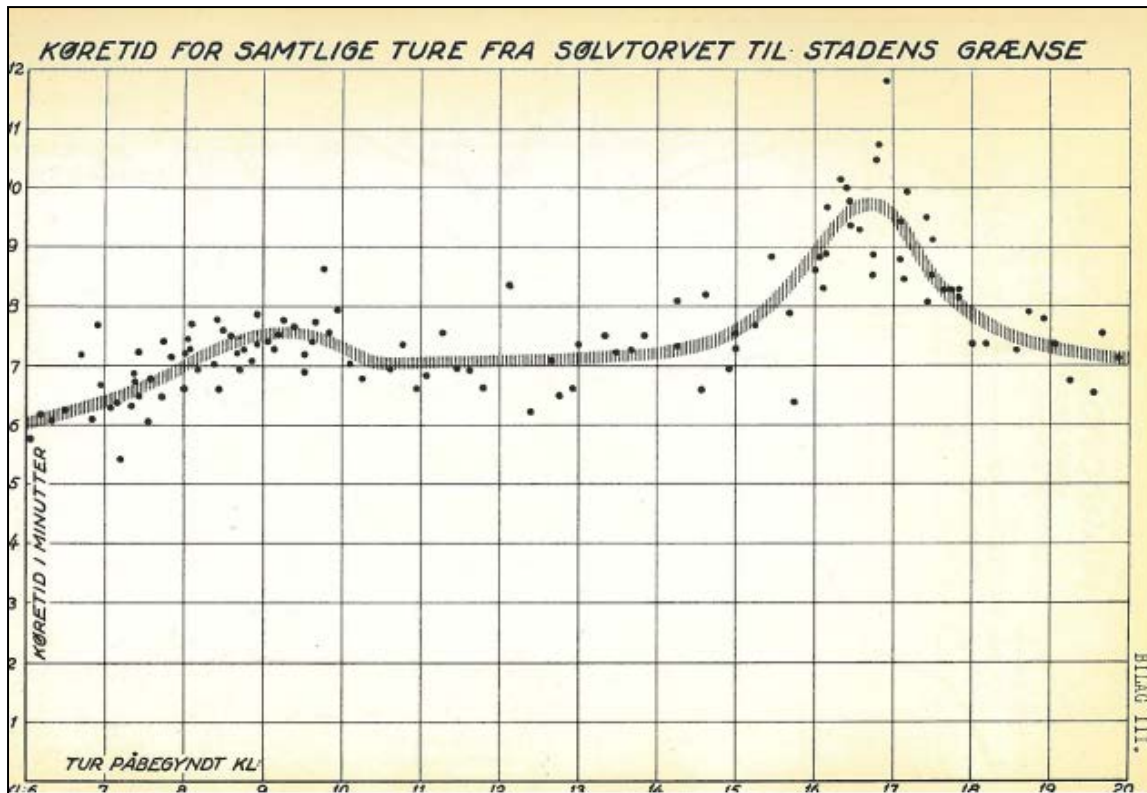


Figure 9.8: Diagram showing the travel time, at different periods of day, on the stretch of the Lyngbyvej running from Sølvtorvet to the city border (Stadsingeniørens Direktorat 1958b)

The stated objective with the experiment was to render calculations of time losses due to congestion and to use the calculated time savings as a base for preparing a prioritized infrastructure investment programme. Investments could then be channelled to those parts of the system where an enhancement of capacity would yield the highest time benefits (Stadsingeniørens Direktorat 1958b). Nevertheless, in spite of the speed/flow investigations that were initiated in order to prepare cost-benefit analyses, the investigations also came to have another influence. As will be shown in the following chapter, identification of speed/flow relations is crucial for modelling capacity restraints in assignment models (see Chapter 2).

The opening up of evaluation practice, which was generated by the transformation in scale of planning, hence involved the simultaneous application of both new and old methods in the Greater Copenhagen travel study of 1956. Yet, even though the comprehensive travel study was innovative in many ways, it did not provide a suitable base for preparing a forecast with the assistance of a computerized transport model. We will return to this in the next chapter.

When the travel survey for the Greater Copenhagen Area was prepared, different forecasting methods were also considered. Methods applied in both Europe and America were reviewed, but the focus was put on the latter. Here, in 1956, the forecasting methodologies developed as part of the Detroit and Chicago comprehensive transportation studies had not yet been disseminated (see Section 2.2.4), and the studies were not mentioned in the report. In fact, the American studies reviewed in the report were problematized for being too incomprehensive due to their mono-modal focus and a strong emphasis on accommodating car traffic. Conversely, in Europe, it was argued, the planning objective was to create a transport system balanced between private motoring and transits. As the report states:

“It follows that the American traffic analyses and the use made of them, can only serve as a model for European studies to a limited extent.” (Stadsingeniørens Direktorat 1956b, p. 34; Own translation)

Hence, the American practice was not accepted uncritically or unmodified (Stadsingeniørens Direktorat 1956b, p 34). However, in the following chapter, we will see that American methods, both in respect to data collection and forecasting method, still came to be of great significance for realizing the forecasting programme, in spite of not being accepted unconditionally.

In regard to forecasting future trip distribution, three methods were considered: the growth factor method, a correlation method, and the gravity model. The main focus was, however, on the latter. Yet, the meaning which Lill originally assigned to the gravity model, that of a physical law, was not accepted. Instead, the gravity formula was given the meaning of a crude statistical correlation. It was not accepted that traffic between two places decreased with the square of the distance, but instead, traffic was assumed to decrease with some other power of the distance, depending on the spatial locality and mode of transportation (Stadsingeniørens Direktorat 1956b). This was also the manner in which the gravity model was applied, as part of the Copenhagen Traffic Committee of July 1st 1944 (see section 9.1.1). The applicability of the gravity model was also conditioned on inclusion of induced traffic. In fact, it was accepted that improved travel conditions generated an increase in travel and this effect ought to be accounted for in the gravity model. As the report states:

“For purposes of forecasting, future values of the exponent n must be determined for each area, taking into account the improvement of traffic conditions, since these improvements can be expected to lead to a lowering of the exponent.” [...] “It is, furthermore, a condition that the formula can use for forecasting purposes, by which one can assess how the coefficients will change with growth in car ownership and the development of the city and its traffic conditions all in all. With the improvement of traffic facilities, the distance’s influence will decrease and the exponent in the formula will approach zero.” (Stadsingeniørens Direktorat 1956b, p. 32-33; Own translation)

In accordance with the findings from Chapter 7, this shows that induced traffic, in the form of increased traveling distance, was also part of the planners’ discursive consciousness within the Department of the City Engineer. Among the three different methods considered, the gravity model was chosen for use after the data collection was completed. Methods for modelling modal split and assignment do not, however, appear to have been considered in advance. The data collection was hence not collected in a tailor-made fashion for a particular forecasting method. In the next chapter, it will be shown how this came to serve as an obstacle for completing the forecasting programme.

The results of the traffic surveys and analysis were issued in three volumes in 1960 (Stadsingeniørens Direktorat 1960a; b; c). The data derived from the number plate writing survey was used to estimate the distance exponent and constants of the gravity formula. In accordance with the results from the 1945 survey, the distance exponent for residential zones was lowest in the central area and increased with the distance to the centre. This implies that

employees living in the outer areas were less dependent of distance in regard to choice work location than their inner-city counterparts. Compared to the results of the travel survey of 1945, the results of the 1956 travel survey did not, however, show the distance exponent to be lowered as much as expected (Stadsingeniørens Direktorat 1960a, pp.17-18). Hence, the data did not show a strong support for the theory of induced traffic.

9.1.6 Completing the forecast and acceptance of American forecasting practice

After collection of travel data was completed and processing of the data was initiated, Ottesen drew up a proposal for a programme for completing the forecast in December 1959/January 1960. The programme consisted of five points:

- 1) Selecting of forecasting method
- 2) Bringing the 1956 travel study up to date
- 3) Development of car ownership forecast
- 4) Development of hypothesis about future urban land-use and infrastructure systems
- 5) Execution of a forecast for 1980

In regard to the first item on the list, a final choice had not yet been made on forecasting methodology, but it was decided that the method should be designed in a manner allowing for calculations of modal split and assignment of road traffic. Statistical relations about how travel time affected mode choice were supposed to be derived from the home interview survey, and on that basis, a modal split model which included biking, transit, and private motoring should be developed⁴⁴. Hence, the considered modal split model fulfilled the multimodal requirements of comprehensive transport planning (see Chapter 2). However, as it will be shown in the following chapters, the inscription of such multimodality turned out to be troublesome. Even though a final decision on forecasting method was not taken, Ottesen nevertheless specified that:

“In the design of forecasting method, we must partly rely on the causal relations found from the traffic of Great Copenhagen and partly on lessons from the traffic analysis made in other cities, where, in particular, it will be important to learn from the American calculation technique, although the results of the Greater Copenhagen travel study do not allow quite as detailed calculations.” (Own translation)⁴⁵

While American methods, due to their narrow focus on car traffic, were found unacceptable when the 1956 travel study was designed (see Section 9.1.4), Ottesen now turned the focus directly towards the USA for inspiration. Ottesen argued that while the comprehensive perspective had previously been lacking in America studies, it was now championed in cities such as Chicago, Washington D. C., and San Francisco. In these cities, the objective was, according to Ottesen, to prepare a plan for a balanced transport system, which was grounded in

⁴⁴ Karl Arnold Ottesen *“Notat vedrørende færdiggørelse af Storkøbenhavns trafikanalyse 1956”*. BP3. 28.01.60. (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁴⁵ Karl Arnold Ottesen *“Skitse til program for udarbejdelse af en generel trafikprognose for Storkøbenhavn”*. BP3. 29.01.60 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

objective and scientific investigations. In these cities, computer models were used to evaluate different regional master plan alternatives so that the most optimal solution could be identified⁴⁶. It appears that the role which transport modelling undertook, particularly in the Chicago Area Transportation Study, served as an ideal for the role which computerized transport modelling was envisioned to take within Danish planning practice. In fact, the figure which depicted the role of the model in CATS was copied within the Department of the City Engineer. Apparently, this copy was used as prototype in the elaboration of how EDP could take part in advancing conventional transport planning towards a more comprehensive approach (see figure 9.9; see Section 2.2.3). In fact, the potential of computerized transport models to make planning truly comprehensive was a prominent rationale for accepting computerized transport models within Danish planning practice. We will return to this argument and elaborate on it in section 9.3.1. Next, however, we will return to Ottensen's programme for finalizing the forecast.

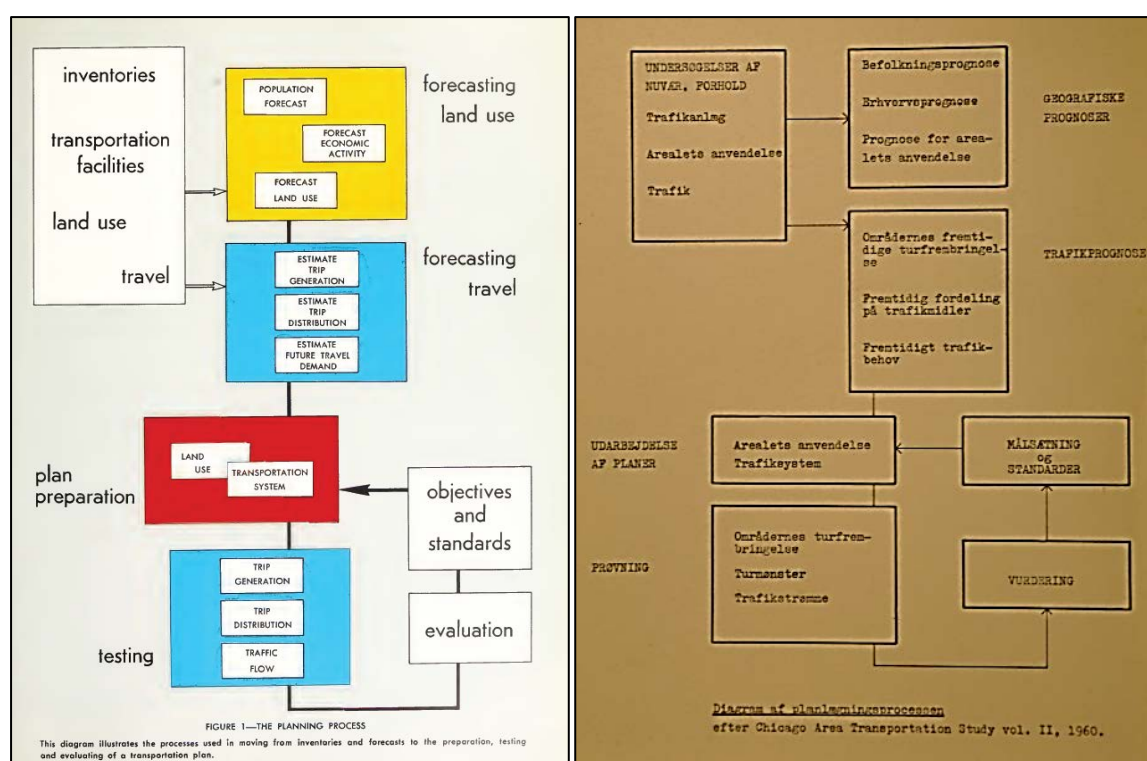


Figure 9.9: Flow chart of the planning process of the Chicago Transportation Study, copied by the Department of the City Engineer⁴⁷

In regard to the second item on Ottsen's programme for finalizing the forecast, namely to bring the 1956 travel study up to date, new traffic counts and new investigations on the development of population and businesses were to be carried out⁴⁸. Particular knowledge about the geographical distribution of workplaces within the metropolitan area was missing. A business census had been conducted in 1958, and it was hoped that when the subsequent processing was

⁴⁶ *Nye tendenser i amerikansk trafikplanlægning* (Plandirektoratets arkiv, Trafikanalyse 1967, 1967, Diverse, Box 1)

⁴⁷ *Hovedkrav til et fleksibelt program for maskinel trafikberegning*, BP3, K.A.O., 18.12.61, (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

⁴⁸ *Notat vedrørende færdiggørelse af Storkøbenhavns trafikanalyse 1956*, BP3, K.A.O. 28.01.60. (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

finalized, the results could be used for the purpose of forecasting. We will return to this in the next chapter.

The fourth item of the programme, namely development of a hypothesis regarding future urban land-use and infrastructure systems, was one of the larger tasks for completing the forecast. In practice, it implied preparation of a proposal for a regional land-use and transport plan. This work was, however, already initiated elsewhere. The societal development in the 1950s had, in several respects, outgrown the assumptions of the Finger Plan, e.g. in regard to population, consumption of space, and car ownership. In other respects, they had not been fulfilled; for instance, the electric local rail network was not extended as assumed. A revision of the Finger Plan was therefore considered urgent, and on the initiative of the Ministry of Housing, the Regional Planning Secretariat was set up in 1958, under the Urban Planning Committee's metropolitan division, with the objective of preparing a new regional transport and land-use plan for Greater Copenhagen Area (Egnsplansekretariatet for Storkøbenhavn, 1960a). As the forecast was to be based on regional land-use patterns, the work of the Regional Planning Secretariat was significant for finalizing the forecast. Ottesen states as follows:

“In cooperation with the Regional Planning Secretariat, one or more hypotheses on the future urban structure and traffic system must be established. As prerequisites for the forecast, assumptions must be made both on the future distribution of residents and employed [within the metropolitan area] and on the future road and transit systems, which will all be included as an important part of the preliminary regional land-use plan which is now under preparation” (Own translation)⁴⁹

The regional land-use and infrastructure alternatives were therefore intended to be prepared in collaboration with the Regional Planning Secretariat. As the story has been told so far, we have seen that even though transformation in practices occurred, there have not been many interruptions of the forecasting programme caused by unforeseen obstacles. In the following, however, this will change, particularly in respect to the preparation of land-use scenarios and the business survey, where the forecasting programme ran into trouble. These issues were not solved easily, even after a computer was enrolled into the programme to assist in the completion of the forecast.

9.2 The spatial policy controversy

This section elaborates on the preparation of the regional land-use and transportation alternatives which the forecast was supposed to evaluate. As mentioned, these alternatives were supposed to be drawn up in collaboration with the Regional Planning Secretariat. However, this work was interrupted by the outbreak of a spatial policy controversy in which the future spatial order of the Greater Copenhagen Area was at stake. Both the Municipality of Copenhagen and the Regional Planning Secretariat were among the combatants, but they stood

⁴⁹ Karl Arnold Ottesen *“Skitse til program for udarbejdelse af en generel trafikprognose for Storkøbenhavn”*. BP3. 29.01.60 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

on opposite sides of the dividing line. The conflict was about the Regional Planning Secretariat's new regional plan proposal. Contrary to the prevailing mono-centric spatial order of the Finger Plan, the new plan proposal advanced a decentralized and more polycentric spatial order. The plan proposal was therefore a threat to the spatial capital tied up to Copenhagen's structural position within the mono-centric spatial order. Next, we will explore how this attack on Copenhagen's spatial capital generated a need for facts, which facilitated the decision to develop the computerized transport model.

9.2.1 Copenhagen's plans for manifesting the mono-centric spatial order

Before elaborating the spatial policy controversy, it is necessary to introduce Copenhagen's development plans as they progressed after the Master Plan Draft was issued. In 1958, the same year the Regional Planning Secretariat was established, the Municipality of Copenhagen issued its first plan which specified the Master Plan Draft's vision for extending the central business district to the inner-Vesterbro (see section 9.1.3). The plan was titled "City Plan West" and concerned redevelopment of the area with high rise office buildings (see Figure 9.10).

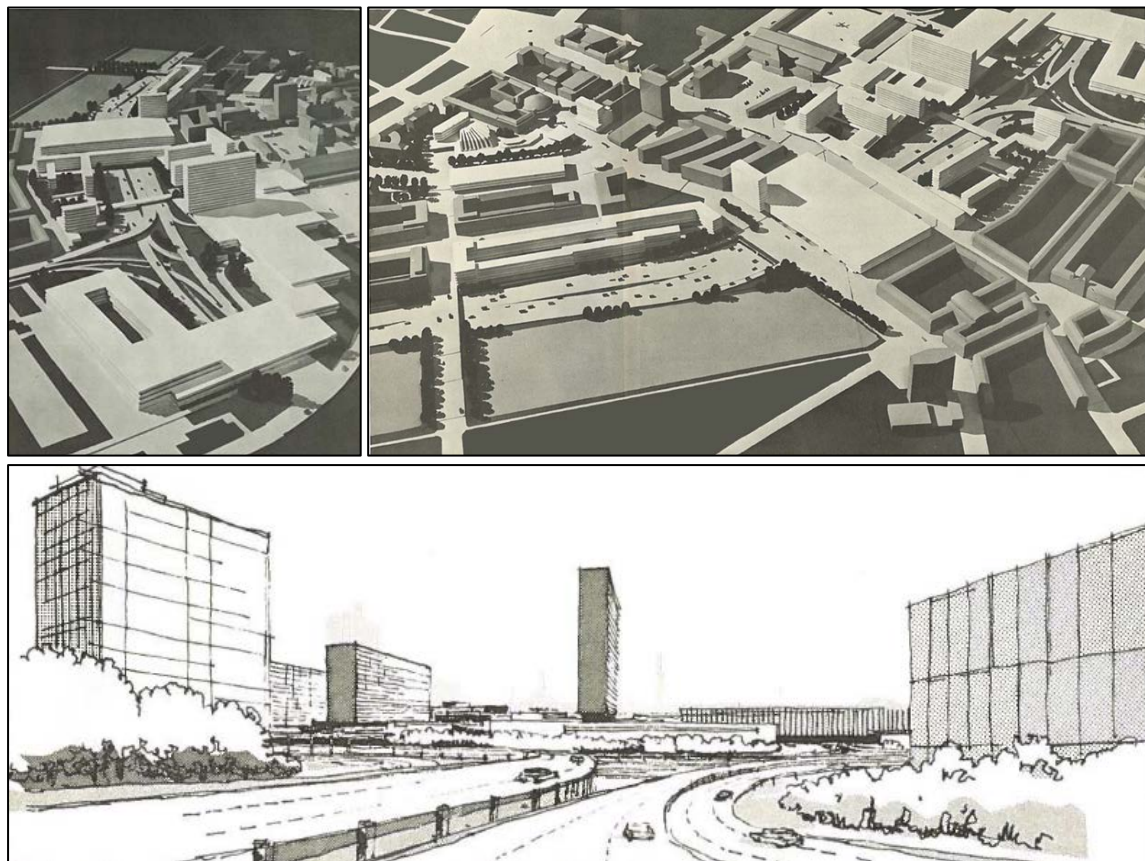


Figure 9.10: Draft models of City Plan Vest (Stadsingeniørens Direktorat 1958a)

The area was intended as a main traffic hub. It was located in proximity to the central train station, a planned subway station, and the junction between the West Motorway and inner semi-circular road, known as the Lake-ring (Stadsingeniørens Direktorat 1958a). In both the Finger Plan and the Master Plan Draft, the Lake-ring was only introduced as a line on a map, but in the City Plan West report, the design of the Lake-ring was specified for the first time (see Figure 9.11). The design was drawn up based on a forecast which also assumed a 50%

employment increase within the central business district. According to the forecast, 80% of future Lake-ring traffic would be oriented towards the Central Business District and only 20% would be through traffic. The forecast was therefore also based on the assumption that the mono-centric spatial order would continue to prevail in the future. Expansion of the central business district, however, implied a risk of overloading the narrow street systems of the area. As a solution to this problem of the mono-centric spatial order, the Lake-ring was designed as a semi-circular feeder road. As it is stated in the report:

“The proposed primary road along the lakes and through Vesterbro to Amager is placed as a protective ring, which collects and distributes traffic flowing towards the city area and diverts irrelevant traffic around this part of town.”
(Stadsingeniørens Direktorat 1958a)

The intention of the Lake-ring’s design was to create a ring which protected the narrow street system of the central business district by efficiently leading motorists close to their destinations within the central business district while simultaneously diverting through traffic away. The Lake-ring was also closely related to the problem of harbour crossing road capacity. The possibilities of further enlarging the capacity of the two central crossings were almost exhausted. Yet, it was foreseen that additional harbour crossing capacity would be needed within a foreseeable future. The evidence indicated that extension of the Lake-ring to Amager could provide a solution to this problem. This solution could also help in diverting through traffic away from the city centre more effectively. We will return to the City Plan West area and the Lake-ring in the next chapter.

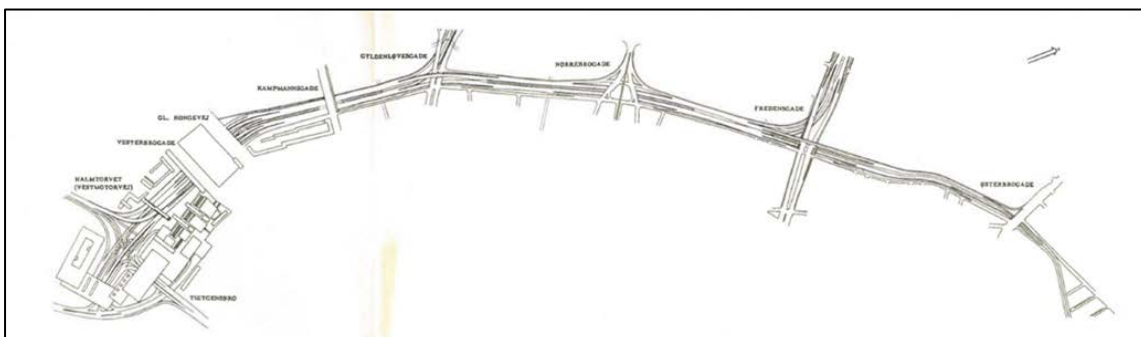


Figure 9.11: Outline for the design of the Lake-ring (Stadsingeniørens Direktorat 1958a)

It was not only in respect to the central business district that Copenhagen specified its expansion plans. In one of his speeches to the Joint Committee, the Chief City Engineer introduced the possibility of further development on the island (Stadsingeniørens Direktorat 1956a). Negotiations with the state about co-ownership of Amager Fælled were reassumed. In spite of the fact that an agreement had not been reached, Copenhagen still issued the proposal of a comprehensive plan for a part of West Amager, which would contain accommodation for 20.000-30.000 inhabitants (Stadsingeniørens Direktorat 1967c).

From the above, it can be seen that Copenhagen’s development plans for expanding the central business district corresponded with the mono-centric spatial order of the Finger Plan. The plan to develop on Amager, however, did not. Yet, as will be elaborated on below, both of these

plans were incommensurable with the new spatial order advanced by the Regional Planning Secretariat in its proposal for a new regional plan.

9.2.2 The new regional plan: Problematizing of the mono-centric spatial order

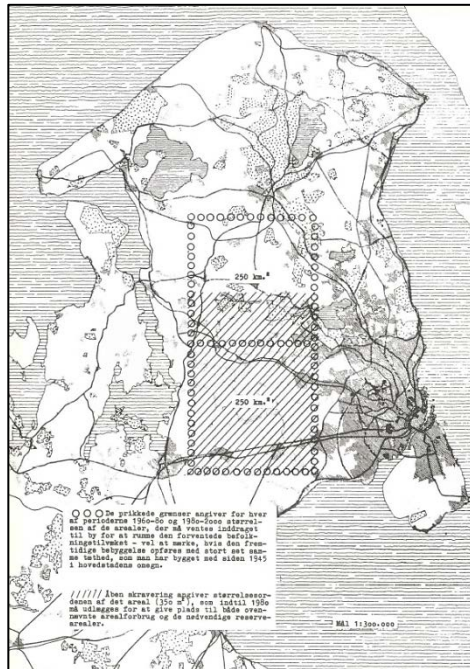


Figure 9.12: Estimated amount of land needed to be set aside for urban development until 1980 and 2000, respectively (Egnsplansekretariatet for Storkøbenhavn 1960c)

In December 1960, the Regional Planning Secretariat issued an outline to the new regional plan, the so-called “Preliminary Outline Plan for the Copenhagen Metropolitan Region”,⁵⁰ hereinafter referred to as the Preliminary Outline Plan. While the assumptions of the Finger Plan reflected a period of recession, the assumptions of the Preliminary Outline Plan clearly mirrored a period of booming growth. In respect to the future population size of the Greater Copenhagen area, the Ministry of Housing and the Statistical Department had both recently prepared a national population forecast for 1980 and 2000, respectively. In order to avoid the small-mindedness of the assumptions underpinning the Finger Plan, the higher of two forecasts was chosen, namely the one prepared by the Ministry of Housing, showing 6 million inhabitants in 2000 (Larsen 1998). Based on assumptions about Copenhagen’s share of this population, it was estimated that the population would grow from approx. 1.5 million in 1960 to 2 million in 1980, and to 2.5 million in 2000. Compared to the 1.5 million assumed in the Finger Plan, the future population size was adjusted upwards by a considerable amount. Under the assumption of 2.5 residences per dwelling, the future population was then converted into a future housing demand of 0.5 million dwellings. As can be seen in Figure 9.12, the area suggested to be set aside for future urban development constituted a significant part of the existing urban area. In fact, it was almost a tripling (Egnsplansekretariatet for Storkøbenhavn 1960b; 1960c).

The question now became how this urban growth should be ordered. Allowing the Metropolis to explode and the population to sprawl randomly over the entirety of Zealand was considered unacceptable. As the report states:

“One must fully realize that of all the imaginable urban structures, is it the scattered city that makes use of transit the most difficult, just as consideration of reasonable cost in respect to the establishment of common technical facilities such as drainage systems talk to the contrary. All in all, the rationality which underpins this type of settlement appears to be in diametrical opposition to the ideas about economic urban development which exist behind the urban-regulatory law. The secretariat considers the idea of “urban landscape” in the sense of an urban

⁵⁰ Principskitse til Egnsplan for Storkøbenhavn

sprawl, where settlements are placed on the basis of aesthetic motives without regard to other functional requirements than outdoor recreation, and where passenger traffic is assumed to be based on passenger cars, and therefore, this idea should not be considered a planning principle to be applied in land-use planning for the Copenhagen region.” (Egnsplansekretariatet 1961a, p. 33; Own translation)

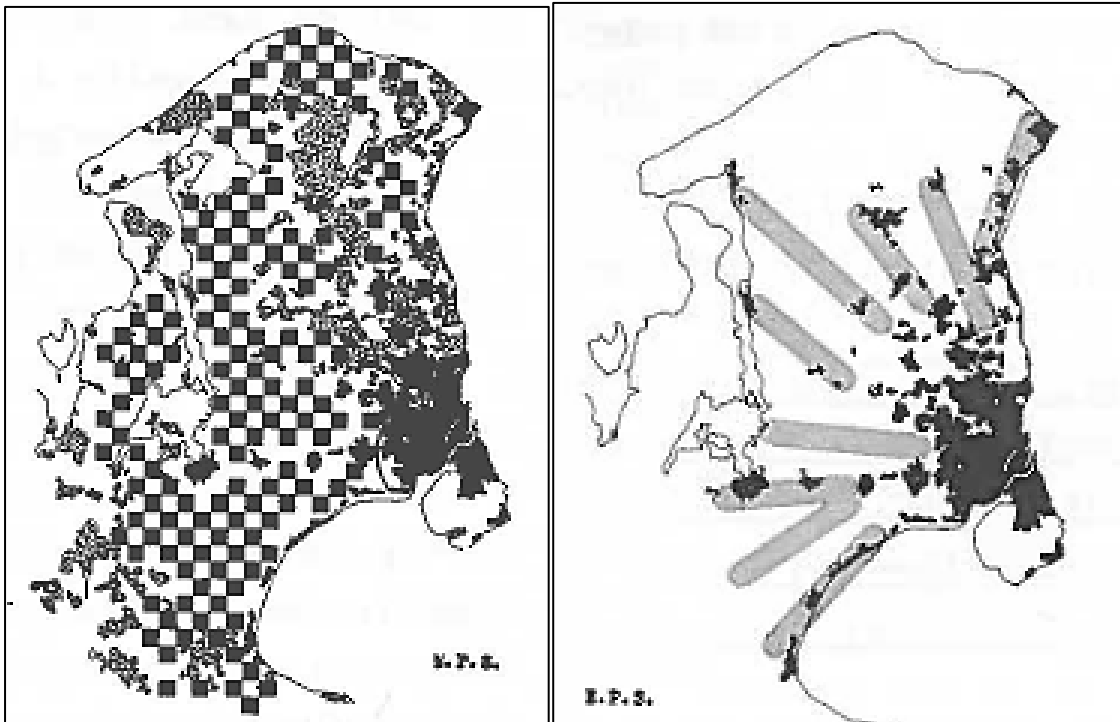


Figure 9.13: To the left, urban sprawl alternative. To the right, alternative with prolongation of fingers and establishment of new ones (Egnsplansekretariatet for Storkøbenhavn 1961a)

Despite the exploding Metropolis being declared unacceptable as the future spatial order, a continuation of the prevailing mono-centric finger structure was also problematic. At that time, the fingers were not allowed to be more than 2 km thick. If the assumed future growth was to take place in accordance with the logic of the prevailing spatial order, the fingers therefore had to be prolonged all the way to the marked towns and additional fingers also had to be constructed (see Figure 9.13). Another concern against the mono-centric city was that increased employment within the inner city areas implied increased traffic load in these areas, and combined with the rise in motoring, this was foreseen to cause tremendous traffic problems. In the report, it is stated.

“If one in such a city [mono-centric] still must be able take up residence fairly freely, without regard to the location of workplace, the very vast majority of employment must still be placed in the inner-city areas. We must therefore anticipate that the city area would spread out to the rampart quarters and inner-city areas. At the same time, we must anticipate up to a doubling of the maximum travelling times and costs. That the already difficult trips across the fingers will become even more time-consuming and troublesome is evident. Also, the possibilities of using passenger cars in the direction facing the Centre will be further reduced. The Secretariat has believed that for such a large city, the mono-

centric structure ... contains such great difficulty that it cannot be maintained in the long run.” (Egnsplansekretariatet 1961a, p. 40f; Own translation)

The mono-centric urban structure which underpinned the Finger Plan and Copenhagen’s Master Plan Draft was hence rendered unacceptable as the future spatial order of the Copenhagen Metropolitan Region. Instead, an alternative spatial order was drawn up in the Preliminary Outline Plan. While the Finger Plan was based on a spatial logic about minimizing travel time to the high number of workplaces within the central business district, the spatial order advanced in the Preliminary Outline Plan was underpinned by a logic focused on minimizing commuting distances by creating local balances in the distribution of residences and workplaces. Hence, despite unorganized urban sprawl not being accepted, the Preliminary Outline Plan accepted organized decentralization as the main spatial logic of order. Moreover, distinct from the prevailing spatial order of the Copenhagen Metropolitan Region, the plan advanced a more poly-centric spatial order. In order to preserve the scenic beauties of North Zealand, it was suggested that the majority of the development be concentrated in a new “super finger” located in the southwest corridor between the Roskilde and Køge fingers. This new development corridor was called the Chain and consisted of a row of districts, each holding 250.000 inhabitants and being connected to central Copenhagen by a rail line without in-between stops (see Figure 9.14). Despite the many discrepancies between the Preliminary Outline Plan and the Finger Plan, they were nevertheless similar in one respect: Both recommended that future development on Amager be suspended. (Egnsplansekretariatet for Storkøbenhavn 1960a).

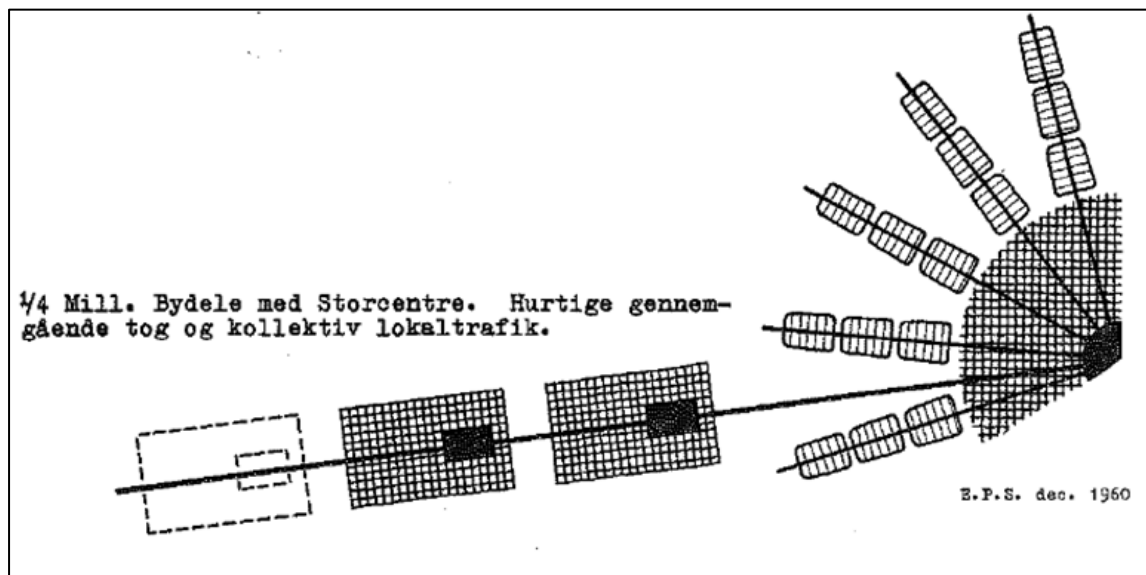


Figure 9.14: The Preliminary Outline Plan was based on organized decentralization as the main planning principal, and advanced a more poly-centric urban structure where the majority of the development was concentrated in the southwest corridor between the Roskilde and Køge fingers, in a row of districts, each holding 250.000 inhabitants and being connected to central Copenhagen by a rail line without in-between stops (Egnsplansekretariatet for Storkøbenhavn 1960a)

In 1961, the Regional Planning Secretariat issued an addendum to the plan, where the proposed Chain alternative was evaluated against the so-called Ring alternative, in which urban development was concentrated in an outer ring located around four of the provincial towns (see Figure 9.15). Both alternatives were based on decentralization as spatial logic, but the spatial order of the Ring was more commensurable with the Finger Plan. The evaluation of these two alternatives was conducted under different assumptions by a gravity model, namely an

organized and an unorganized city alternative and with low and high distance dependency, respectively (Egnsplansekretariatet for Storkøbenhavn 1961b). In the organized alternative, the rate of internal trips was high, and vice versa. Also, two alternatives were also investigated in respect to modal split, and a rough transport economic evaluation was conducted. Despite the difference being minor, the results of transport economic evaluation showed that the Chain was preferable.

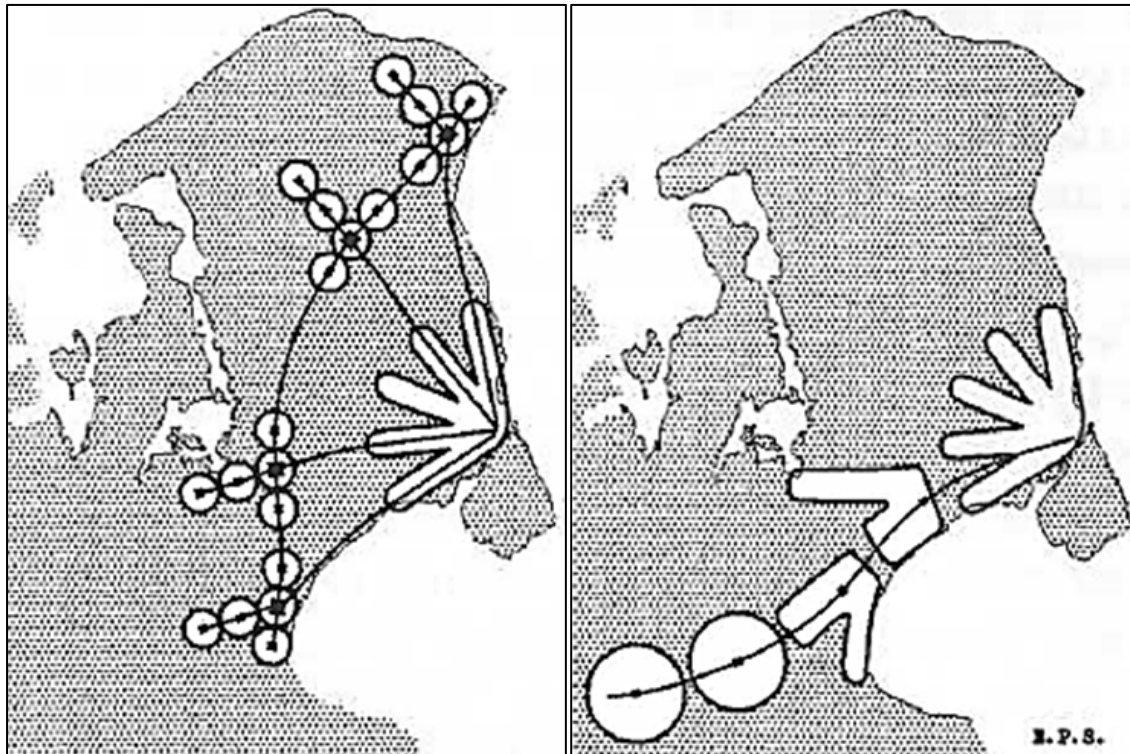


Figure 9.15: The Chain and the Ring (Egnsplansekretariatet 1961a, p. 53)

Summing up, the spatial order advanced in the Preliminary Outline Plan for the Copenhagen Metropolitan Region was hence incommensurable with the spatial order underpinning the Finger Plan and Master Plan Draft. Moreover, the underrated mono-centric spatial order was problematized on the basis of its being ineffective in the new era of the car. Instead, a more poly-centric and decentralized spatial order was advanced, and the superiority of this spatial order was reified by scientific calculations.

9.2.3 De-reification of the Regional Planning Secretariat's traffic evaluation

The new regional plan proposal generated a heated debate among the different planning authorities within the Greater Copenhagen area, and the proposed decentralisation and poly-centricity were met with non-acceptance by the Municipality of Copenhagen and State agencies affiliated with the transport sector, among others. Copenhagen had a special interest in sustaining the mono-centric spatial order of the Finger Plan and hoped to de-structure the Regional Planning Secretariat's attempt to challenge the established order. Due to the decentralization trend, the Municipality of Copenhagen was already declining in respect to business and population, and hence also in respect to revenues from taxation. Contrary to the interest of Copenhagen, the Preliminary Outline Plan would reinforce the decentralization

trends rather than reverse them. Therefore, the proposed poly-centric spatial order did not only constitute an attack on Copenhagen's "spatial capital" but also on its tax base.

This sub-section explores how the Municipality of Copenhagen reacted to this attack on its structural position and how the attract on the spatial capital generated a need for facts, which facilitated the emergence of computerized transport modelling.

In defence of its spatial capital, Copenhagen attempted to de-reify the assumptions of the Preliminary Outline Plan. Even though it was generally accepted that the future population assumed in the Finger Plan was underestimated, the population forecast of the Regional Planning Secretariat was criticized for being overestimated. The proposed infrastructure systems were also criticized for being too cost-intensive, as many new constructions were required. Moreover, the amount of land suggested to be set aside for future urban development was problematized for being too spacious. Also, the Regional Planning Secretariat's traffic evaluation was attacked. In that regard, Karl Arnold Ottesen from the Municipality of Copenhagen criticized the Regional Planning Secretariat's proposal, both in an article from June 1961 in Danish planning journal "Byplan," and in an internal working paper⁵¹. In these papers, Ottesen attempted to render the assumptions upon which the new regional plan proposal was based on for arbitrary. In regard to the traffic evaluation, he states as follows:

"If the reduction in traffic costs really is perceived as an objective of primary importance, it would be appropriate to aim for a more extensive utilization of the area than provided in Preliminary Outline Plan, so that there could be established an effective and profitable public transport operation. [...] From the traffic economic assessment, it is evident is that it is imagined that the new districts will come to rest in themselves and will only produce a minimum of traffic with the outside world. Although a numerical balance between residents and working places is established in the new districts, it will never be possible to make the traffic between them insignificant, especially not when there are exceedingly rapid transport links. It also says that the principle of the plan is intended to relieve the traffic load in the central districts [by making the new districts self-contained]. [...] These efforts are all honour-worthy, but it seems very doubtful whether the desired effect can be achieved with the proposed formulation of the Preliminary Outline Plan. After a realistic assessment, the new districts produce more traffic with the outside world than what is imagined, and this traffic will, as a result of the city's division into a Northern and a Southwest sector in particular, be directed towards the central districts and probably attack these in a particularly dangerous way because traffic pressure is channelled predominantly in a single direction."
(Ottesen 1961, p. 13-14; Own translation)

Based on arguments related to the compact city model, Ottesen therefore claimed that the new outer districts would increase traffic rather than reducing it as argued by the Regional Planning Secretariat. In regard to the organized and unorganized alternatives evaluated by the Regional Planning Secretariat (see section 9.2.2), Ottesen argued that compared to the result of the 1956

⁵¹ (Plandirektoratets arkiv, Egnspaner, 1960-1961, 1960-1961, Box 1)

comprehensive travel study, the number of external car trips in the suburban municipalities assumed in the Regional Planning Secretariat's unorganized alternative, was actually representing a very organized city. Likewise, the degree of internal trips assumed in the organized city alternative resembled an unattainable utopia. On that ground, Ottesen argued that in the organized alternative, commuting between districts was grossly underestimated, and the unorganized alternative seemed to be the more likely of the alternatives. In accordance, in respect to modal split, he argued that the car-based alternative also was more likely than the transit alternative. If the evaluation was based on these two assumptions, then the Chain and the Ring would perform equally well according to the Regional Planning Secretariat's calculations. However, under these assumptions, a serious consequence of the Chain would be that a 20-laned road would be required between the main city of the new outer districts and the nearest chain link. Contrary to the conclusion of the Regional Planning Secretariat, Ottesen therefore claimed that the overall amount of travel generated by the Ring would be less than in the Chain (Ottesen 1961, p. 21). Yet, it would be necessary to evaluate more alternatives based on more detailed and realistic assumptions in order reach a final conclusion concerning which of the alternatives was the better traffic-wise. While it was argued in section 7.2 that the County Road Surveyors' non-acceptance of the demand for the engineering firm's proposed intercity expressway system was partly tied to a desire to maintain the dominating social order, the above shows that non-acceptance of new structuration practices also can be tied to a desire to maintain the prevailing spatial order.

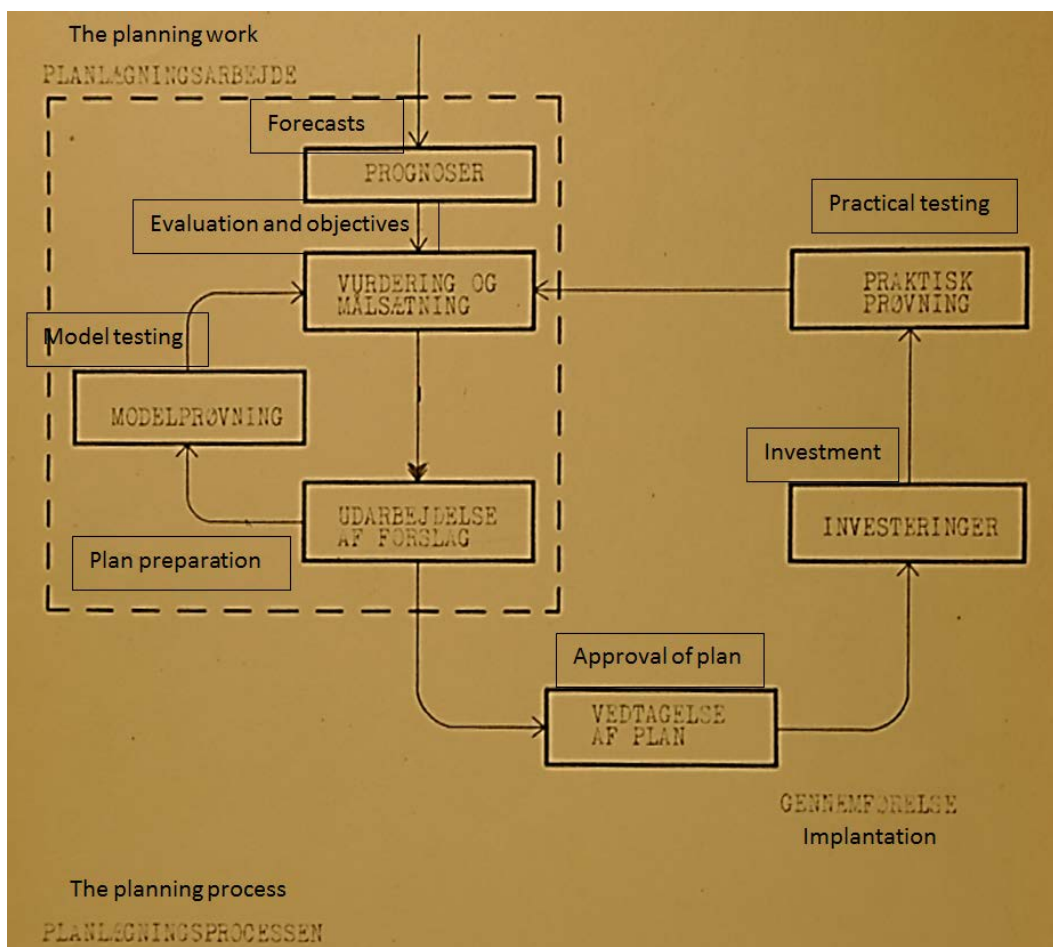


Figure 9.16: The role of transport models in an iterative planning process (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

In the article, Ottesen (1961) argues further that theoretical traffic models executed by the assistance of computers were a particularly suitable tool for making an evaluation. Such models could provide a scientific, objective, and cost-effective evaluation of many alternatives. Computerized transport models would also enable more iterative planning processes by which the proposed alternatives could be evaluated, and on the basis of this evaluation, the alternatives could be revised and optimized. The new proposals should then be evaluated once again and then further optimized in the light of the evaluation results, thereby causing the planning process to continue in a spiral. The traffic forecast was therefore to serve a general function in the planning process, acting as a tool for testing and evaluating alternative proposals to the region's future urban structure and corresponding traffic systems, in accordance with a rational, comprehensive approach to planning (see Figure 9.16). According to Ottesen, computerized traffic models should serve to bring closure to and de-politicize the controversy surrounding the Greater Copenhagen Area's future spatial order. Approximately a year later, while the policy dispute was still on-going, Copenhagen decided to initiate development of a computerized transport model.

9.2.4 Opening spatial planning up despite non-acceptance

Due to the critical response towards the regional plan, the Ministry of Housing appointed an expert committee in February 1961, with the objective of preparing a technical evaluation of the plan and orchestrating an agreement between the parties participating in the spatial policy dispute. This sub-section explores how the Regional Planning Secretariat's attack on the prevailing mono-centric spatial order contributed to opening up and re-politicizing the issues regarding the future spatial order of the Greater Copenhagen Area.

Although the Regional Planning Secretariat's proposal was met with non-acceptance, it still succeeded in questioning the underappreciated nature of the mono-centric finger structure and re-politicizing the issue of the Greater Copenhagen Area's future spatial order. Within this opportunity for change, planners were undoubtedly thinking out of the box, as the sketches (see Figure 9.17) found in the archive very clearly depict.

Moreover, in spite of the Regional Planning Secretariat's proposal being met with non-acceptance by the Municipality of Copenhagen, it nevertheless contributed to reopening the Master Plan Draft and allowing for potential changes to be made. At a meeting in the Technical Committee in May 1962, Ole Thomassen from the Department of the City Engineer stated that:

"The enormous development in car traffic has necessitated a re-dimensioning of the road system proposed in the Master Plan Draft, and the development has necessitated a new qualitative assessment of this draft - a complete revision - although it is not yet 10 years old and has never really been approved. The Preliminary Outline Plan for the Copenhagen Metropolitan Region has helped raise these questions." (Thomassen 11.04.62)⁵²

⁵² Udvalget til teknisk gennemgang af Principskitsen til en egnsplan. 12. møde. Oversigt over udvalgets møde den 11. april 1962 i "Byplanhuset". P. 6 (Plandirektoratets arkiv, Egnplaner, 1960-1961, 1960-1961, Box 1)

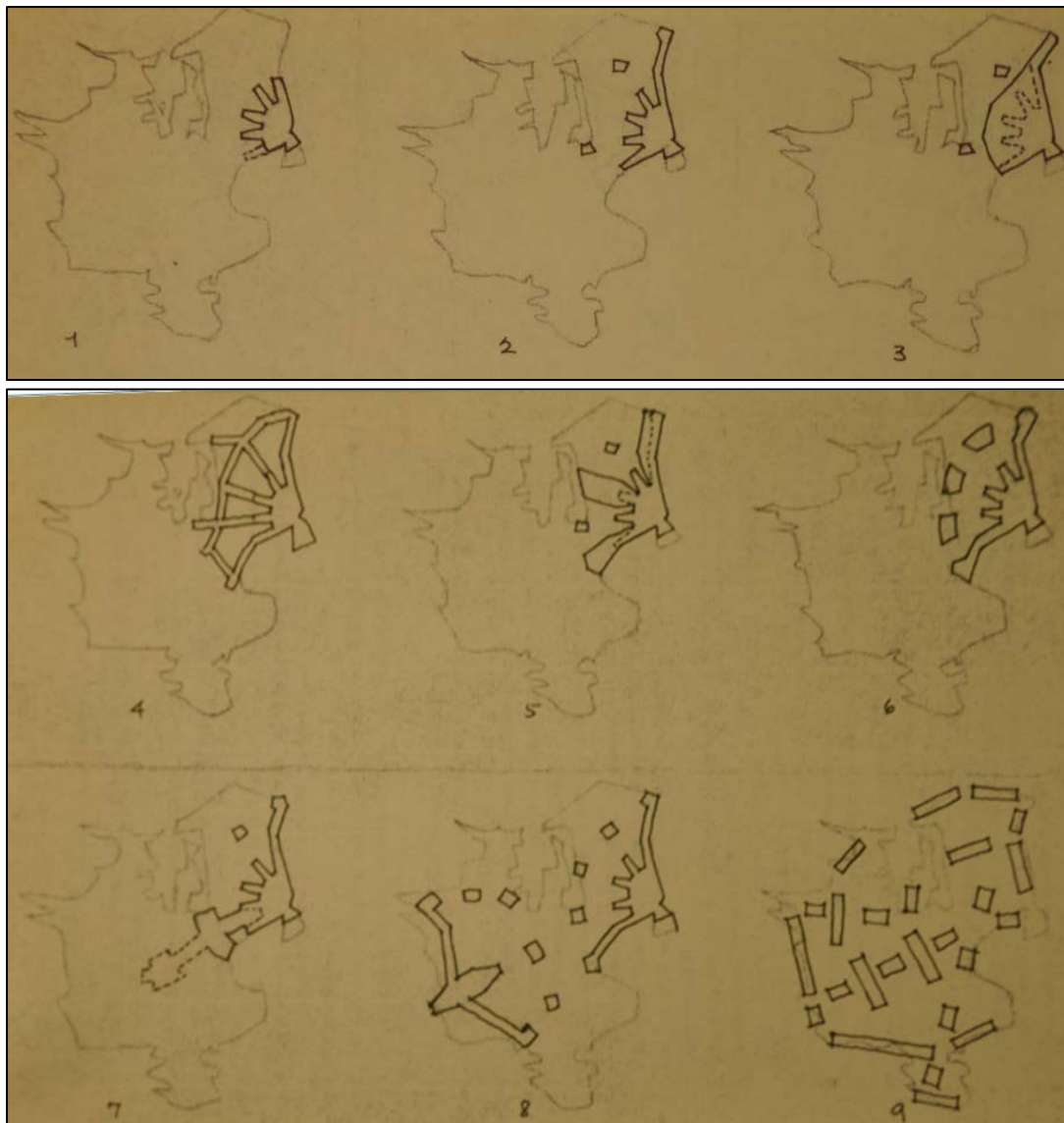


Figure 9.17: Draft of different urban structures, found in an archive concerning regional planning between 1960-61. (Plandirektoratets arkiv, Egnspaner, 1960-1961, 1960-1961, Box 1)

The reopening of the Master Plan Draft did not only imply that the capacity of the primary road system had to be resized. A proposal had also been prepared to create a so-called “re-centralization belt” located within municipal borders of Copenhagen, along the semi-circular road of the Goods-ring (see Section 9.1.3; see Figure 9.18). This proposal stated that companies and institutions which, by virtue of the catchment or business area, were in need of a location with high accessibility to the rest of the metropolitan area, but which did not require or have the economic ability to be located within the central business district, should be encouraged to relocate within this belt through a deliberate urban renewal policy (Stadsingeniørens Direktorat 1962). In this way, the workplaces which were crowded out from the central business centre due to the processes of decentralization and differentiation within the central business district could be kept within the municipal borders (see Figure 9.18). This would mean that the decentralization of the Central Business District would not undermine Copenhagen’s tax base.

As part of the policy dispute, the Municipality of Copenhagen developed several urban development alternatives. An alternative with a common stay of development until 1980 was

suggested. This first stage did not prejudice any of the long term development alternatives (see Figure 9.18). From Figure 9.18 it can be seen that the re-centralization belt was included in all the alternatives proposed by the Department of the City Engineer. Moreover, it should be specially noted that the alternative resembling the Regional Planning Secretariat's Chain proposal included increased urban development on Amager. This shows that the Municipality of Copenhagen was only willing to accept the Regional Planning Secretariat's proposal if they got something in return.

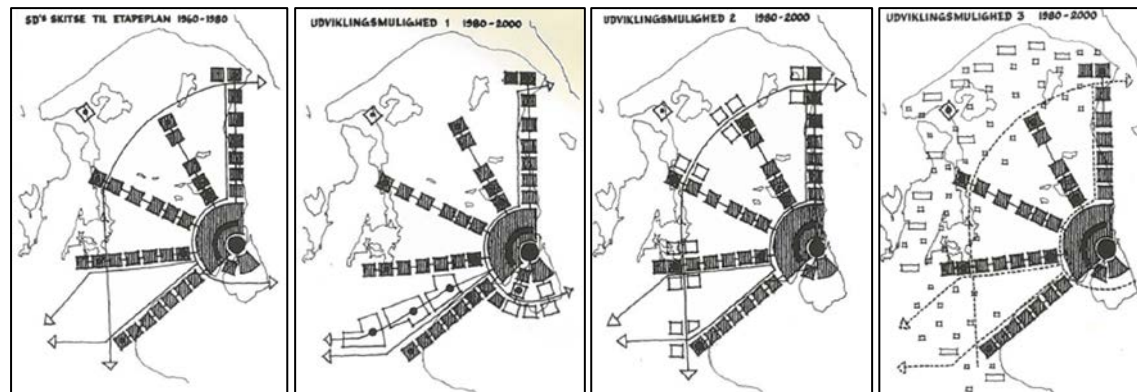


Figure 9.18: The Department of the City Engineer's alternative proposals for long-term development plans until 2000, with an inner re-centralization belt incorporated. From the left, Common development plan until 1980; Development alternative 1, the chain with increased development on Amager; Development alternative 2, the ring; Development alternative 3, urban sprawl (Stadsingeniørens Direktorat 1962)

9.2.5 Temporary closure in the spatial policy controversy

This sub-section explores how closure was brought to the spatial policy controversy. In April 1962, the Urban Planning Board decided that the Technical Committee should finalize its deliberation in the fall of that year. The committee had not, however, been able to reach an agreement in all matters of the dispute. As the Chief City Engineer, Poul Vedel, stated at one of the meetings:

"There is not, however, agreement on one essential point: mono or poly-centric city. It is important to get this issue resolved. The Municipality of Copenhagen advocates an urban structure with one city and several centres." (Vedel 11.04.62)⁵³

In December 1962, the Technical Committee issued its final report, but it had not managed to reach a consensus on a long-term urban development plan. Nevertheless, a compromise had been made in respect to a commonly accepted 1st stage development plan intended to last until 1970. According to the agreement, development in those years should be concentrated in the fingers of Roskilde and Køge, and secondary centres should be developed in Lyngby, Høje-Taastrup, and Hundige. On Amager, development was moderate, adding 5.000 new dwellings. Two groups of committee members, each advocating different alternatives, had drawn up a proposal to the 2nd stage for use until 1980. Alternative A was based on the spatial order of the Finger plan, but with prolongation of the fingers. Even though this alternative also contained a

⁵³ "12. møde, "Oversigt overudvalgets møde den 11. april 1962 i "Byplanhuset"", Udvalget til Teknisk Gennemgang af Principskitsen til en Egnspan, (Plandirektoratets arkiv, Egnspaner, 1960-1961, 1960-1961, Box 1)

number of secondary centres, Copenhagen would remain positioned as the all-dominating centre. In respect to West Amager, the alternative also contained development of an additional 15.000 dwellings (see Figure 9.19). Surprisingly, this alternative was not prepared and supported by the Municipality of Copenhagen, among others. The other alternative, alternative B, was a revised version of the Regional Planning Secretariat’s proposal. The majority of the development was placed in the southwest sector, and only contained an additional 5.000 dwellings on Amager (see Figure 9.19) (Egnsplansekretariatet 1962).



Figure 9.19: The Technical Committee’s development plans. On the left: Commonly accepted 1st stage development plan. In the middle: Long-term development draft A. On the right: Long-term development draft B (Egnsplansekretariatet 1962).

In January 1963, the 1st stage development plan was unanimously accepted by the Urban Planning Board. However, it was stressed that a solution with respect to a long-term development plan should be reached as soon as possible (Egnsplansekretariatet 1963). The 1st stage development was also signed by the Chief City Engineer and accepted by the Copenhagen Major of Urban Planning, Wassard Jørgens (Thomassen 1964).

In the first time around, Copenhagen managed to defend the “spatial capital” of its structural position within the spatial order of the Greater Copenhagen Area against the Regional Planning Secretariat’s attempt to render it arbitrary. However, Copenhagen was still in need of facts in order to reify the mono-centric finger structure, so for the period after 1970 and shortly before the 1st stage plan was agreed upon, the Municipality of Copenhagen decided to set up the special working group under the City Engineer’s Department with the objective of preparing a forecast with the assistance of a computer. This will be elaborated on in the next section.

9.3 The objective of developing a computerized transport model

In this section, the objective of developing the computerized transport model will be elaborated on and a second parallel story line will be introduced. This storyline concerns the state’s rationale for accepting and implementing EDP with transport planning and project design in general, particularly in respect to computerized transport modelling. Despite the fact that development of the first computerized transport model was initiated in 1962 by the Municipality of Copenhagen, the State had already set up the so-called Road Data Processing Committee,

which also worked with the issue in 1960 (Vejdatabehandlingsudvalget). The following explores the rationales of the Road Data Processing Committee and the Department of the City Engineer for accepting computerized transport models, and the different meanings and objectives they assigned to such models, as well as which meaning came to prevail in the end.

9.3.1 Copenhagen's rationales for accepting computerized transport modelling

In December 1961, Ottesen made a new proposal for a programme for completing the traffic forecast. The forecasting team was to be staffed with 15-20 people: three engineers, two architects, three Masters of Economics, one secretary, one designer, and a varying number of student helpers and illustrators⁵⁴. Collaboration with a punch card or computing centre was also part of the programme. In the same month, Ottesen prepared a note where he listed the following seven requirements of a flexible computerized transport model, namely that it should be⁵⁵:

1. Applicable to both small and big areas
2. Able to calculate total traffic, as well as modal split
3. Applicable to both corridors and systems
4. Able to assign traffic on both existing and proposed traffic systems
5. Cheap enough to allow step-by-step calculation to be conducted several times, enabling optimization of alternatives through an iterative process
6. Able to calculate trip frequencies between districts based on several methods and constants
7. The assignment model should include both capacity constraints and all-or-nothing assignment

As can be seen from this list, the type of model which Ottensen considered computerizing was one which fulfilled the requirements of comprehensive transport planning (see Chapter 2). But why were computerized transport models so acceptable to the Department of the City Engineer that it was willing to take on the pioneering work of developing the first Danish computerized transport model?

One reason is found in Copenhagen's need for facts in order to reify its structural position within the future spatial order of the Greater Copenhagen area (see section 9.2). In fact, Vedel declared at a meeting with the Road Directorate that he desired to use the computerized transport model to evaluate the two alternatives for a 2nd stage development plan against each other⁵⁶.

Another reason concerns that there was an expectation within the Department of the City Engineer that the level of investment in the Copenhagen infrastructure would increase in near future. In the prioritized investment programme which the Traffic Economic Committee had

⁵⁴ "Forslag til organisering af trafikprognosearbejdet", BP3, 18.12.1961 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁵⁵ "Hovedkrav til et fleksibelt program for maskinel trafikberegning", BP3, K.A.O, 18.12.61. (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1,)

⁵⁶ Referat af 2. Møde vedrørende udarbejdelse af trafikprognose for Storkøbenhavn. Mødet fandt sted den 20. juni 1963, Vejdirktoratet (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1,)

recently issued, investments adding up to billions of kroner being put into the Greater Copenhagen Area's local infrastructure were put first. The committee report states:

“The Committee has come to the conclusion that the construction of the electrified metropolitan railways of Copenhagen and commencement of the subways must be the most urgent tasks, in respect to the transport investment programme for the whole country. This also applies a number of larger street and road-building schemes in the Greater Copenhagen Area, e.g. the impending enlargement of the Lyngbyvej, the West Motorway, and the Lake-ring, as well as parking facilities.” (DetTrafikøkonomisk Udvalg 1961, 85; Own translation)

The expectation of massive infrastructure investments within the municipal border made it particularly relevant for Copenhagen to take up the task of engaging in the development of a computerized transport model (Stadsingeniørens Direktorat 1963). The Department of the City Engineer also considered it attractive to apply EDP to prepare the forecast, because after the 1956 travel study had been completed, it was realized that the amount of work needed to prepare a forecast was of a magnitude difficult for the Department to manage on its own. The number of calculations needed in order to evaluate just one alternative required a tremendous amount of effort. Nevertheless, a forecast was urgent, and in order to utilize the collected data to test alternative land-use and infrastructure scenarios in a rational manner, the Department of the City Engineer argued that it was necessary to make use of modern computing machinery⁵⁷. Practicality was therefore another rationale for using a computerized transport model. Planning fashion also constituted a reason. As Arne Stærmosse states:

“I believe it was just the fashion. There is also fashion within planning. It was fashionable to do traffic forecasts. For example, the CATS – we also had to have one these.” (Interview 2012; Own translation)

Also, the transformation in the dominant system of thought within planning towards comprehensiveness (see section 9.1) also constituted one of the main rationales for accepting computerized transport models, as they were believed to make systemic and comprehensive planning practice possible. In an internal working paper titled *“The objective and function of traffic forecasts in planning,”* Ottesen discussed the tasks of the forecasting group, which was newly established at that time. In accordance with the jurisdiction of the Department of the City Engineer, Ottesen declared that the primary objective of the forecast was to examine the need for future improvements of the road system within the Municipality of Copenhagen, particularly in respect to a primary road system, and to provide information with respect to its tracing and capacity. This task, however, could only be solved meaningfully if the scope was extended beyond road traffic. Since the future development of the tramway, the bus, and rail system would have great influence on the future needs for individual traffic, it was necessary to calculate the overall passenger traffic including transit. Moreover, because the traffic which loaded the traffic system of Copenhagen typically departed in the neighbouring and suburban municipalities, it was necessary to expand the study area beyond the municipal borders and

⁵⁷ Referat af 2. Møde vedrørende udarbejdelse af trafikprognose for Storkøbenhavn. Mødet fandt sted den 20. juni 1963, Vejdirktoratet (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1,)

encompass the entire Greater Copenhagen Area. As the problem of a regional land-use plan was still unresolved, it was also necessary to take several hypotheses about the future urban structure into account. Hence, although the objective of the forecast was narrowly centred on producing a base for designing the primary road system, this task was given meaning within a comprehensive system of thought. Therefore, the following course of action was to draw up alternatives for future urban land-use and transport infrastructure of the metropolitan area, based on the available proposals of the Department of the City Engineer, the Planning Secretariat, DSB, and the Road Directorate, plus a number of other alternatives that had been judged to be relevant. In accordance with the iterative planning process envisioned by Ottesen (see Section 9.2.3), each of these proposals would then be evaluated in the model and then optimized through an iterative process based on their evaluations. The end result was an objective numeric material containing an assessment of alternative plans' pros and cons, suitable for handing over to politicians for decision making. However, if no proper data set was acquired or if the forecast was used in a conventional manner to evaluate just one alternative, Ottesen considered the effort of computerization partly wasted. For Ottensen, one of most promising aspects of the new possibilities made possible by EDP was that it enabled testing and evaluating several land-use and infrastructure alternatives against each other, based on rational and objective transport-related economic criteria. He envisioned that traffic forecasts were to serve a general function in planning processes, acting as a tool for testing and evaluating alternative proposals for urban structures and corresponding traffic systems. He states as follows:

"The new methodology will be poorly utilized if it is only considered as a subordinated special service for conventional road planning and not fully exploited for its opportunities by way of being accepted as the basis of a more rational way of town and traffic planning." (Ottensen 7.6.62)⁵⁸

EDP could therefore render the iterative rational comprehensive planning process possible, and according to Ottesen, this was the basis upon which computerized transport models should be accepted, thereby allowing town and traffic planning to become truly rational.

9.3.2 The Road Data Processing Committee

However, it was not only the Municipality of Copenhagen which had an interest in using EDP to assist in road planning. The Minister of Public Work had taken the initiative in 1960 and set up the so-called Road Data Processing Committee. The objective of this committee was to assess the possibility of using computers to assist in road planning and project design, among other things, in respect to traffic forecasting. In order to deliberate the research question concerning why computer based transport models emerged and were accepted in the first place, the rationale for setting up the Road Data Processing Committee will be elaborated on below.

In a letter dated July 7th 1960 from the Minister of Public Work, the Chief County Road Surveyor of Copenhagen, Ivar Jørgensen, was asked if he would chair a road data processing committee with the following terms of reference:

⁵⁸ *"Trafikprognosens formål og funktion i planlægningen"* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

- 1) *“To draw up and delimit those tasks within the road administration’s field of responsibility, which advantageously can be solved by data processing*
- 2) *To gather the theoretical and practical knowledge from within the technical, economical, statistical, and mathematical disciplines, which are necessary partly for the above-mentioned point and partly for drawing up practical guidelines for the work*
- 3) *To produce suggestions for the practical implementation of those tasks mentioned under point 1), including collaboration with the central data processing agency and the road administration.”* (; Own translation)⁵⁹

In the letter to Ivar Jørgensen, it is stated that road administration in a number of other countries, particularly the USA, technical and economic calculations had successfully been computerized. Traffic forecasting was specifically mentioned as an example. The scene was therefore set for computerized transport models to form part of the committee work.

The setup of the Road Data Processing Committee in 1960 happened at a very early point in time compared to implementation of EDP within other governmental domains. But why was this so? What went on within the road administration at that time to make computerizing transport planning a particularly attractive option? In the letter from the Minister of Public Work to Ivar Jørgensen, two reasons for setting up the committee were stated:

“Since the Ministry acknowledges that many of the calculations not only with immediate economic benefits can be transferred to data processing, but that such a stirring also can contribute to counteracting the currently prevailing lack of qualified technical and economic labour, the Ministry of public works has decided to set up a Road Data Processing Committee.” (Own translation)⁶⁰

EDP was therefore associated with both economic and labour-saving benefits. The latter of these two benefits, however, appears to have been the main rationale underpinning its acceptance. We will return to this below. But why were these two properties of EDP particularly valued within the Road Administration at that time? In order to answer this question, it is necessary to recall the large-scale infrastructure projects which were being planned around this period of time (see section 7.3). When the Road Data Processing Committee was set up in 1960, the Transport Economic Committee was about to finalize its report, which recommended construction of 700 km motorway during the 20-year investment period, among other things. Because of this, when the Committee was set up, there was a clear expectation both within the Ministry of Public Work and the Ministry of Finance that the level of investments in transport infrastructure was going to increase in the following period of time⁶¹. It is within this context

⁵⁹ Ministeriet for offentlige arbejder. Trafikministeriet, 7. juli 1960, Journal nr.48-12, Brev nr. 8844, Kai Lindberg/ F.J. Boas (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶⁰ Ministeriet for offentlige arbejder. Trafikministeriet, 7. juli 1960, Journal nr.48-12, Brev nr. 8844, Kai Lindberg/ F.J. Boas (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶¹ It is evident from the archive material that some of the Road Directorate’s members of the Road Data Processing Committee also were participating in the meetings of the Transport Economic Committee. The

that the establishment of the committee should be understood. As one of the members stated at a committee meeting:

“The advantage of using electron calculators is, according to foreign experiences, primarily in respect to the possibility of saving engineering labour, and without technical aids of this nature the intended design of the rather considerable Danish motorway facilities will hardly be possible to implement” (06.10.61; Own translation)⁶²

The shortages of qualified road engineers thereby implied that it was perceived as impossible to realize the road construction programmes without the assistance of EDP. The rationale for accepting computerized transport models was also framed in terms of shortages on engineering labour. In his Ph.D. thesis from 1964, Knud Rask Overgaard states:

“Even for Danish provincial towns where traffic calculations might only include parts of the methodology, as described in the previous chapters [of his Ph.D. thesis], the computer simply provides faster and cheaper forecasts and enables quick, step-by-step calculations of several different proposals for new roads; not to mention, we might not be able to obtain the labour required for manual calculation.” (Overgaard 1964, p. 178; Own translation)

The same argument about a potential staffing crunch was also levelled at one of the Road Data Processing Committee’s meetings, where it was stated that:

Such [transport] model calculations will undoubtedly provide useful impetus to road planners, but can only serve to act as support because it is impossible to build such realistic models that all road planning problems can be resolved mechanically. It will scarcely be desirable to determine in advance such narrow rules for balancing all the transport, economic, aesthetic, demographic, and national planning consideration influences on road planning in order to account for all the variables in a purely mechanical system such as that of the electron calculators. But, net-model calculations will provide a part of the basic material which road planning must build on and which otherwise would require tiring routine work being done by qualified personnel. If computers are taken into use, road engineers and traffic economists will be freed to address the essential issues that require the real professional effort.” (Own translation)⁶³

From this, it can be seen that the rationale for accepting computerized transport models was not framed as a mechanical truth production technology rendering professional and political judgment superfluous. Rather, computerized transport models were to be accepted because

vision for the construction of the 700 km motorway was hence known to the members of the Road Data Processing Committee.

⁶² Vejdataudvalget, 06.10.1961, Ivar Jørgensen/ Bernth Ministeriet for offentlige arbejder.

Trafikministeriet (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶³ Udkast til del af Vejdatabehandlingsudvalgets beretning. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

they could free qualified staff to do tasks requiring professional skills beyond mechanical computation.

After having elaborated on the State's rationales for engaging with computerized transport modelling, we now turn to the committee's work on the system. The Committee did, to a great extent, look abroad for experience. However, in respect to transferring programs into Danish practice in an unmodified form, technical matters constrained the transformation of a program developed for one type of computer to one that would work with another. According to Overgaard (1964), this was one of the reasons why so many different transport modelling programs were developed in America during this period rather than the same programs simply being adapted for different urban transportation studies. Overgaard puts it as follows:

"The many different types and manufacturers of computers each require their own special programs; however, the same program can be used with some modifications by closely related machines. When the program is written in language such as ALGOL or FORTRAN, it is possible to introduce minor changes, but as soon as it comes to slightly larger changes, it would be as easy for experts to write a new program as to reshape the existing." (Overgaard 1964, p. 182)

The non-standardization of computer language therefore stimulated non-standardization of evaluation methods since programs frequently had to be rewritten in order to be applicable to local conditions. Although the Data Centre was affiliated with FORTRAN and the Computing Centre with ALGOL, it was often necessary to make corrections to foreign programs in order for them to be commensurable with the prevailing Danish planning practice. For instance, in Sweden, rather advanced earthmoving operation programs had been developed, but since the Danish road standards differed from the Swedish, these programs could not be used in an unmodified form.⁶⁴ Both the Computing Centre and the Data Centre therefore each developed their own earthmoving operation programs, which they claimed were at the same level as those of the Swedish. This shows that even though inspiration, knowledge, and practical implications were collected from abroad, these techniques had to be made to correspond with the prevailing domestic practice in order to gain acceptance. Below, how context served as a base for accepting different computerized transport models developed abroad will be elaborated on.

In the committee's early deliberation on the transferability of different computerized transport models developed abroad, context was considered a critical issue. Due to the large structural differences between American and European cities, Callesen from the Data Centre argued that the American models could not simply be copied into Danish practice. Instead, the focus centred on a model developed in Zurich⁶⁵. The Committee expressed a desire to illuminate the possibility of transferring this model into Danish practice. Callesen, however, wanted to consult with an urban planner before making a statement on the issue. To this, the committee member from the Department of the City Engineer's road section, Guldstad, expressed that a solution to the

⁶⁴ *Referat af vejdatabehandlingsudvalgets møde fredag den 15. september 1961 kl. 14 i Københavns amtsråd.* Vejdatabehandlingsudvalget. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶⁵ *Anvendelse af en elektronregnemaskine til trafikprognose for vejsystemet i en by.* Vejdatabehandlingsudvalget. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

problem of computerized transport models was urgent⁶⁶. At the first committee meeting, Guldstad expressed that the problem of how to calculate traffic load on road systems under different land-use assumptions was one of two problems, pressing for the Municipality to address it. The other issue he mentioned was finding a way to coordinate traffic signals in larger networks⁶⁷.

From my material, I cannot see exactly how the contact was established between the Road Data Processing Committee and Ottensen and Lyager from the Urban Planning Office, who, in beginning of 1962, were still preparing to set up a forecasting group. However, Gulstad must have played a mediating role. In Marts, He and Callesen were given the task of consulting Lyager and Ottesen about the possibilities of developing a computerized transport model. During this meeting, Ottesen and Lyager reported on a number of cities abroad (particularly in America) which had successfully used EDP to assist traffic forecasting. Lyager and Ottesen also expressed great interest in participating in a sub-group of the Road Data Processing Committee concerned with transport modelling⁶⁸. Ottesen had drawn up a suggestion for terms of reference for such a group. Here, the stated objective was to assess the need for computerized traffic forecasts within Danish urban and road planning and to prepare a detailed program for the preparation of a forecast using the assistance of a computer. The group was to collect information about computational traffic forecasting methods used abroad and to assess their applicability to Danish circumstances. Furthermore, it was agreed that the computer programs developed should both be as general and flexible as possible so they could be used to evaluate corridors as well as larger networks. Moreover, the programs were to account for total traffic, traffic between districts, modal split, and assignment⁶⁹. The implications of the terms of reference proposed by Ottesen were essentially to develop a four-step transport model.

At the following meeting of the Road Data Processing Committee, Guldstad and Callesen reported from their meeting with Ottesen and Lyager. While the Road Data processing Committee had thus far had its focus on Europe, Lyager and Ottesen had their particular focus on the transport model developed as part of the Chicago Area Transportation Study. In the minutes from the meeting, it is stated that this model was capable of processing a network consisting of up to 14.000 sub-links and 500 nodes, making it far more complex than the previously-considered Zürich model. However, the Committee expressed concern about the level of ambition of the proposed sub-group being too high. In order to ensure that the group kept contact with reality, it was desired that a particular task be assigned to it. The suggestion was made that the objective of the sub-group should be to analyse how traffic would be diverted during the period where the northern radial road, the Lyngbyvej, was

⁶⁶ *Vejdatabehandlingsudvalget*. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

⁶⁷ *Vejdatabehandlingsudvalget*. Referat af vejdatabehandlingsudvalgets møde i Vejdirektoratet onsdag den g. november 1960 kl. 1(Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶⁸ Til Formanden for Vejdatabehandlingsudvalget, København 16.03.62, Erik Gulstad (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

⁶⁹ *"Udarbejdelse af generelle programmer for trafikprognoser"*.BP3, K.A.O, 12.03.62 (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 1)

reconstructed.⁷⁰ The Road Data Processing Committee and the Department of the City Engineer thus assigned different meanings to the objectives which the computerized transport model should be capable of fulfilling. While the Road Data Processing Committee proposed a corridor-based study in accordance with conventional practice, the Department of the City Engineer's proposal was that of a network-based study in accordance with American practice and comprehensive approaches to planning. This conflict regarding meaning also became evident in the following meeting of the Road Data Processing Committee. Here, the minutes from the previous meeting caused a number of remarks. It was specified that the objective of developing a computerized transport model was to calculate traffic distribution on the primary roads in the Copenhagen area, not diversion of traffic during the period of the Lyngbyvej's enlargement. It was further specified that the Chicago model could not process a network with up to 500 nodes, but up to 5000 nodes.⁷¹ The issue about the transport modelling group's term of reference was not solved at the meeting, but the group was then unofficially established. The roster consisted of Ottesen, Lyager, and Callesen, and expanded to include Stenbæk from the County of Copenhagen in June.⁷²

Here, in the beginning of 1962, there was still no decision on whether the effort should be concentrated on computerizing conventional corridor techniques or on system-based transport models. Additionally, there was no consensus on whether a European or American model should serve as the prototype. Next, we will explore which of the meanings came to prevail and became computerized.

9.3.3 The envisioned objective and role of the computerized transport model

Around April-June 1962, about the same time as the sub-group within the Road Data Processing Committee was unofficially established, the forecasting group under the Department of the City Engineer was set up. In late August 1962, a meeting was held between the Department of the City Engineer, the Road Directorate, and the chairman of the Road Data Processing Committee regarding the possibility of using EDP for finishing the forecast based on the 1956 travel study. According to the representatives from the Department of the City Engineer, it was expected that the computerized traffic forecast could be completed in 1965. The Chief Highway Engineer, Kaj Bang, did not disagree with the promising aspects of utilizing EDP to prepare the forecast, but he did argue that important planning decisions for the Greater Copenhagen area had to be made before 1965. He feared that preparation of the computerized forecast would serve as a pretext for doing nothing and requested preliminary results. The Department of the City Engineer was cautioned against this, being advised that a preliminary forecast would delay the final result.⁷³

⁷⁰ *Referat af vejdatabehandlingsudvalgets møde i Københavns Amtsgård fredag d. 4. maj 1962* (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

⁷¹ *Referat af vejdatabehandlingsudvalgets møde i vejdirektoratet, fredag den 8. juni 1962.* Vejdatabehandlingsudvalget. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

⁷² *Referat af vejdatabehandlingsudvalgets møde i vejdirektoratet, fredag den 8. juni 1962.* Vejdatabehandlingsudvalget. (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

⁷³ *Referat af 2. Møde vedrørende udarbejdelse af trafikprognose for Storkøbenhavn. Mødet fandt sted den 20. juni 1963, Vejdirktoratet (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1,)*

Kaj Bang also expressed doubts about the usability of the 1956 travel study. He feared that the data would be outdated before the three years had gone by, particularly in respect to motoring, which had increased dramatically since then. The 1956 travel study was, however, defended by representatives from the Department of the City Engineer, who argued that even though supplementary investigations were needed, it still provided a suitable base for preparing a forecast. It was decided that the more general scope of the Road Data Processing Committee sub-group's terms of reference should be changed, and the special focus of utilizing the 1956 travel study as the base for a computerized traffic forecast for the Greater Copenhagen area should be included.⁷⁴

In October, Ottesen prepared a memo regarding the terms of reference to the traffic forecast for the metropolitan area and to the composition of a forecast Committee. According to this memo, the forecast needed to contain the following properties:

- Future traffic within the Greater Copenhagen Area should be calculated in order to procure a base for planning of both the road and transit system.
- It should be considered if leisure and goods should also be included.
- The calculations should be based partly on the regularity derived from the 1956 travel study and partly on regularities used in forecasts for other larger cities. Additional data collection was necessary, particularly in respect to modal split, population, and business.
- One forecast should be prepared for a 15-20 year period, which could be used for capacity dimensioning, and another forecast for a 40-50 year period, which could be used as the base of evaluating different urban forms against each other.
- Preparation of a number of urban land-use scenarios and corresponding transport systems, and evaluation of these alternatives against each other based on transport economic criteria.

The memo emphasized the importance of not limiting the function of the forecast to merely sizing the capacity of only one transport system. Several land-use and infrastructure alternatives should be evaluated, and it would be of benefit if representatives from the highway authorities, DSB, Copenhagen Tramways, regional and national planning authorities, and the Transport Economic Committee were included in a steering committee.⁷⁵ In the memo, it was also emphasized that the forecasting program of Greater Copenhagen, which had a particular focus on Copenhagen, did not render superfluous the sub-group of the Road Data Processing Committee, the work of which was of a more general scope. Nevertheless, the transport modelling working group under the Road Data Processing Committee was put on hold in August 1963, until the results of the Municipality of Copenhagen's program were disseminated. As the two groups largely consisted of the same persons, they would otherwise be working under double terms of reference. Instead, the Road Data Processing Committee followed the work of

⁷⁴ *Referat af møde i Vejdirektoratet den 28. august 1962.* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁷⁵ *Notat vedrørende kommissoriet for trafikprognosen for hovedstadsområdet og sammensætning af prognoseudvalget.* BP3, K.A.O & L.Y 18.10.1962 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

Copenhagen from the side-line.⁷⁶ It was ultimately the meaning ascribed by the Department of the City Engineer to the development of a computerized transport model which came to prevail, but whether this meaning actually was successfully inscribed into the first computerized transport model developed within Danish planning practice will be the topic of the next chapter. However, before going into the development of the computerized transport model, an answer to the secondary research question addressed in this chapter will be drawn.

9.4 Sum up

The secondary research question addressed in this chapter was: *how and why did computerized transport modelling emerge within Danish planning practice?* The how part of the question will first be elaborated on, followed by the why.

It was shown that in order to understand how computerized transport modelling emerged within Danish planning practice, it was necessary to account for a number of social, spatial, and technical transformations within planning practice, generated by the increased prevalence of particular systems of thought, namely comprehensive planning in the form of comprehensive-rational and system approaches. The increasing prevalence of comprehensive planning facilitated a transformation in the spatial scale of planning. The implications of going from a corridor to a system perspective led to conventional methods of transport project evaluation starting to be problematized, and this contributed to opening evaluation practice up for change. The enlarging of the planning perspective also contributed to increasing the data requirements and thereby the need for calculation capacity, which served to facilitate a transformation in the computing technology used to assist the calculations.

In respect to the why part of the secondary research question, the answer will be structured in accordance to practical, instrumental, rational, and political reasons. These will be discussed in turn in the following paragraphs.

In respect to the practical reasons why computerized transport modelling emerged within Danish planning practice, it was shown that due to the amount of calculations needed to draw up a forecast based on the 1956 travel survey, it was perceived to be practically impossible to finalize the forecast without the assistance of a computer. It was also shown that, following the Traffic Economic Committee's recommendations, there was a clear expectation about that large sums were going to be investigated in the Copenhagen transport infrastructure. This made it particularly relevant for the Municipality of Copenhagen to undertake the task of developing a computerized transport model. Another practical reason was the shortage of qualified engineering labour in the early 1960s. This shortage meant that it would be practically impossible to implement the large-scale road transport infrastructure investment programmes drawn up in the late 1950s and early 1960s unless computer programs were developed to free engineering labour from doing routine calculations.

⁷⁶ Referat af vejdatatabehandlingsudvalgets 23. møde i Københavns amtsgård tirsdag den 24. september 1963. Vejdatatabehandlingsudvalget 04.10.1963 (Trafikministeriet, Vejdatatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

In respect to the rational planning reasons towards why computerized transport modelling emerged within Danish planning practice, one of the main purposes of developing a computerized transport model was to provide a basis for the dimensioning of the Copenhagen primary road network and to assist in designing its layout. The computerized transport model should also make cost-benefit analysis possible, with the objective of drawing up a prioritized investment plan. It was shown that computerized transport modelling was accepted because it was perceived to render an iterative planning process possible, allowing for several alternatives to be evaluated based on transport, land-use, and transport-economic criteria combined. Throughout the period, American transportation studies increasingly became accepted as the best practice in terms of comprehensive planning. In fact, it was shown that computerized transport modelling was accepted on the ground that it was perceived to make possible truly rational town and traffic planning based on rational-comprehensive and systematic approaches.

Despite the fact that rational planning arguments served as important reasons for why computerized transport modelling emerged within Danish planning practice, emergence of computerized transport modelling cannot be detached from politics. It was shown how the spatial policy controversy about the future spatial order of the Greater Copenhagen Area was a prominent contextual factor facilitating the decision to develop the computerized transport model. It has been shown that computerized transport models were called upon in the spatial policy controversy, where facts were needed by Copenhagen to defend the spatial capital tied up to its structural position within the mono-centric spatial order of the Finger Plan. Moreover, the questioning of the taken-for-granted spatial order of the Finger Plan led to spatial planning being opened up for change to come about, and computerized transport modelling, in the form of an scientific and objective planning tool, beings called upon to bring closure to this spatial policy controversy. In fact, the desire to evaluate the two proposals for a second stage development plan was a contextual factor shaping the decision to initiate development of the computerized transport model.

10 Development of a computerized transport model

This chapter explores the process of developing the computerized transport model as well as the creation of alternatives. The initial objectives and considerations concerned with development of the model will be presented first. Then, the initial considerations regarding input data will be discussed. In that vein, there will be an analysis of how a number of obstacles required detours to be taken, resulting in transformations of the initial objectives. Moreover, analysis will be presented on how the spatial policy controversy and the absence of a long-term regional plan shaped the drawing up of land-use alternatives. Next, the process of developing the computer programs will be explicated, along with an exploration of whether the technical framework of the model was a copy of American practice or whether it was shaped by the prevailing practice into which it was domesticated. Hereafter, focus is shifted back to the data collection, and the process of preparing a new comprehensive travel study will be explained. Next, there will be discussion of how re-politicization of spatial planning in the Greater Copenhagen Area contributed to reopening the initial assumptions of the computerized transport model. This is followed by an elaboration of the process of finalizing the trip distribution calculations and deliberation of whether the effects of induced traffic were included in the model. Lastly, an answer is drawn to the sub-question particularly addressed in this chapter, namely *“How were the development of the transport model and the making of alternatives shaped by various mechanisms?”*

10.1 Presenting the forecasting group

The forecasting group was established under the Department of the City Engineer’s Third Planning Office around April/June of 1962 (see sections 9.3.1 & 9.3.3). The group was given working premises at Hauser Plads and consisted of approximately 15 staff members, though only six were permanent. In section 9.3.2, it was argued that one of the main rationales of the State for accepting and engaging in the development of computerized transport planning tools, including transport models, was due to shortage of qualified engineering labour. However, throughout this embedded case, it will be shown that shortage of qualified engineering labour also served as a constraint on developing the computerized transport model. Shortly after the forecasting group was formed, an agreement with the Data Centre was reached about its assistance in programming the computer models. Peter Bredsdorff, the former head of the Urban Planning Office, had resigned and become a professor at the Royal Danish Academy of Fine Arts after the Master Plan Draft was issued. His position was, however, not reopened, and the office therefore lacked an overall leader (Lyager 1992). Fortunately, Poul Lyager and Karl Arnold Ottesen were the heads of the forecasting group. Lyager was the overall leader, but it was Ottesen who had the technical insight and who directed the day-to-day management (Interview Stærmose, 2012). Ottesen was a rather introverted, nerdy and a peculiar type, and not the same sort of dynamic leader as Lyager. Nevertheless, he was extremely talented in technical respects, and on that ground, he was highly respected by the crew (Interview Stærmose 2012). Even though Ottesen was highly technically skilled, nobody in the forecasting group had practical experience with either executing comprehensive transportation studies or with development of computerized transport models. Instead, knowledge of computerized transport modelling was brought into the group through other sources. One of these sources

was scientific papers and reports, particularly from America. From here, both theoretical and practical knowledge were collected. The transportation studies conducted in the cities of Chicago, Washington, D. C. and Toronto were particularly useful and regarded as the best practices.⁷⁷ In addition to literature reviews, knowledge from the USA was also transferred into the Department in an embodied form. Within the Municipality of Copenhagen, there was an arrangement concerning a travelling scholarship, custom-made for the staff of the Urban Planning Office. It was therefore rather easy for young engineers and architects to be assigned this scholarship and go abroad to study in the USA. Arne Stæremose, who was part of the forecasting team, was assigned the scholarship twice. During his second stay, Stæremose followed some courses in transport planning at Northwestern University, Illinois, where he became acquainted with the Chicago Area Transportation Study (interview Stæremose, 2011). Some of the permanent staff members of the forecasting group, Ottesen in particular, also participated in international conferences on planning and transport modelling. At these conferences, the work of the forecasting group was disseminated and new knowledge was brought back into the Department. Even though America was the pioneering country and served as the best practice for development of the computerized transport model, there was also considerable exchange of knowledge between the larger Nordic cities. A Nordic Forecasting Committee was established in 1963, jointly by Copenhagen, Stockholm, Gothenburg, Malmö and Oslo. The cities took turns arranging meetings where their technicians exchanged knowledge on forecasting methodology, data collection and practical implications. These meetings allowed committee members to exchange both knowledge and data. For instance, Copenhagen borrowed data from a large travel study in Stockholm and used it to test different trip distribution methods. Moreover, Copenhagen also borrowed interview guides developed as part of travel studies in Oslo and Stockholm to serve as inspiration for the drawing up of a Copenhagen interview guide. In addition to the Nordic collaboration, a study group was also established in Copenhagen, where people with a special interest in the topic discussed different methods of forecasting. The study group consisted not only of in-house participants, but also people from the outside. For instance, both N.O. Jørgensen and Knud Rask Overgaard were involved in the study group (see section 7.3) and were also helpful in respect to distribution of literature.⁷⁸

10.2 Initial considerations about the forecast's basic assumptions

In the initial phase of the forecasting programme, it was necessary for the forecasting group to take a position on a wide range of issues regarding what the forecast should contain. However, as this was Denmark's first time to develop a computerized transport model for a large-scale area, there was no precedence on which to lean. Choices about what the forecast should contain were therefore rather open for deliberation in the initial phase. In late August 1962, Ottesen sent out a memo, titled *"Problems regarding development and testing of urban and transport*

⁷⁷ *Forarbejde til gennemførelse af en generel trafikprognose for Storkøbenhavn*. BP3, K.A.O 12.11.1963. (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁷⁸ Letter to N.O. Jørgensen from Karl Arnold Ottesen, Copenhagen 16.07.1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Vej- og transportsystem -nordiske prognosemøder, Box 1)

scenarios,⁷⁹ in which he discussed which assumptions of the forecast were to be considered as constant and which as variable. Because the objective of the forecast, in addition to producing a base for sizing of capacity, was to evaluate different alternatives on the basis of transport economic criteria, it was desirable that the forecast should be based on total 24 hour traffic, distributed between car and transit, and not only peak-hour traffic. However, it was only in respect to forecasting of the home-work traffic that a solid theoretical foundation existed; for leisure and goods traffic, the base was rather weak. Therefore, a potential option was to reduce the basis of the forecast to peak-hour traffic. In regard to the constants of the forecast, Ottesen suggested that the forecasting period be fixed to a 15-20 year time frame. The future population size should also be kept constant in all alternatives. It was, however, beyond the scope of the group members to produce a population forecast on their own. Instead, an official produced forecast should be utilized, provided that one considered to be based on reasonable assumptions was available. The geographical scale of the forecasting area was also proposed to be treated as a constant. However, compared to the 1956 travel study, the forecasting area now considered was substantially larger (see Figure 10.1).

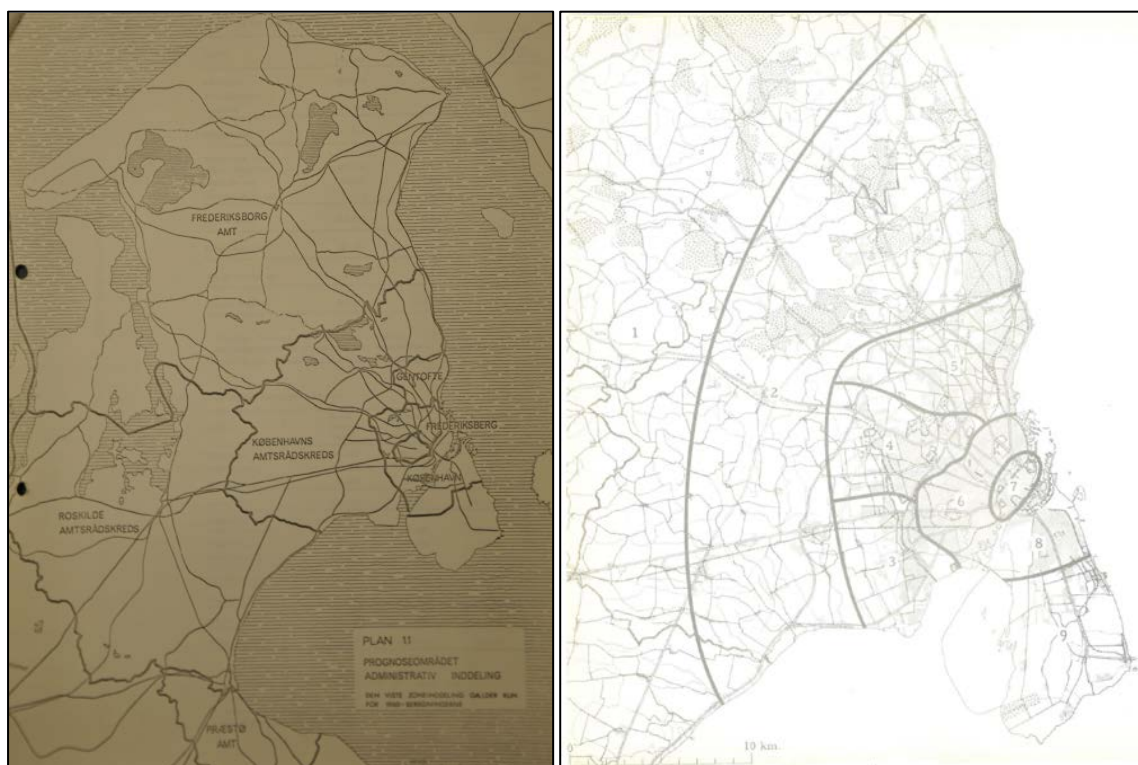


Figure 10.1: To the left: the considered forecasting area, divided into administrative units. To the Right: the area covered by the 1956 travel study

In regard to the variables of the forecast, Ottesen desired that travel behaviour be treated as a variable in regard to modal split and dependency on distance and time. In respect to future urban form, Ottesen suggested that the following seven alternatives were the best to evaluate:

1. Successive growth
2. Extension of the finger structure

⁷⁹ *Problemer vedr. udarbejdelse og prøvning af by- og trafikmodeller*, BP3, K.A.O. 28.08.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

- a. Prolongation of fingers
 - b. Development of new fingers
- 3. Linear growth
(The Regional Planning Secretariat's proposal)
- 4. Development of a ring of satellite towns
 - a. Existing market towns
 - b. Development of new cities
- 5. Dispersed urban growth

As can be seen from the list of considered urban forms, all the alternatives, except alternative 4b, were either grounded in proposals which had been considered in respect to the preparation of the Finger Plan (Alternative 1-2) or the Preliminary Plan for the Copenhagen Metropolitan Region (Alternative 2-5). This squares with the argument put forward in the previous chapter, concerning that development of the computerized transport model was primarily accepted due to a need for reification of a particular urban form in order to bring closure to the spatial policy controversy regarding the future spatial order of the Copenhagen Metropolitan Region. Ottesen argued that it would be preferable to keep the size of the future urban region's land use constant. However, this could turn out to be problematic, as a transit-oriented alternative ought to be based on higher densities than a car alternative. Therefore, it was suggested that the forecast combine the alternative urban forms with the following variations in regard to the inner urban structure, namely:

- 1. Varying degree of density of residential areas
- 2. Varying alternatives for centre structure
- 3. Alternative infrastructure systems (car, bus and rail)

Nevertheless, even though Ottesen wanted to evaluate all of the alternatives, he argued that due to constraints on manpower and grants, it was necessary to limit the number of land-use alternatives and put some restraint on the assumptions in order to avoid a situation with a countless number of alternatives. In order to narrow down the number of alternatives, the most unacceptable could be discarded, such as the successive growth and urban sprawl.⁸⁰ Ottesen was therefore conscious of the necessity of limiting the number of variables in terms of practicability. Yet, he intended to include a considerable amount. In fact, even though Ottesen accepted the need for simplification, the meaning he ascribed to the forecasting programme was not development of a simplified computerized transport model. In fact, Ottesen and his team tried to push the limits and aimed for development of a state-of-the-art computerized transport model. However, as will be shown in the remainder of this chapter, during the process of developing the computerized transport model, Ottesen and the group came to be faced with a wide range of unforeseen obstacles, particularly in respect to data availability. Ultimately, even though great efforts and many detours were made to overcome these problems, simplifications beyond those which were initially accepted still had to be made.

⁸⁰ *Referat af møde d. 30 august 1962*, (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

10.3 Data Collection

After having presented the initial considerations, the process of collecting data on population, business and car ownership, as well as that of drawing up the land-use and infrastructure alternatives, will be presented, and the mechanisms shaping these items will be explored.

10.3.1 Population forecast

The population forecast was one of the first issues considered by the group. The future population was regarded as decisive for drawing up the urban land-use scenarios, as it constituted the criteria for how much land should be set aside for future urban development. The population forecast would hence be invaluable for knowing whether the urban growth could be contained within the finger structure and whether the plans should include one or more new ¼ million districts. Therefore, it was important that the population was not estimated on a rudimentary basis, but forecasted as accurately as possible. This raised issues within the group, concerning what the determinant was for the future population. It was discussed whether there was a co-dependent relationship between the population growth and business growth within the metropolitan area or whether the forecasts on the two issues could be prepared separately.⁸¹ On this matter, it was concluded that such a relationship likely did exist, but it would be necessary to simplify further as it was beyond the capacity of the group to prepare forecasts on the basis of this assumption. In fact, it was beyond the scope of the group to produce any population forecast on their own. Instead, different available forecasts for the metropolitan area produced by other planning authorities were to be evaluated and the most suitable would be selected. The task of the forecasting group would then be to distribute the population in the different zones within the forecasting area. In the search of an available population forecast, the forecasting group first contacted Mrs. Bagger from the Ministry of Housing in order to make inquiries regarding a forecast which she currently was revising, namely the forecast which had influenced the Regional Planning Secretariat's proposal to the new regional plan (see section 9.2.2). Based on the snowball method, Mrs. Bagger also informed the group of a number of other planning authorities which were either preparing new population forecasts or revising existing ones, namely:

- The Statistical Office of Copenhagen
 - The forecast was based on a projection of the Greater Copenhagen Area's existing population
 - The forecast was based on too narrow a delimitation of the Greater Copenhagen Area
- The Regional Planning Secretariat
 - The forecast for the Greater Copenhagen area was based on a national forecast prepared by the Ministry of Housing. It is assumed that 50% of national urban growth will take place within the Metropolitan area
 - Assumed population in 1980: approx. 2.000.000
- Ministry of Housing's revised forecast by Mrs. Bagger.

⁸¹ Vedr. fremskaffelse af befolknings-og erhvervsstatistik til brug for trafikprognose. BP3, K.A.O, 14.06.1962 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

- This forecast was a revision of the above. It is assumed that 48% of the national urban growth will take place within the Metropolitan area
 - Assumed population in 1980: 1.975.000
- The National Planning Secretariat (Antonsen & Hjortkær).
 - National forecast 50%
 - Assumed population in 1980: 1.865.000
 - National forecast 40%
 - Assumed population in 1980: 1.810.000

Ottensen was, however, sceptical towards most of the available forecasts. He argued that the forecasts of the Statistical Office of Copenhagen, the Regional Planning Secretariat and the Ministry of Housing were all based on overly high assumptions regarding the metropolitan area's share of the nation's expected future urban growth.⁸² This argument gained credence when a recent decline in the metropolitan area's growth rate was taken into account.⁸³ Instead, the attention of the group was directed towards the forecast prepared by Hjortkær for the National Planning Committee. This forecast was based on the most advanced methods and the fertility rate was lower compared to the other available forecasts. This forecast was also desired because it was certified by the state. The likelihood of acceptance would increase if the traffic forecast was based on the same assumptions as the work of the National Planning Committee. However, this forecast was prepared for the nation at large and not particularly for the Greater Copenhagen Area. The method of estimating the future population was based on a fixed percentage of the national urban growth rate, which was not regarded as optimal. Therefore Hjortkær was approached by the forecasting group with the objective of persuading him into produce a forecast especially for the metropolitan area.^{84, 85, 86} He could not, however, guarantee that such a forecast could be produced within the time frame of the forecasting group's working programme. Therefore, it was decided in February 1963 that if it was impossible to apply Hjortkær's forecast, the population assumed by Regional Planning Secretariat should be used instead. This would allow for an objective evaluation of the Regional Planning Secretariat's regional plan proposals against the proposals to be drawn up by the forecasting group. Nevertheless, in 1964, the National Planning Committee issued a number of population forecasts, one for each of the individual parts of the country, including the metropolitan area, and in September, it was decided to use this as the basis of the traffic forecast. According to the National Planning Committee's forecast, the population within Copenhagen and the three metropolitan Counties was calculated to 1.998.300 inhabitants in 1980, and out of this, the

⁸² *Referat af møde d. 13. august 1962* (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

⁸³ *Notat vedrørende befolkningsprognoser for hovedstadsområdet*, BP3, K.A.O. 21.06.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

⁸⁴ *Vedrørende henvendelse til formanden for Landsplanudvalget, Kontorchef Vagn Rud Nielsen, angående befolkningsprognose*. BP3, K.K. & K.A.O. 06.03.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁸⁵ *Referat af møde d. 1.11.62 i Landsplanudvalget vedrørende befolkningsprognose*, BP3, K.K. 07.11.62 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁸⁶ *Befolkningsprognose. Arbejdsprogram*. BP3, K.K. 08.10.62 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

urban population amounted to 1.931.900.^{87, 88, 89, 90} Hence, the chosen population size did not differ significantly from the 2.000.000 assumed by the Regional Planning Secretariat, despite the fact that Copenhagen had previously criticised this forecast for being too optimistic.

10.3.2 Business forecast

In correspondence with the population forecast, a business forecast for the Greater Copenhagen area was also crucial for drawing up the land-use scenarios and for estimating trip production. In this regard, however, the forecasting group was faced with a huge challenge, as no statistical makeup existed on the distribution of workplaces. In the 1956 travel study, this information was collected as part of the home interview survey, but as only 3000 interviews had been conducted, the sample was not statistically representative. A business census had been conducted within the metropolitan area in 1958, but this survey also had a number of shortcomings with respect to the purpose of traffic forecasting. First of all, it included only trade and industry rather than all occupational sectors, therefore excluding service and public administration, which were estimated to constitute around one third of total employment. Second, the employees were all registered by the address of the employer and not the address of the actual workplace. In respect to preparing a traffic forecast, this implied that the material was biased. The amount of workers in the inner-city would be overestimated, as many of the firms located in this area also had branches, storerooms, or repair shops located in other parts of town. However, in spite of the business census' shortcomings, it was still the best available material. Therefore, a number of corrective and supplementary examinations were initiated, such as telephone interviews with regard to employment within the public administration. However, this method was regarded as both uncertain and time-consuming, so the forecasting group was required to make a detour and initiate a new data collection process.^{91, 92, 93} We shall return to this issue in section 10.5.

10.3.3 Car ownership

In respect to the geographical variation in the level of car ownership within the forecasting area, an assessment had already been prepared in October of 1962. This consisted of a number of correlation analyses run on data from the travel study of 1956, including both socio-economic and urban structural variables. The density of a district, measured by the proportion of single-family housing, did not show a good correlation. Instead, the best fit was found between income

⁸⁷ *Befolkningsprognose og det fremtidige antal boliger. Status*, BP3, K.K. 21.09.1964 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁸⁸ *Møde den 24. sep. Til stede: P. Lyager, V. Egebæk, Ottesen, Klixbüll, Stærmosé, Christiansen, Wettergren*, BP3, S.W. 25.09.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

⁸⁹ *Befolkningsprognose og det fremtidige antal boliger. Status*. BP3, K.K. 21.09.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

⁹⁰ *Referat af mødet med repræsentanter fra Københavns Kommunes Statistiske Kontor og byplankontoret tirsdag den 19. juni 1962 angående udarbejdelse af en erhvervsprognose*, BP3, E.C. 20.06.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

⁹¹ *Foreløbigt notat om erhvervsprognosen*, BP3, E.C. 07.06.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata)

⁹² *Vedr. fremskaffelse af befolknings- og erhvervsstatistik til brug for trafikprognose*. BP3, K.A.O, 14.06.1962 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁹³ *Foreløbigt notat om erhvervsprognosen. 3*, BP3, E.C. 07.06.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata)

and car ownership. However, the analysis also showed a good fit in respect to distance to the city centre, both in terms of kilometres and travel time. The good correlations were, however, dependent on the two areas that were excluded from the analyses, namely Birkerød and Hørsholm. This was assumed to be caused by a difference in the level of transit service in the respective districts. Based on the analyses, it was recommended that further studies on the geographical distribution of car ownership were to be based on income, distance to the city centre, and quality of transit service.⁹⁴ This shows that there was, apparently, a high degree of spatial consciousness within the forecasting team. In fact, it does not appear to have been standard practice at that time to operate with spatial variations in car ownership. The large degree of spatial consciousness within the forecasting group might be due to the fact that development of the computerized transport model occurred within an urban planning office and not a road department. In fact, representatives from the Road Directorate tried later to render such spatial differentiation unacceptable (See section 12.5.3).

10.3.4 Urban land-use alternatives

This section elaborates on the forecasting group's considerations in regard to the drawing up of the land-use alternatives, which the model was supposed to evaluate.

According to Ottesen, a forecast practicable as a base for sizing capacity of the future primary road system could only be prepared meaningfully if it encompassed the whole metropolitan region (see section 9.3.1). This meant it was necessary to define the land-use alternatives in correspondence with regional planning. However, due to the spatial policy controversy surrounding future urban form, a certified regional land-use plan did not exist after 1970 (see section 9.2). This spatial policy controversy served as a contextual factor, shaping the content of the future land-use scenarios in several respects. First of all, as two proposals existed for development until 1980, it was necessary to include several land-use alternatives in the forecast (see section 9.2.3 & 9.3.1). Second, the controversy implied that the forecasting group had to prepare the long-termed regional land-use alternatives on their own. Both the population and the business forecast were supposed to serve as important elements in this work. However, it was also necessary to map the current geographical distribution of dwellings, residents and jobs, and study the trends within the geographic distribution of population and jobs, as well as to assess the individual municipalities' plans for the future land use, including urban renewal. Based on these considerations, the land-use alternatives should then be drawn up in respect to the future geographical distribution of dwellings, residents and jobs within the study area (Stadsingeniørens Direktorat 1967a). Preparing the land-use alternatives was hence a very labour-intensive task. Even though Ottesen had already suggested simplifying the model by limiting the number of alternatives, some of these suggestions were still subsequently reconsidered. Next, the initial work with preparing these future urban land-use alternatives will be explored.

In spite of the fact that Ottesen had previously suggested treating the geographical demarcation of the forecasting area as fixed (see section 10.2), this assumption was reconsidered in

⁹⁴ *Notat vedrørende undersøgelse af biltætheden i de Storkøbenhavnske omegnskommuner.* BP3, B.M, 06.10.1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

September of 1962. At a meeting, it was proposed to demarcate the forecasting area more narrowly than originally intended (see section 10.2). This proposal was based on strategic considerations about how to enrol other planning agencies in the data collection. If the forecasting area was demarcated narrowly, it was likely that the counties or the Road Directorate would ask for information outside the forecasting area, and on that basis, collaboration could be established in respect to data collection. This strategy was not, however, chosen as one to pursue.⁹⁵ At the meeting, the number and content of the urban land-use alternatives were also discussed. In correspondence with what had been done in Philadelphia, Ottesen desired to include five alternatives, but admitted it could be necessary to do with two or perhaps even one alternative. In the end, the number of alternatives would be determined by the workload, and at that stage, this could not be determined. However, even though Ottesen had previously argued that an urban sprawl alternative was unacceptable and therefore could be excluded (see section 10.2), it was now reconsidered whether to include such an alternative. This was not because the forecasting group had taken up another position and now accepted urban sprawl as desirable, but rather because it should serve for “*dread and warning*”.⁹⁶ This suggests, in accordance with what has been argued above, that the substantial planning paradigm prevailing within the Urban Planning Office was the compact city model.

At the end of 1963, a number of land-use alternatives were still considered, but urban sprawl was not one of them. In order to proceed with the work of drawing up more detailed distributions of workplaces and residences, it was necessary to limit the number of alternatives. In November, Bent Jørgensen, who was responsible for drawing up the distribution of workplaces and residences, therefore prepared a note in which he elaborated the pros and cons of a number of land-use alternatives considered (see figure 10.2).⁹⁷

Model A's 2nd stage was an extension of the Technical Committee's 1st stage, corresponding to the long-term draft A, while the 3rd stage represented the most consistent prolongation of the 2nd stage. Inclusion of model A in the further forecasting programme was desired due to its official character and its preservation of the stellate traffic conditions. Moreover, model A could be extant with a 4th stage within the forecasting area, whereas extension of the other 3rd stage models would have to be prolonged beyond the area.

Model B's 2nd stage was an extension of the Technical Committee's 1st stage, corresponding to the long term draft B, while the 3rd stage represented a logical extension of the 2nd stage. Inclusion of Model B was also reasoned by its official charter. However, because the workplaces were located in areas more detached from existing urban areas, this alternative would also be particularly suited for making experimental traffic calculations under varying assumptions with regard to the degree of integration of traffic and business between the new and existing urban areas.

⁹⁵ *Referat af møde d. 24. september 1962* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁹⁶ *Referat af møde d. 24. september 1962* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

⁹⁷ *Udvælgelse af Storbymodeller*. BP3, B.P.J, 13.11.1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata)



Figure 10.2: The 2nd and 3rd stages of land use alternatives considered by Bent Jørgensen in November 1963.⁹⁸

The 2nd stage of Model C also represented an extension of the Technical Committee's 1st stage, but assumed that no larger concentrations of workplaces were located at the planned secondary centre of Høje-Taastrup. The reason for this deviation from the certified plan was that it was assumed to blur the more decentralized character of Model C when compared to Model A. The 3rd stage was a prolongation of the 2nd, but with urban development in an outer ring along marked towns. In this alternative, it was assumed that an Oresund crossing, in the line of Helsingborg and Elsinore, would be established, and that this would occur before a crossing between Copenhagen and Malmö.

Model D's 2nd stage was only of interest to include in the further forecasting programme because it represented an alternative to model A's 2nd stage and thereby a preliminary stage to Model B's 3rd stage. Nevertheless, it would still be desirable to include this alternative because

⁹⁸ (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

the possible impacts of an urban development along ring B5 would be elucidated. Model BD, 3rd stage, represented a mixture of the spatial logics underpinning models D & B. However, this alternative was assumed to involve a blurred and unstructured picture of the traffic conditions and was therefore not found relevant to include.

Also, the 2nd stage of Model E was only considered of interest as it represented an alternative to the 1st stage of model B and thereby served as a preliminary stage of Model BE, 3rd stage. It was, however, considered superfluous to conduct traffic calculations on the basis of this alternative, as it was expected to give results similar to model B's 2nd stage. However, it was decided that Model BE, 3rd stage, might be included in the forecasting programme if the calculations of model B, 2nd stage, showed good results.

Model AB, 3rd stage, was a mixture of the spatial logics underpinning models A & B. However, due to the same reasons given for Model BD, this alternative was not considered relevant to include.

On the basis of Bent Jørgensen's evolution of the considered land-use alternatives, the focus was hence mainly on models A, B and C, and to a lesser extent, model D's 2nd stage and BE's 3rd stage.⁹⁹ Around New Year 1963, the discussion about which land-use scenarios to include appears to have reached some degree of closure. At least, the focus was narrowed to three main alternatives for the development until 2000, namely models A, B, and C (see figure 10.3).

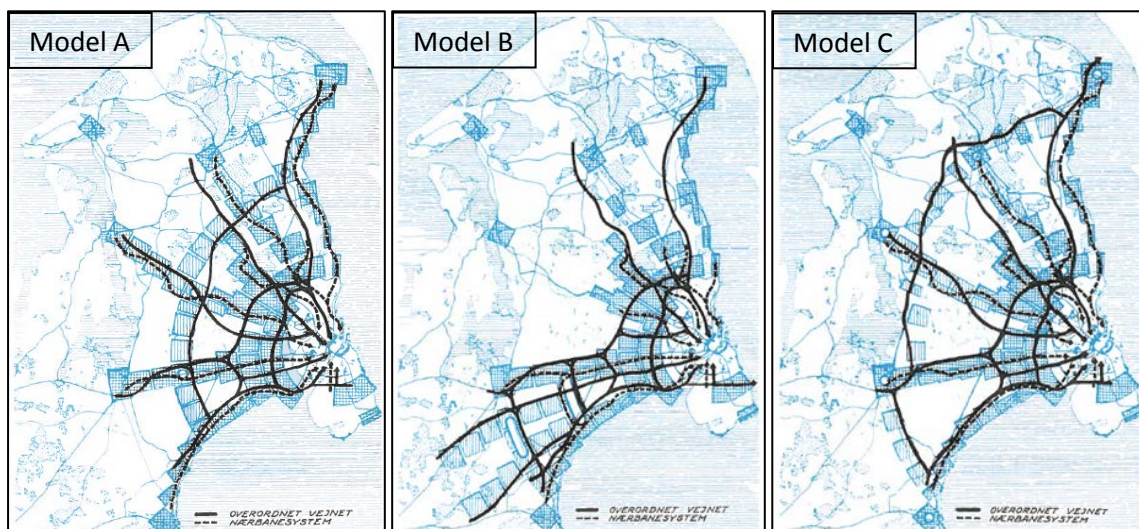


Figure 10.3: The three main land-use and infrastructure alternatives. The sketches show three possible alternatives for urban structure around the year 2000, where the entire metropolitan area is assumed to hold 2.500.000 inhabitants and 1 000.000 dwellings. The accepted 1st development stage plus areas considered prime for urban development are shown with crosshatch, which comprises an urban area equivalent to approximately 260.000 dwellings. The non-ideal settlements are shown with single hatching, and resemble an urban area equivalent to approximately 155.000 dwellings (Stadsingeniørens Direktorat 1964).

Hence, the land-use alternatives which the group members decided to include in the forecasting programme greatly resemble the spatial policy controversy centred on the future urban structure of the Greater Copenhagen Area, and in that sense, the spatial policy controversy was inscribed into the model. However, as the matter at issue in the spatial policy controversy

⁹⁹ *Udvælgelse af Storbymodeller*. BP3, B.P.J, 13.11.1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata)

subsequently transformed, so did the land-use alternatives of the forecasting programme. This will be elaborated on further in section 10.6.

10.3.5 Road infrastructure alternatives

In respect to drawing up the infrastructure networks which the model should evaluate and assist in designing, it is remarkable how little material I have found on this matter. An explanation might be that, distinct from the work with defining and drawing up the land-use alternatives, which was carried out within the Urban Planning Office, the work concerning the design of the primary road system was largely carried out in the Road Department and Road Plan Committee, established jointly with the Road Directorate in 1959 (see section 8.3).

Nevertheless, at the initial stage of the forecasting programme, the infrastructure system within the municipal border was supposed to be based on the Department of the City Engineer's proposal to the primary road system. Outside the municipal border, the infrastructure system was supposed to be based on the network presented in the Road Directorate's Zealand report from 1963 (see section 8.3 & figure 10.4) (Stadsingeniørens Direktorat 1964).



Figure 10.4: On the left: The Department of the City Engineer's proposal to the Primary Road system in the year 1959. In the middle: The Department of the City Engineer's proposal to the Primary Road system in the year 1965. On the right: The Road Directorate's proposal to the motorway network on Zealand outside the Municipality of Copenhagen (Stadsingeniørens Direktorat 1967c)

While the Danish Highway Authority was marked by a decentralized organizational structure, when it was decided to initiate development of the computerized transport model in 1962, this changed with the passing of a new road bill in 1963. The 1963 road bill delegated the authority of the main highways, including Copenhagen's primary road network, to the state. In cooperation with the engineering firms' argumentation in the 1930s (see Chapter 8), the centralization of the Highway Authority was motivated by a desire to manage the overriding planning of the motorway system. According to the new Road Bill, a construction bill had to be approved by the Parliament before construction of new motorway facilities could be initiated. However, now it was the State which had to cover all costs. This meant that Copenhagen's influence on the primary road system was ultimately reduced to approving or disapproving the National Parliament's decisions. However, the Road Bill did not imply that the counties and municipalities no longer played a part in the planning and design. According to the Minister's authorisation, the municipalities still managed the planning and subsequent construction work,

but they were now subjected to increased top-down control (Lyager 1996; Jørgensen 2001, p. 343-6). However, while the authority of the primary road network became delegated to the State, the Department of the City Engineer still headed the planning of the primary road network, and several modifications were proposed throughout the period of drawing up the forecast (see figure 10.4).

Even though the computerized forecast was supposed to support decisions on the future primary road network, political decisions were taken in principle before the results of the computerized transport model were available. In 1963, the Lake-ring and the insertion of Lyngbyvej were, in principle, approved by the Copenhagen City Council, and in 1964, the Goods-ring was approved as well. In respect to the Lake-ring, it was decided that it should not be established as a motorway, but as an arterial road in one level. Nevertheless, the Lake-ring was a major road scheme and required 28 metres of the Lakes be filled in. In 1964, the National Parliament passed a bill authorizing the Municipality of Copenhagen to plan and construct the Lyngbyvej and Harreskovvej. It also authorized the initiation of planning and design, but not construction, of the Lake-ring and the insertion of the West-motorway into the Lake-ring (Lyager, 1996).

We leave the storylines concerning the road infrastructure alternatives for now, but we will return to them in section 10.6. We will also return to the Lake-ring and the Goods-ring in Chapter 12, and explore the transport model-based knowledge production in regard to these projects. Next, the storyline concerning data collection is taken up again and we will encounter one of the first transformations in the objective of the forecast.

10.3.6 The need for further investments

Even though the work with improving the businesses census on the basis of phone interviews continued, it was realized that it would be extremely time and labour-intensive to upgrade data to the required level of quality on the basis of this approach. Therefore, the possibility of making a more simplified forecast was considered in the beginning of 1963. It was deliberated whether a forecast which was based neither on a total make up, nor a large representative sample of the workplaces' distribution, could still achieve a level of quality which could justify an effort of 1½-2 years of work. Lyager favoured this solution, but Ottesen opposed it, arguing that such a simplified forecast would be too inaccurate to serve as a proper base for sizing the capacity of the primary road system; it was therefore of limited value, but still required a considerable amount of work. Such a forecast could only be accepted if it was considered as preliminary for a more comprehensive forecast. Further investigations were therefore considered necessary.¹⁰⁰ In order to circumvent the problem of the geographical distribution of workplaces, three different approaches were considered, namely:

- 1) Continued improvement of the business census of 1958
- 2) Inclusion of a question about the location of workplace on the form of the population census of 1965
- 3) A new travel study primarily based on home interviews

¹⁰⁰ *Møde fredag d. 15 februar 1963.* BP3, B.P.J, 12.02.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

Improvement of the 1958 business census data was already on going. The second option was relatively cheap and was regarded to be the least labour intensive. In addition to information on the location of workplaces, it would also yield information about the relation between residents and workplace, and as this corresponded with the method used in the home-work survey of 1945, it would be possible to analyse the interim development. The third option, the home interview method, would yield a large amount of information, but even if interviews were restricted to a relatively small proportion of households, it still required much work. Therefore, this method could only be justified by the additional information gained about the households' travel behaviour. The advantage of home interviews was also that information about the total

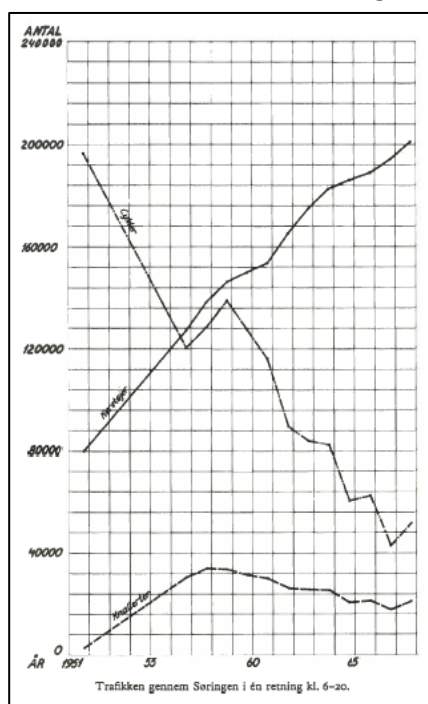


Figure 10.5: Actual traffic development in the Lake-ring section, 1951-68. Dramatic increase in motoring, and equally radical decline in biking (Stadsingeniørens Direktorat 1969, p. 25)

24 hour traffic could be gained, rather than just commuting traffic. This information was desired on the ground that it would provide a base of making a socioeconomic evaluation of the alternatives.¹⁰¹

However, data was not only a problem in respect to the geographical distribution of workplaces. At a follow-up meeting in June of 1963, between the Department of the City Engineer and Road Directorate, the applicability of the 1956 travel study was discussed. Although the Department of the City Engineer had originally considered the 1956 travel study as a practicable base of the forecast (see section 9.3.3), a new position was now taken on the matter. The home interviews conducted as part of the 1956 travel study were only based on around 3000 interviews. This fraction of the households was too small to be statistically representative. The implication of this in regard to modelling of modal split was that the 1956 study was more or less useless.¹⁰² Moreover, in some respect, the travel study was already regarded as outdated, as private motoring had increased by around 170% since 1956 (see figure 10.5).

However, one of the major drawbacks of the 1956 study was that it covered a too narrowly demarcated geographical area.¹⁰³ As a solution to the data problem, the Department of the City Engineer therefore proposed conducting a new comprehensive transportation study. While the number plate writing method had been the main investigation technique in the 1956 travel study, this method was no longer considered. Instead, the transportation study was proposed, to be based on home interviews of approx. 3.5 % of the households, in accordance with American practice, equalling around 20,000 interviews. A professor in sociology at Copenhagen University, who had also assisted with the home interviewing in the 1956 travel study, had

¹⁰¹ Metoder der for tiden påtænkes taget i anvendelse til at danne sig et skøn over den geografiske fordeling af antal beskæftiget indenfor undersøgelsesområdet. BP3, E.C. (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

¹⁰² Notat vedrørende den af Stadsingeniørens Direktorat under udarbejdelse, værende trafikprognose for hovedstads-regionen, BP3, 09.12.1965 Vejdirktoratet (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1,)

consented to organize and execute the interview survey. It was expected that the study could be completed in the spring of 1964. Unfortunately, this would mean that the original 1965 deadline for issuing of the forecast would most likely be missed. In general, the people from the Road Directorate endorsed the considered transportation study, but expressed concerns about the slip of the deadline. As political decisions about large infrastructure investments had to be made in the near future, completion of the forecast was considered urgent.¹⁰⁴

As an outcome of this meeting, one of the first transformations in the objective of the forecast occurred in September of 1963. Here, a revised proposal for the forecasting group's terms of reference was drawn up. The objective did still correspond with the initial terms of reference, but due to the problems of data quality, a correction was introduced. Now, the forecast was to be partly based on the 1956 travel study and partly on new investigations.^{105, 106, 107, 108} Around December of 1963, the problem of data availability also generated other transformations in the objective of the forecast. Initially, preparation of a preliminary forecast had been opposed on the ground that it would delay the final forecast. It was, however, realized that the actual forecast could not be completed in 1965 as intended. The forecast was strongly requested, and in order to reduce the delays, it was decided to make a preliminary forecast. Where the final version would measure total traffic, as originally intended, the preliminary forecast would be based on home-work traffic. Moreover, the forecast was to be based on available material combined with the supplementary investigations on the development of the distributions of workplaces. Hereafter, a new comprehensive transportation study was to be conducted, serving as the basis of preparing the actual forecast. Three alternative work schedules for the preliminary forecast were set up. In the optimistic alternative, the preliminary forecast was assumed to be completed in 1964. However, in order to keep this deadline, it would be necessary to apply a coarse distribution of workplaces and limit the number of alternatives considered. Still, this alternative was only considered realistic if the staff was expanded, and this had previously been proven impossible.¹⁰⁹ In the pessimistic alternative, it was assumed that the preliminary forecast could be completed in the beginning of 1966. However, this was regarded as inappropriate as it would collide with the transportation study, which was now assumed to be carried out in 1965 instead of 1964. The so-called realistic alternative assumed that the forecast could be finished in the summer of 1965. Hence, while it was initially considered realistic to complete the actual forecast in 1965, the problems of data availability implied that this objective

¹⁰³ *Referat af møde i Vejdirektoratet den 20. juni 1963.* (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁰⁴ *Referat af møde i Vejdirektoratet den 20. juni 1963.* (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁰⁵ *Til Stadsingeniøren*, BP3, L.Y. September 1 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

¹⁰⁶ *Udkast til skrivelse fra vejdirektør Bang, stadsingeniør Poul Vedel samt amtsvejinspektør Ivar Jørgensen til diverse styrelse vedr. udpegnig af repræsentanter til et prognoseudvalg*, BP3, L.Y. 03.09.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

¹⁰⁷ *Brev til hr. vejdirektør Kaj Bang fra Poul Vedel*, Stadsingeniørens Direktorat, 03.10.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

¹⁰⁸ *Forslag til kommissorium for et trafikprognoseudvalg for hovedstadsområdet*, BP3, Lyager, 29.07.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

¹⁰⁹ *Forslag til arbejdsprogram for foreløbig prognose*, BP3, 18.12.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

was transformed. Now, the preliminary forecast was assumed to be completed that year. However, as will be seen in the following, even the pessimistic alternative actually turned out to be optimistically biased.

In the beginning of 1964, the methodology of the further investigations was not yet resolved. However, in order to investigate the rationalities underpinning mode choice, it was necessary to make a number of home interviews, notwithstanding the method finally chosen. Likewise, inclusion of the workplace's address of the census form was desired regardless. Therefore, the forecasting group carried on with both a home interview survey and inclusion of the workplace's location in the census form as possibilities (Stadsingeniørens Direktorat, 1964).

In respect to the method of including a question about the workplace's location on the census form of 1965, an approach was made in mid-1964 to the Ministry of Economic Affairs, which organized the census.¹¹⁰ In order to increase the likelihood of gaining acceptance from the Ministry, the forecasting group had built up an alliance with the Transport Economic Committee, the National Planning Committee and the Civil Defence of Copenhagen, among others, before the approach was made.^{111, 112, 113, 114, 115} However, because the census was conducted in provision to the law of the National Register of Persons, belonging to the field of law under the Ministry of the Interior, the request was forwarded to this ministry. They, however, declined the request because inclusion of the question was inconsistent with the law of the National Register of Persons. The Ministry also refused to include the question in a separate form, because it was feared that it would lower the response rate of the census.^{116, 117} As including a question about the workplace's location on the census form was no longer an option, the group decided to move forward with the comprehensive transportation study. However, as the home interview survey was labour intensive, it would be impossible to carry it out before the fall of 1965 unless

¹¹⁰ Letter to: *Økonomiministeriet*, Stadsingeniørens Direktorat, Wassard Jørgensen, 13.06.1964

(Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹¹ *Notat vedrørende bolig – arbejdssted undersøgelse i forbindelse med folketællingen 1965*. BP3, K.A.O. 28.09.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹² Letter to: *Overborgmesternes afdeling*, Stadsingeniørens Direktorat, B. Tengqwis, 15.07.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹³ *Bolig/arbejdssteds undersøgelse i forbindelse med folketællingen i 1965*, Stadsingeniørens Direktorat, Poul Vedel, 30.06.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹⁴ *Referat af møde den 9. Juni 1964 i Stadsingeniørens Direktorat Hauser Plads 1, k., vedrørende gennemførelse af en bopæl – arbejdssteds – undersøgelse i forbindelse med folketællingen 1965*, BP3, K.A.O., 11.06.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹⁵ Letter to: *Margistratens 4. Afdeling, vedr.: Folketællingen 1965*, Stadsingeniørens Direktorat, V. Malling (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹⁶ Letter from: *Indenrigsministeriet* 18.11.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹¹⁷ Letter to: *Økonomiministeriet*, Stadsingeniørens Direktorat, Wassard Jørgensen, 13.06.1964 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

the results of the preliminary forecast were delayed further. Therefore, it was decided to prioritize finalization of the preliminary forecast and to postpone the travel study until 1966.¹¹⁸

For now, the storyline about the further data collection will be put on a hold, and instead, the process of developing the computerized transport models will be elaborated. The storyline about data collection will, however, be taken up again in section 10.5, where it will be shown that executing the transportation study remained difficult when the group tried again.

10.4 Computer models

This section explores the processes of developing the computer models. Even though the forecasting group was familiar with both types of sequential model structures (see Chapter 2) as well as with equilibrium modelling,^{119, 120} the initial focus was on a sequential model structure with the order of trip production, trip distribution, modal split and assignment.¹²¹ However, because the preliminary forecast was to be based on home-work traffic, trip production was assumed to be determined by employment and employees within a zone. Therefore, no model was developed for the first step: trip production. Next, the processes of developing the three other models will be explored.

10.4.1 Trip distribution

This sub-section explores the process of developing the trip distribution model. In many American transportation studies, probability models were used instead of gravity models (Interview Overgaard 2012). While probability models in general were regarded as appropriate by Ottesen, the particular probability model used in the Chicago Area Transportation Study was not accepted because it could not be used to assess assumptions about high or low distance decay. Hence, although Chicago served as a great source of inspiration, it was not accepted unreservedly. Even though probability models were accepted, gravity models appear to have been the favoured trip distribution method, and one for which there already existed a practice of use within the Department of the City Engineer.¹²² The forecast group did not, however, accept the standard type of American gravity models. This was because these did not differentiate the distant exponent between districts, as was practiced within the Department of the City Engineer (see section 9.1.1 & 9.1.5). The forecasting group had also acquired similar material from other cities (e.g. Stockholm) and detected a corresponding relationship. The evaluation practice which prevailed within the Department of the City Engineer came to serve as

¹¹⁸ *Møde den 4. December, Hauser Plads, BP3, K.K. 08.12.1964 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)*

¹¹⁹ *Udvalgt litteratur om trafikplanlægning, trafikanalyser, og -prognoser: Forløbellig fortegnelse forlagt på 2. Nordisk prognosemøde, København, 14.-15. Oktober 1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Vej- og transportsystem -nordiske prognosemøder, Box 1)*

¹²⁰ *Oversigt over vejvalgmodeller (metoder ved trafikens fordeling på vejnet, traffic assignment). Indledning af K.A.Ottesen ved diskussionen om vejvalgmodeller 2. nordiske prognosemøde, København, 14.-15. Oktober 1963. (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Vej- og transportsystem -nordiske prognosemøder, Box 1)*

¹²¹ *Forarbejder til gennemførelse af en generel trafikprognose for Storkøbenhavn, BP3, 12.11.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)*

¹²² In Denmark, the practice of using the gravity model was not particular to Copenhagen but prevailed nationwide (interview Overgaard).

an important basis for developing the computerized trip distribution model. Not only was the gravity model favoured over other methods from the beginning, but the particular variant of gravity model which was applied previously was also inscribed into the computer program. Hence, the particular practice which prevailed came to serve as a technological frame, and this frame constituted the basis from which different methods were regarded as acceptable or non-acceptable.

However, the trip distribution software program developed was not a copy of the Copenhagen gravity model, but was based on a combination of this variant of the gravity model and a method developed by the Traffic Research Corporation in Toronto. According to Overgaard (1964), the Toronto model was state-of-the-art at the time, allowing an iterative calibration of the gravity model's parameters. The programming started at the Data Centre in end of 1962 and the first version of the program was completed in August of 1963. The program was written for the IBM 7070 and contained two main functions:

1. Analyses of existing travel data
2. Forecast of future traffic

The program contained two different gravity formulas and these could be varied according to the following four parameters:

1. Common parameter value for all zones
2. A parameter value for each generation zone
3. A parameter value for each attraction zone
4. A combination of methods 2 and 3

All in all, the program could be used to calculate eight different variations of the gravity model. Although the first version of its trip distribution model was regarded as state-of-the-art by the forecasting group, some shortcomings were acknowledged. The first version could only be used to calculate a maximum of 100 zones and was only capable of calculating trips between zones and not within them.¹²³¹²⁴ In 1964, a second version of the trip distribution program was completed. This version enabled calculations based on a larger number of zones as well as internal trips.¹²⁵ A third version of the trip distribution model was also developed. In this version, the program was made more flexible, as the different sub-programs were separated so they could be used individually. Users could choose whether the internal trips should be included or excluded.¹²⁶

¹²³ *Mødereferat, I/S Datacentralen af 1959, København, 17.10.1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)*

¹²⁴ *Forslag til en kombineret beregning af turfrekvenser mellem zoner og fordeling på trafikmidler, BP3, K.A.O, 28.04.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)*

¹²⁵ *Forslag til arbejdsprogram for foreløbig prognose, BP3, 18.12.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)*

¹²⁶ *Turfrekvensprogram 3, kommenteret beskrivelse, S.D. K.A.O, 28.02.1968 (Plandirektoratets arkiv, Trafik teori og metode, u.år-, Turanalyse af gl. Program - turfrekvensprogram III, Box 1)*

10.4.2 Modal split

Although it was decided that the forecast should be used as the basis for sizing the capacity of the road system, modal split was included in the originally-stated objectives of the forecast. Yet, as will be explained in this sub-section, due to constraints on data availability, it was not easy to inscribe this objective into the model. Initially, a number of different methods for modelling modal split were reviewed. However, due to the 1956 travel study's poor data quality on mode choice, a suitable basis for testing the considered methods did not exist. Therefore, it was impossible to determine which distribution model to prefer before additional investigations were conducted on the issue. Nevertheless, the forecasting group had drawn up the following three criteria, namely:

1. The traffic users are divided into choice or captive.
2. The mode distribution model should only contain the choice group.
3. It should enable inclusion of more than two modes.

Based on these three criteria, the choice of distribution models was narrowed down to three options.

1. A model where the distribution was based on factors of travel and waiting time, perhaps with the addition of income. Whether these factors were also suitable for modelling of biking could only be determined when the new material was available.
2. The second model did not include waiting time as an independent distribution factor, but was still included in the total travel time and with a higher weight than actual travel time.
3. The third model was derived from Voorhees, and was considered particularly relevant because it was commensurable with a combined trip distribution and modal split model proposed by N. O. Jørgensen. Voorhees' model was based on accessibility ratios as the distributing factor.

The final decision was supposed to be made when new data had been collected and the models had been tested on this. However, regardless of which type of modal split model was chosen in the end, it was desired that biking should be measured in addition to car and transit travel (see Figure 10.6).¹²⁷ While biking had declined considerably in Copenhagen during the first part of the

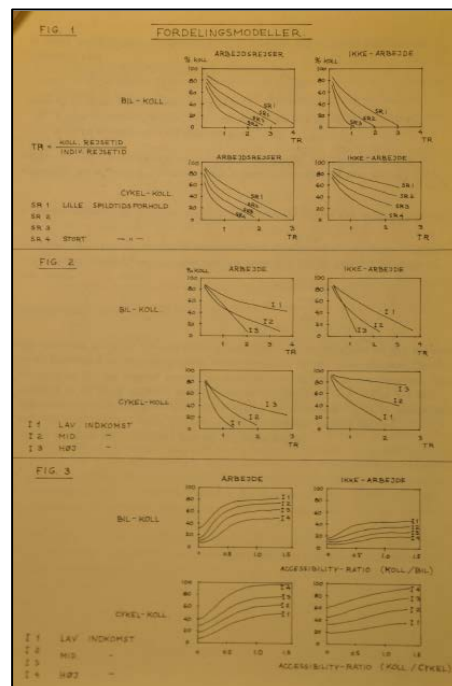


Figure 10.6: Diversion curves regarding car transit and biking transits for the tree different modal split models considered.¹

¹²⁷ Foreløbigt resultat af overvejelserne vedrørende beregning af trafikens fordeling på trafikmidler, og der til dette brug påtænkte hjemmeinterview-undersøgelse, BP3, B.E. 31.03.1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

1960s, it was still an important means of conveyance (Ottesen & Eir, 1967). In accordance with the argument put forward in the above section concerning that the trip distribution model was not a copy of American methods, it can be argued that the desire to include biking was an attempt to domesticate the modal split model into the Copenhagen transport project evaluation practice. However, even though the forecasting group desired to include biking, they did not know how to do so. As Bjarne Eir puts it in a note:

“While we, for the calculation of the distribution between car and public transport, can, to a great extent, be aided by experiences from the United States, our prior knowledge of bicycle traffic is very poor. It is therefore uncertain whether the factors (travel time and waiting time) that describe the distribution between car and public transport are also the best to render the distribution between bicycle and other means of conveyance.” (Own translation)¹²⁸

Inscription of biking was therefore not easy, and in fact, the forecasting group had a suspicion that factors such as trip lengths, social class, and weather conditions were more important than travel and waiting time.¹²⁹ Hence, despite biking constituting an important part of the Copenhagen traffic, it could not be inscribed into the model and further investigations into the rationales underpinning mode choice were therefore necessary.

10.4.3 Assignment

In respect to the assignment model, the forecasting group decided early in the planning process that capacity constraints should be included.¹³⁰ If the model was to be used to evaluate the different land-use alternatives on the basis of transport economic criteria, this was a necessary feature to include in the assignment model. In fact, the assignment model was supposed to be developed further, so it also contained a sub-model for calculating travel costs in addition to capacity constraints.¹³¹ However, in order to include capacity restraints in the model, it is necessary to draw up capacity functions for different types of road classes. In America, a considerable amount of work had been conducted in that regard, but as the American traffic conditions differed from the Danish, copying these capacity functions was not acceptable.¹³² Instead, it was necessary to conduct special investigations in Copenhagen. This work had already been initiated as part of the 1956 travel study (see section 9.1.5), and as he had been then, Arne Stæremose was once again given the task. In order to conduct these investigations, however, it was first necessary to classify the individual stretches of arterial road network so they could be

¹²⁸ *Notat om forløbige overvejesler vedrørende hjemmeinterview-undersøgelse. Forelægges på studiekredsmødet 3.5.65.*, B.E, 28.04, 1965 Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹²⁹ *Foreløbigt resultat af overvejelserne vedrørende beregning af trafikens fordeling på trafikmidler, og der til dette brug påtænkte hjemmeinterview-undersøgelse*, BP3, B.E. 31.03.1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹³⁰ *Undersøgelser af trafikforhold på gader og veje*. BP3, A.S. June 1962 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Vej- og transportsystem -nordiske prognosemøder, Box 1)

¹³¹ *Forslag til arbejdsprogram for foreløbig prognose*, BP3, 18.12.1963 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 1, Box 1)

¹³² *Etablering af beregningsnet og udvikling af kapacitetsfunktioner. Indlæg ved 4. nordisk prognosemøde i Stockholm, 2.-4. November 1964 af Arne Stæremose, byplankontoret, København.* (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Vej- og transportsystem -nordiske prognosemøder, Box 1)

coded on the basis of their respective characters. This was originally intended to measure the speed-flow relations for all stretches of the arterial network. However, mapping the physical characteristics of the arterial road network was laborious in itself, and it was soon realized that this was too labour intensive. On that ground, it was decided only to make investigations on speed-flow relations for a fraction of the network, focusing on stretches assumed representative of the identified road classes (see Figure 10.7).¹³³

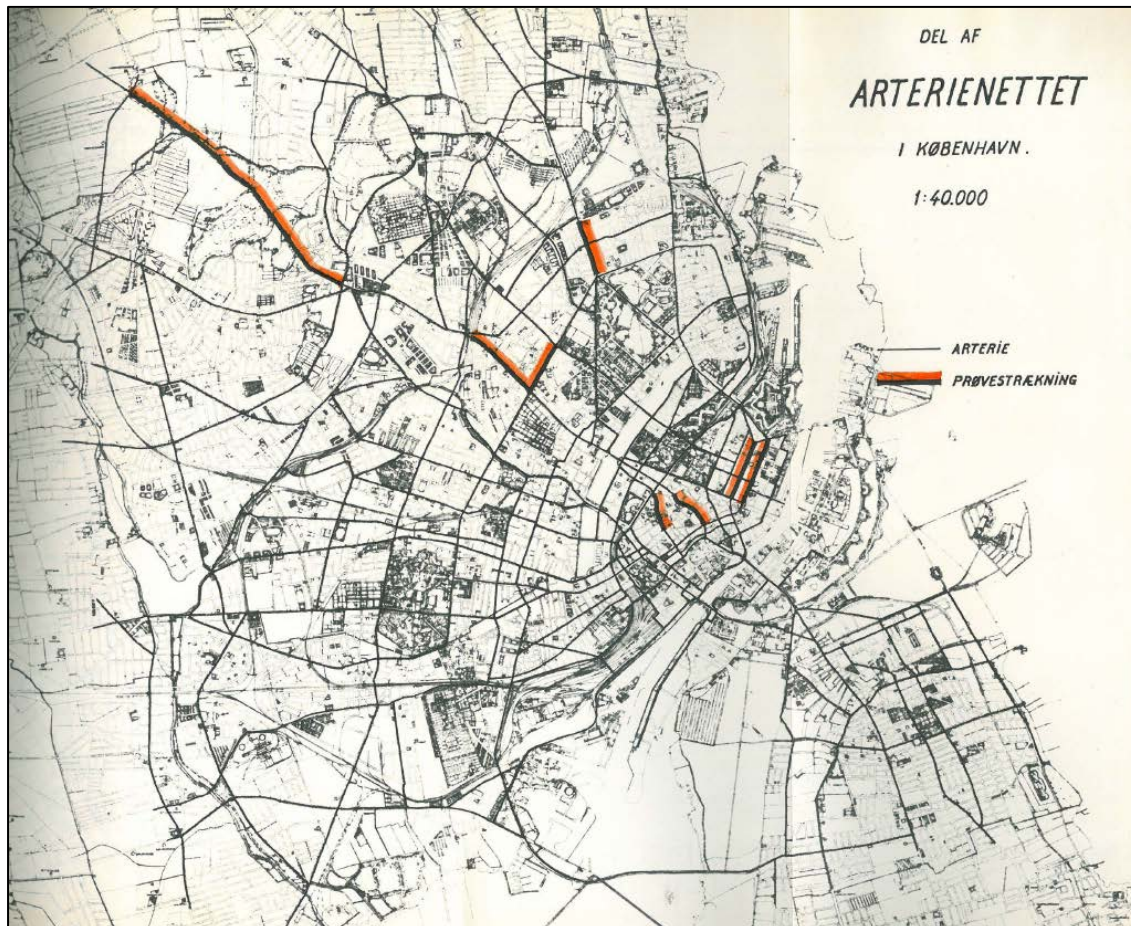


Figure 10.7: Parts of the arterial road network, and the stretches for which capacity curves had been prepared (Jørgensen 1964, p. 44)

Although the forecasting group had made an early decision regarding including capacity constraints in the assignment model, there was still an unresolved issue about how to include them. As part of the Detroit Area Traffic Study, Robert Smock developed an iterative method for the distribution of traffic routes in 1962. This method appears to have been favoured by the forecasting group from 1963, which shows that they kept themselves updated with state-of-the-art literature. Smock's assignment model had, however, been criticized for using simplified capacity curves. As part of his Ph.D. thesis, Knud Rask Overgaard had developed an assignment model for the provincial town of Kolding based on an improved design version of Smock's assignment model, which used exponential capacity functions for the individual road stretches (Overgaard, 1964).

¹³³ *Undersøgelse af trafikforhold på gader og veje 3*. BP3, A.S. 02.12.1963 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

Mosher, from the University of California, Los Angeles, had developed a similar assignment model in 1963, but had instead chosen to base it on a hyperbolic capacity function. This capacity function was assessed to be more advanced than the capacity functions developed by Overgaard, but the group nevertheless chose to apply Overgaard's model. There were two reasons for this. First, the hyperbolic function was regarded as more troublesome to work with than Overgaard's compounded exponential function. Second:

"Contributing to the choice of the rather simple exponential function was that the Data Centre had a complete default program for linear regression analysis. A special programming would be considerably more expensive to use than the finished program." (Jørgensen, 1964 p. 94; Own translation)

Despite the forecasting group being conscious of more advanced methods, they accepted a more simplified approach due to technological and economic constraints. This shows, in accordance with development of the modal split model, that the forecasting group was not capable of inscribing every desire they had into the transport model. Instead, Overgaard's model developed for Kolding was expanded so it could be applied on a network consisting of 1000 nodes and 4000 stretches. In accordance with the trip distribution model, the assignment model was considered as state-of-the-art back then. However, the iterative approach also had its drawbacks. Iteration demanded that the runtime be increased, thereby raising the financial costs as well. In fact, the financial aspect of running the iterations meant that the forecasting group "cheated" in some cases; while the program was supposed to execute 10 iterations before converging, it was sometimes stopped after fewer (Interview with Stæremose).

This example illuminates a constraint on incorporating feedback mechanisms. If iterations within an individual sub-model increased the computing costs to a degree, meaning that the number of iterations was reduced, then incorporating feedback all the way back to trip production would increase the cost of computing by a considerable amount, as not only would the whole model have to be run through an iterative process, but iterations in the sub-models also had to be run once again. Inclusion of induced traffic in the form of increased trip production would hence cause the cost of running the model to increase considerably, and this might be an additional contributing factor towards why induced traffic, in this sense, was not included in the framework of standard models (see Chapter 8).

10.5 A new transportation study

In this section, the storyline about data collection will be taken up again. Above, it was shown that the available data was, in several respects, ill-suited for drawing up the computerized forecast. This served as a constraint on the model development, particularly in respect to the modal split, where the work could not progress until new data was available. Below, initiatives for commencing collections of new data will be explored.

10.5.1 Transportation study of 1965/66

In 1965, the preliminary forecast was not about to be finalized as originally scheduled (see section 10.3.6). Still, the forecasting group resumed the considerations on data collection. In that regard, a new transportation study and a programme for carrying out home interviews was

prepared. The pilot study was now planned to be conducted in the fall of 1965 and the large study in the spring of 1966.¹³⁴ The pilot study was to serve two purposes. First, it should have a special focus on mode choice, so the considered modal split models could be tested.¹³⁵ Second, it should serve to collect practical implications for the large study. The pilot study was supposed to be limited to six zones. These six zones had been selected based on criteria of respectively high and low levels of: transit service, income and distance to the city centre. The pilot study was supposed to consist of 5.000 home interviews, equalling a sampling size of 10% of the population above 18 years old (see figure 10.8).¹³⁶ The questionnaire to be used in the pilot study was specially designed for testing the three selected distribution models, and therefore it contained questions which were not included in the large study.¹³⁷

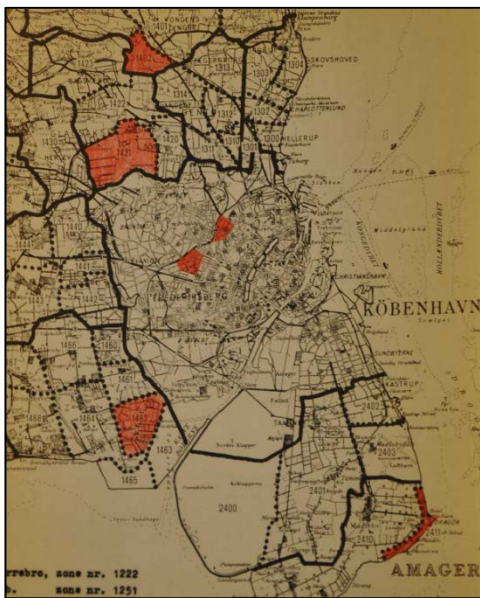


Figure 10.8: The six selected zones for the pilot study on mode choice¹

In June of 1965, the forecasting group re-approached Professor Svalastoga from the Social Research Institute to ask if he could assist in executing the home interview study in the autumn of that year. At the time, the professor was occupied with another large survey, but it was decided that if the pilot study and large survey were conducted simultaneously, the Social Research Institute could assist in the spring of 1966. However, Ottesen was of the opinion that the pilot study on mode choice was urgent. The next day, a new meeting was arranged. Then, the Social Research Institute suddenly confirmed that it could assist in the pilot study if it was conducted in September 1965.¹³⁸ ¹³⁹ Unfortunately, the Social Research Institute could not assist in the selection of respondents as had originally been intended. This raised a number of problems for the forecasting group. The respondents were to be selected from registers of taxpayers, and these were only available

¹³⁴ *Hjemmeinterview-undersøgelse (foreløbigt forslag til hjemmeinterview-undersøgelse af trafikvaner hos befolkningen i København)*, BP3, A.S. 31.05.1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹³⁵ *Foreløbigt resultat af overvejelserne vedrørende beregning af trafikens fordeling på trafikmidler, og der til dette brug påtænkte hjemmeinterview-undersøgelse*, BP3, B.E. 31.03.1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹³⁶ *Notat angående samplingsstørrelse ved hjemmeinterview-undersøgelse 1*. BP3, B.E, 29.06.1965. (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹³⁷ *Notat om foreløbige overvejelser vedrørende hjemmeinterview-undersøgelse. Forelægges på studiekredsmødet 3.5.65.*, B.E, 28.04, 1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹³⁸ *Notat vedrørende hjemmeinterview-undersøgelse i forbindelse med prognose arbejdet*, BP3, V.E. 03.07.1965 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Prognose København 2, Box 1)

¹³⁹ *Vedr.: Prognosearbejde. Undersøgelse af kriterier for valg af trafikmodel*, Stadsingeniørens Direktorat, 20.08.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

in the concerned municipalities and through the Statistical Department. Moreover, the registers only existed in a limited number of duplicates and were used steadily. If the forecasting group was to be able to borrow them at all, it would only be for short periods at a time. Even if the registers of taxpayers were available, it would still be difficult to get the staff needed to carry through the selection of respondents.¹⁴⁰ In spite of the difficulties faced, Poul Vedel asked the 4th Municipal Department for a permit to launch the pilot study at the cost of 40.000 DKK. This amount was supposed to be withdrawn from a block grant of three years at 250.000 DKK. However, the total cost of the forecasting project was now assumed to increase to 320.000 DKK, including the expense of the pilot study. Therefore, the pilot study could not be executed unless a supplementary grant was permitted. Moreover, because a mistake had caused an application not to be submitted, the appropriations not fully used in the two previous years had not been carried forward. Vedel therefore applied for a supplementary grant of 150.000 DKK in total.¹⁴¹ However, it was not possible to transfer the additional grants from the previous years before the beginning of September, and it was therefore necessary to postpone the pilot study.

10.5.2 Transportation study 1966/67

In the spring of 1966, the Department of the City Engineer once again applied for funds to cover the costs of the transportation study and a floorage survey within the metropolitan area. The floorage survey was to serve as a base for estimating the geographical distribution of workplaces in the land-use scenarios. In May, grants were permitted for both investigations.¹⁴²

As was the case previously, the plan was to conduct the pilot study on mode choice first. According to the schedule, this was to be carried out in September-November of 1966, and the large interview survey in the spring of 1967. The Statistical Office of Copenhagen was first asked to assist the transportation study. However, due to an on-going dwelling survey, the Statistical Office's burden of duties was heavy that year. Therefore, it could only assist with the transportation study to a limited extent.¹⁴³ The Social Research Institute was also re-approached and requested to assist in the following tasks, namely: selection of respondents, interviewing of 50.000 respondents and the drawing up of a final report.¹⁴⁴ However, due to a shortage on interviewing staff, the Research Institute could not promise that it would be able to carry out the pilot study in the fall. Neither could it assist with the selection of respondents.¹⁴⁵ In respect to the goods vehicle survey, which was part of the transportation study, the task of selecting respondents was extra labour intensive. The register from where the selection should take place was not yet transferred to punched cards, meaning that the selection had to be done

¹⁴⁰ *Tilrettelæggelse af hjemmeinterview undersøgelse*, BP3, B.E. 22.07.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹⁴¹ *Vedr.: Prognosearbejde. Undersøgelse af kriterier for valg af trafikmodel*, Stadsingeniørens Direktorat, 20.08.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹⁴² Letter to: *Socialforskningsinstituttet*, Stadsingeniørens Direktorat, Poul Vedel, 25.05.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹⁴³ *Referat af mødet den 20.-5.-66*, BP3, E.C. & B.E., 27.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

¹⁴⁴ Letter to: *Socialforskningsinstituttet*, Stadsingeniørens Direktorat, Poul Vedel, 25.05.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹⁴⁵ Letter to: *Stadsingeniørens Direktorat*, Socialforskningsinstituttet, 13.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

manually.¹⁴⁶ If the transportation study was to be carried out as planned, this would require a considerable amount of extra work for the Urban Planning Office, particularly for the forecasting group. However, despite both Anders Nyvig A/S and the Norwegian Transport Economic Institute having been hired as consultants, the forecasting team was still understaffed. Even though the computerized transport models were now completed and one land-use scenario for 1980 had been prepared¹⁴⁷, there was still a considerable amount of work to be done before evaluation of all the land-use alternatives could be initiated. Because it was impossible for the key persons of the forecasting group to take on more work, it was suggested that the group concentrate its efforts on completing the preliminary forecast and postpone the transportation study once again.¹⁴⁸ ¹⁴⁹ On that basis, a new schedule was drawn up. Thus, the pilot study was expected to be carried out in the spring and the large study in the autumn of 1967.¹⁵⁰ This would also make it possible to initiate collaboration with relevant planning authorities concerning their involvement in a technical committee consisting of politicians and technical experts. If the transportation study was supervised by the authorities who would ultimately consider the results, the likelihood of gaining acceptance increased.¹⁵¹ We leave the storyline on data collection for now, but we will return to it in section 10.7.2.

10.6 Re-politicization of spatial planning and reopening of the computerized forecast

While the explorations of this chapter have mainly focused on technical issues so far, the more political issues will take on a much more central role in this section, where the story is shifted back to the drawing up of the land-use and infrastructure alternatives. At this stage, some degree of closure had been reached on which land-use and infrastructure alternatives to evaluate in the model (See section 10.3. 4). However, in this section, it will be explored how the spatial planning within the Greater Copenhagen Areas was re-opened and re-politicized both in respect to land-use and infrastructure planning. Moreover, it will be explored how this shaped the land-use and infrastructure alternatives. First, Copenhagen's plan for extensive urban development on Amager and the planning of the so-called City Plan West area will be presented, respectively. Next, it will be explored how they contributed to shaping the model alternatives with regard to land use and infrastructure. Lastly, we explore the means through which competing transport model-based knowledge claims that expressed criticism towards Copenhagen's expansion plans were marginalized.

¹⁴⁶ *Referat af mødet den 20.-5.-66*, BP3, E.C. & B.E., 27.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

¹⁴⁷ The first results from evaluation of this alternative were expected to be available in the end of October 1966.

¹⁴⁸ Letter to: *Poul Vedel*, Kai Lemberg, 25.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

¹⁴⁹ *Notat vedr. Gennemførelsen af analyse- og prognosearbejdet*, BP3, K.A.O., 27.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

¹⁵⁰ Letter to: *Socialforskningsinstituttet*, Stadsingeniørens Direktorat, 25.07.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview)

¹⁵¹ *Notat vedr. Gennemførelsen af analyse- og prognosearbejdet*, BP3, K.A.O., 27.06.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

10.6.1 Amager and re-opening of the spatial policy controversy

The three main land-use alternatives, on which the group seemed to have reached some degree of closure, more or less resembled the 2nd stage development plans A or B (see section 10.3. 4). However, in 1965, the forecasting programme included additional alternatives which resembled neither the 2nd stage development plan A, nor B. Yet, they were strongly tied up to the spatial policy controversy about the future spatial order of Copenhagen (see section 9.2). Although the 1st stage development plan had been commonly accepted among the parties of the dispute, the policy controversy broke out again in 1964-1965. However, this time, the front of the controversy shifted from the urban form to the inner structure of the Greater Copenhagen area. More specifically, development on Amager became the new sticking point.

In 1962, the Social Democrat, Urban Hansen, came into office as Lord Mayor of Copenhagen. Urban Hansen was an energetic politician. At the top of his platform was the plan to act on the social and economic problems the Municipality was facing and reverse the downward tendency. In order to do so, Urban Hansen aimed to expand the municipality's tax base by launching a massive housing construction programme within the municipal borders. While the Preliminary Master Plan had shown caution about using the last undeveloped areas in the short term, Urban Hansen established his own Housing Office and created, over the head of the Major of Urban Planning, a plan for developing every undeveloped plot within the municipality. This resulted in the so-called Urban Plan, which amounted to approximately 25.000 dwellings (see figure 10.9). However, many of the designated areas were marked for other purposes, and a critical scrutiny of the plan by the Urban Planning Office reduced the number of dwellings considerably (Lyager 1996; Thomassen 1980; Rasmussen 1994).

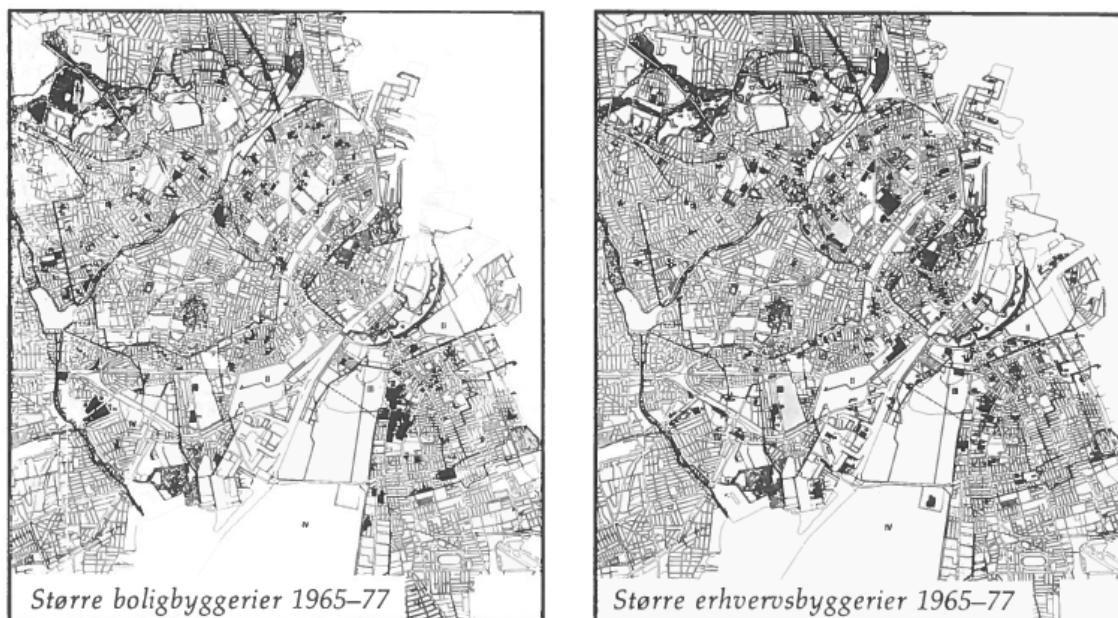


Figure 10.9: The so-called Urban Plan for development of housing (left) and businesses (right) in Copenhagen 1965-77 (Thomassen 1980)

Even though larger areas, useable for developments, were more or less exhausted within the Municipal borders, Amager contained large areas of potential. In 1961, an outline plan for Amager was prepared with the purpose of indicating how a certain housing growth could be

placed on West Amager in the following few years. According to the outline plan, approximately 1.200 new apartments could be placed around the area of Peder Lykkes Vej. The outline plan also presented a long-termed development perspective. However, a large development of the island was conditioned on circumstances beyond the control of the Municipality. If the South Harbour was expanded, it was considered inappropriate to construct dwellings for more than 25.000 persons. However, if the South Harbour was relocated, and a new harbour crossing established, then housing for 75.000 people could be constructed. If the airport was relocated as well, then housing for 150.000 people in total could be developed on West Amager (see Figure 10.10) (Stadsingeniørens Direktorat, 1961).

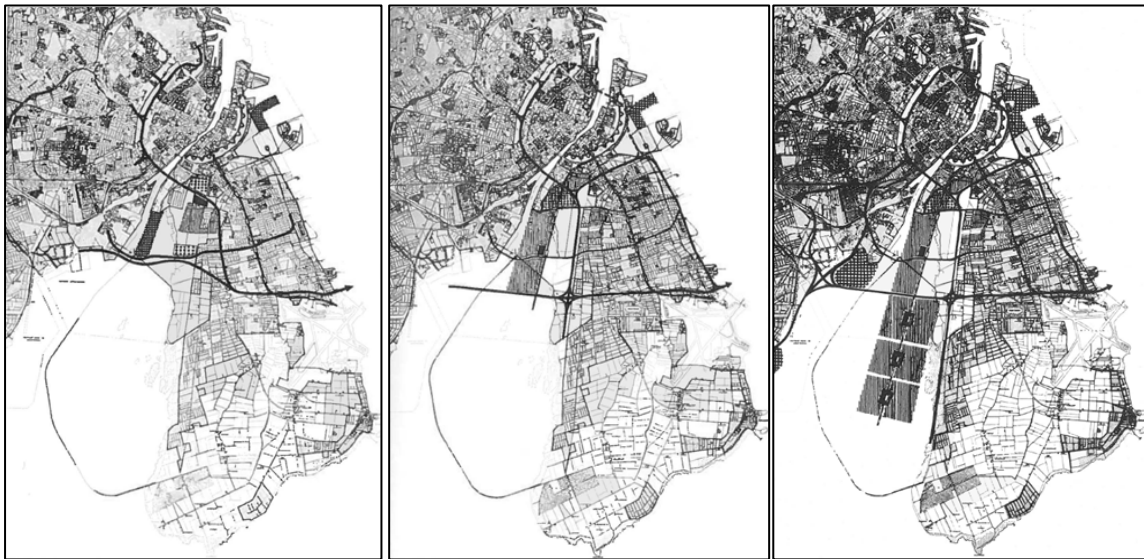


Figure 10.10: Perspectives for development on Amager. To the left: existing condition 1963. In the middle: Preliminary outline for Development plan for Amager, containing 10.000-11.000 new dwellings. To the Right: Long term perspective, with possibility for development of 30.000 additional dwellings on the condition of relocation of the military rifle range.

In February of 1963, Urban Hansen wrote a recommended letter to Vedel, where he clarified that he was:

“rather worried about” [the limit of 5,000 apartments on Amager], *“however it should be possible to achieve something more in 7-8 years “. ... “it should be possible on Amager Fælled and the land between Zealand Bridge and the line for a new Oresund crossing to build 10-11,000 apartments ... immediately after the area south of Peder Lykkes Vej is finished.”* (Quoted from; Lyager 1996, p. 22; Own translation)

Urban Hansen’s request to Vedel was hence incommensurable with the 1st stage regional development plan, which restricted development of new housing on the island to 5.000 until 1970. Both Vedel and the Major of Urban Planning, Wassard, had accepted this agreement, but Urban Hansen did not. In 1962, he resumed negotiations with the state concerning the co-ownership of Amager Fællede (Rasmussen 1994, p.293). Previously, he had tried to solve the economic problems of Copenhagen by reaching an agreement with the suburban municipalities concerning a compensation account, but had met no success (Hansen 1965; Illieris 2010).

In 1964, Urban Hansen succeeded in reaching an agreement with the Social Democratic Government's Minister of Finance, Poul Hansen, concerning co-ownership of Amager Fælled. In the division of property, the state was allotted to 45% of the area and the Municipality the remaining 55%. Copenhagen now came into possession of a major area. If fully built-up, it could contain 200.000-300.000 residents. Moreover, as the most centrally-located part only was about 2 kilometres away from the city centre, it was very attractive to develop. In fact, this area could form part of a development according to the agreement.



Figure 10.11: The two fellow partisans Urban Hansen (left) and Poul Hansen (right) finalizing the co-ownership agreement in friendly manners (Thomasen 1980)

Nevertheless, the agreement required that a comprehensive plan for the area was prepared and that a Nordic architectural competition was launched. Moreover, it was required that the plan had to be approved by the Ministry of Housing before construction could be initiated (Lyager 1996; Illieris 2010; Rasmussen 1994). In November of 1964, the architectural competition was launched. In the clause, it was specified that new housing was found particularly desirable and that the most central part of the area could be utilized for a new district. With this distinction from the previous regional plans, the scene was now set for intensive development on Amager, and there was not a precondition stating that the incoming proposals must be commensurable with the existing regional plan. In fact, in the clause, it was stated that Amager could be given a new status in regard to regional planning (Stadsingeniørens Direktorat 1967c). Hence, while the common acceptance of the 1st stage development plan had brought a temporary closure to the spatial policy controversy regarding the future urban structure of the Greater Copenhagen area, the finalization of the co-ownership agreement contributed to opening it up again. Nevertheless, this re-politicization of the prevailing spatial order was not accepted within planning circles. Just before the architectural competition was launched, Peter Bredsdorff wrote as follows in the national paper Politiken:

"It is bad enough that the Copenhagen regional planning has thus far had to scrape a bare living without having a background in particular national planning efforts, but even worse is the fact that the proposed urban development on the reclaimed areas clearly is contrary to the principles that underlie the hitherto prepared long-term plans for Greater Copenhagen." (Bredsdorff 1964; Own translation)

Hence, according to Bredsdorff, the scene set in the competition brief was incommensurable with the prevailing spatial order of the Greater Copenhagen area and was therefore unacceptable. He found it regrettable that the accepted 1st stage development plan was now more or less overthrown by the competition. Bredsdorff further pointed out that development on Amager was inconsistent with the principles of the Master Plan Draft (see section 9.1.3). Even some planners within the Department of the City Engineer levelled critical voices at the considered Amager Development (Thomassen 1964, p. 124)

Even though development of Amager was incommensurable with the 1st stage development plan, this did not make an Amager development unacceptable to Urban Hansen. To him, Amager constituted an opportunity for Copenhagen to reverse the economic and social problems faced by the municipality, and this was more important than commensurability with the regional plan. He puts it as follows:

"... Copenhagen has [among the municipalities of the Greater Copenhagen area] the lowest average income – yet. The population has declined over the last 15 years, falling by 80.000 to 687.000, so there are fewer and fewer people to pay and there are more and more, who preferably should receive more and more [in social benefit]. Now is the chance for Copenhagen to take decisive action and plan a development of 50.000 dwellings on Amager Fælled and the old reclaimed area. There will have to be created dwellings, and with a condemnation programme of 35.000 homes, there is no room for a similar number of people in the redevelopment neighbourhoods. So let us try to see it as a positive factor that Copenhagen has been able to get Amager Fælled. We must not become hysterical because developments do not match the planning stages of 10 years ago. Nor must planners forget the practical political considerations of just annoyance." (Hansen 1965; Own translation).

Urban Hansen argued that it was more or less legitimate that Copenhagen expanded its spatial capital by development on Amager, even though this was in opposition to the prevailing order of regional planning.

The architectural competition ended in September. In general, the panel of judges was pleased that many of the 35 incoming proposals had taken up issues of regional planning for consideration. In the end of July 1965, the Urban Planning Board had stressed that a solution to

the problem of a long-termed development plan soon had to be reached¹⁵², but many issues related to regional planning were not yet settled.

The project awarded 1st prize was prepared by Anders Nyvig and Børge Kjær. It contained a proposed city-belt stretching from east to west, just south of the municipal border. In the east, the city belt had a connection to an Oresund fixed link, and in the West, it connected to the secondary centre in Høje-Taastrup, which was assumed in the 1st stage development plan. The city belt was to contain business, public enterprises, exhibition areas and cultural institutions. The airport was assumed re-located to the island of Saltholm and the South Harbour was replaced by a new harbour on the east side of Amager. Based on these assumptions, densely built-up residential areas, containing 100.000 new dwellings and amounting to approx. 300.000 inhabitants, were proposed. This development was the most intensive among the proposals and was clearly incommensurable with the spatial order which had prevailed for Amager until that point in time. The project was also divided into two stages of development. In the first stage, the most central part of the area was to be developed (see figure 10.12).

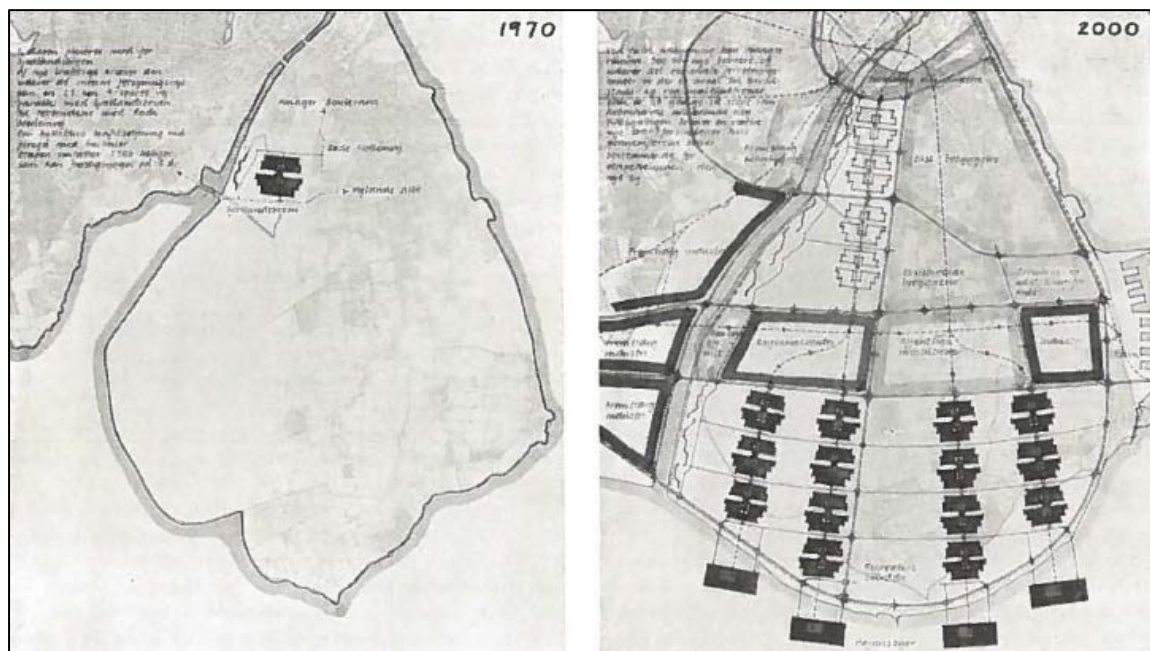


Figure 10.12: Sketch of Nyvig's and Kjær's 1st prize winning project. On the left, is the first development stage depicted. The right depicts the project when fully built up.

The project also contained a proposal for a rather fine grained rail system and a subway which connected with the central business district (see figure 10.12 & 10.13). In fact, the capacity of the proposed rail system was larger than the proposed primary road system. However, the project also contained a number of corrective suggestions to the primary road system.

In order to reduce the damaging effect of the inner semi-circular lake-ring on the inner city areas, a proposal was made to reduce the traffic load on this part of primary road system. While four of the main radial roads were merged pairwise at the stretches where congestion was most significant in the Department of the City Engineer's proposal (see figure 10.4 & figure 9.10.13), it

¹⁵² Udkast til en fælles redegørelse om en mulig byudvikling i Kalvebodsektoren, BP3, F.T. 30.07.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata, Box 1)

was instead suggested to insert the radial roads individually, and thereby spread their points of attack on the Lake-ring (see figure 10.13). Also, if ramps to the planned car parks under the lakes were improved, a rough calculation had confirmed that the Lake-ring could be reduced to a one level street. However, even though the Lake-ring was downsized, it would still constitute a major thoroughfare, consisting of a six-laned one-way road on both sides of the lakes. Hence, the first prize winning project did not only oppose the prevailing spatial order of regional planning, it also questioned the Department of the City Engineer's proposed design of the primary road system.

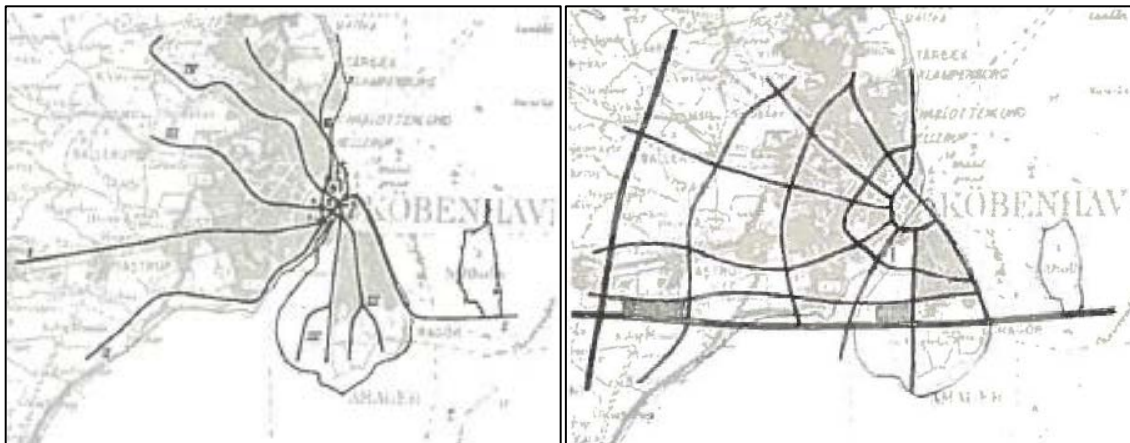


Figure 10.14: The rail system (left) and road system (right) proposed in the first place project (Arkitekten 1965, p. 9)

Also, a number of other projects were awarded and purchased. In general, these were based on very different principles, ranging from densely to sparsely built-up areas, transit to car-based transport system, etc. Urban Hansen states as follows:

"We have got valuable material, but before we come to the end of the road, both with the more comprehensive outline plan and with the specific land-use plans, many working hours must be spent. Both the outline plan and its regional planning perspective require negotiations with many parties, including also the other municipalities in the metropolitan area. Unfortunately, we have not yet created the regional planning council within the Metropolitan municipalities' joint council, which has been much discussed. I hope that the regional planning council is soon created so that we obtain a forum for discussion of our plans. Fortunately, the winning project allows the opportunity for us to, without prejudicing the further development, go ahead in the northern part of Amager Fælled, and to this end, we in the co-ownership Management Board discussed the preparation of land-use plans, conduction of drilling samples, surveying, etc." (Quoted in Arkitekten 1965; Own translation)

Hence, according to Urban Hansen, a large scale development of Amager could not be initiated before acceptance from other planning authorities had been obtained, but nevertheless, Copenhagen instantly initiated a development of the northern part of the competition area, closest to the city centre. Moreover, although Urban Hansen had previously been unsuccessful in establishing a new regional planning arrangement for the metropolitan area, things now started to happen in that respect. A restructuring of the Regional Planning Secretariat's organizational affiliation was likely to happen in the near future. Nevertheless, gaining

acceptance of the Amager plans from the suburban municipalities would require a considerable work of power. Several municipalities had problematized the Amager plans, including the Municipality of Høje-Taastrup, which was singled out as secondary centre for the western sector in the first stage development plan. The Municipality feared that an Amager development would foil these development plans, a concern that was not unjustified. The uncertainty about the long-term regional land-use plan resulted in Høje-Taastrup's loan-taking opportunities having been constrained. Therefore, Høje-Taastrup regarded the Amager plans as an obstacle for carrying out rational and long-termed planning (Politiken, 1965).

Hence, Copenhagen needed to obtain acceptance before massive development of Amager could be initiated. However, such a development was inconsistent with the idea of the spatial capital, which had been legitimately conferred upon the structural position of Copenhagen. Therefore, Copenhagen was once again in need of facts in the spatial policy controversy, but this time, the information was needed in order to reify the legitimacy of expanding the spatial capital tied up its structural position rather than to try to defend it. We will next explore how this need for truth influenced the content of the traffic forecast.

10.6.2 City Plan West and problematizing of the outlined Lake-ring design

In addition to Copenhagen's Amager plans, the planning initiated for the so-called City Plan West area also contributed to questioning the underappreciated spatial planning and opening up the computerized forecast.

The City Plan West area covered the inner district of Vesterbro, where the West Motorway was planned to intersect with the Lake-ring. In the Master Plan Draft, this area was singled out as a suitable re-development area where the central business district could expand, (see section 9.1.3) and a more specified plan for this area was issued in 1958 (see section 9.2.1). In 1964, the National Parliament approved a construction bill for the northern radial road, Lyngbyvej, as an urban expressway inserted into the lakes as well as a projection law for the Lake-ring. This meant that the whole area around the inner district of Vesterbro now became of increasing interest for redevelopment, resulting in Copenhagen launching a new plan-making process for the area in 1965. Next, it will be explored how transport model-based knowledge production, which was prepared as part of the planning of the City Plan West area, contributed to rendering traffic in the Lake-ring section knowable in a new manner, which problematized the proposed design of the Lake-ring.

However, the planning of the City Plan West area was not conducted in-house, but by a private consultancy firm. Several of the high officials within the Urban Planning Office, including the head of the forecasting group, Poul Lyager (see section 10.6.1), had handed in their resignations due to dissatisfaction with the conditions of work within the Department of the City Engineer (Information, 1965). The dissatisfaction was particularly due to understaffing and the position of the office, which was responsible for the master planning, at the bottom of the organizational hierarchy within the department's structure, even though it served as an administrative department for the Chief City Engineer and the Mayor of Urban Planning. However, before Lyager had formally left, he was offered a consulting position heading the planning of the City Plan West area. Lyager accepted the offer and formed a firm called the City

Plan West Office. Ole Thomassen, Knud Rasumssen and MSc Jørgen Vedel¹⁵³ were among those who joined him (Lyager, 1996).

The design of the City Plan West area was quite dependent on the design of the main thoroughfares in this part of the city. Therefore, it was first necessary to clarify the traffic requirements of these road sections and broadly define their layout and principles of design before the more detailed work with designing the development of the area could be initiated. Therefore, one of the first planning tasks which the City Plan West Office embarked on was to prepare a forecast for 1990 in respect to the traffic loading the harbour crossing section, the City Plan West area and the Lake-ring.^{154, 155}

When the first plan for the City Plan West area was drawn in 1958, it was based on a forecast which assumed 50% growth in employment within the central business district (Stadsingeniørens Direktorat, 1958a). The forecast prepared by the City Plan West Office was, however, based on an assumption about stagnation within the central business district.¹⁵⁶ In respect to Amager, the forecast was prepared just after the architectural competition ended, and on that ground, housing for additional 70.000 people was assumed.^{157 158} It is important to note that the forecast, in respect to its methodological base, was prepared on rather crude assumptions. In the following, we shall, however, only concentrate on the result of the forecast and its implications. We will return to the assumptions in section 10.6.4.

The result of the forecast was available in October of 1965 and questioned the taken-for-granted of the traffic's volumes and composition in the Lake-ring section. In respect to the distribution between through traffic and city-oriented traffic, the result differed considerably from what had been assumed. Both in the inner and outer parts of the primary road system, city-oriented traffic was shown to constitute the minority of total road traffic. This was partly due to the relatively effective transit coverage of the central business district. This good coverage was, however, limited to the area within the Goods-ring because traffic between the dense inner-city areas and the outer areas generally had no choice but to make use of individual means of transport, meaning that large traffic volumes were detected both across and along the Goods-ring. In order to divert as much through traffic as possible away from the Lake-ring, it was therefore suggested

¹⁵³ Jørgen Veldel should not be confused with the Chief City Engineer, Poul Vedel.

¹⁵⁴ *Udviklingen i trafikken over havneløbet i årene 1965-1990*. J.V. 11.05.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁵⁵ *Notat vedrørende City Plan Vest-rapport nr. 65/12, Fremtidige Trafikstrømme omkring City Plan Vest (jfr. Møde den 13.januar 1966 hos Stadsingeniøren)*, BP3, V.E, 20.01.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁵⁶ The City Plan West Office was not the first to accept stagnation in employment within the central business district. Based on traffic counts and comparison of the home-work travel survey of 1945 and the transportation study of 1956, Kryger from the Department of the City Engineer arrived at the conclusion that city-oriented traffic was stagnating, The increased traffic problems which could be observed in the inner city were, according to him, due to an increase in motoring and through traffic to and from Amager (Kryger 1962). Gert Moltke from the Regional Planning Secretariat had arrived at the same conclusion in respect to the city-oriented traffic (Lyager 1996).

¹⁵⁷ *Afskrift efter Døllnors referat vedrørende: diskussionsmøde om Amager-konkurrencens 1. præmie projekt. 1. februar 1966*. BP3, F.T. 15.02.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁵⁸ *Udviklingen i trafikken over havneløbet i årene 1965-1990*. J.V. 11.05.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

that the primary road along the Goods-ring should be designed with a very large capacity and the southern part of the ring supplied with good connections to the Western motorways.

When the first Lake-ring draft was prepared in 1958, 80% of its future traffic was assumed to orientate towards the Central Business District, while through traffic only was assumed to constitute the remaining 20%. On that basis, the Lake-ring was designed as a circulation road, leading road users to the exit ramps nearest their destination within the central business district (Stadsingeniørens Direktorat, 1958a). The rationale which underpinned the design of the Lake-ring in 1958 was hence that it should serve to protect the narrow street system of the Central Business District against overload. However, according to the forecast of the City plan West Office, more than half of the total Lake-ring traffic would consist of through traffic in 1990. The result of the new forecast was hence inconsistent with the compositions of traffic previously assumed, and this contributed to raising consciousness about problematic aspects of the Lake-ring's design. As the Lake-ring was designed to lead traffic into the city centre, there was a risk that the narrow street system of the Central Business District would be overloaded with through traffic. In order to protect of the narrow street system of the historical core, the City Plan West Office argued that in the light of how traffic had been rendered knowable by the forecast, traffic had to be governed differently in order to be governed effectively. On that ground, an order of segregation between different types of road users was proposed, stating that this new order of segregation should be achieved by a redesign of the Lake-ring's material structure. It was suggested to segregate Lake-ring traffic between through traffic and city-oriented traffic, and divert through traffic away from the central business district instead of distributing traffic into it. In order to obtain this effect, it was suggested that the Lake-ring should be designed exclusively for through traffic by establishing it as a misaligned urban expressway without approach and exit ramps in the inner-city areas. Instead of the Lake-ring, the city-oriented traffic should approach the city centre through the local streets of Søgaderne and Farimgaderne (see figure 10.15), and traffic between Amager and the central business district was proposed to be served solely by the two existing central harbour crossings. According to the forecast, the capacity of these two crossings was sufficient to handle the city-oriented harbour crossing traffic, even if Amager was developed further.

In respect to the future harbour crossing capacity, the forecast showed a demand of 23.400 PU. Including the planned capacity enhancement of the three existing bridges, the total capacity was around 10.000 PU. According to the forecast, this would imply that an additional nine lanes in each direction were needed.¹⁵⁹ Based on these results, some overall conclusions were drawn (Krogh 1967a):

1. There is very poor correspondence between the desired architectural and urban design of the Lake-ring and the forecasted traffic loads
2. The future load of the traffic flow through the City Plan West area will be so great that it hardly can be handled by the design of the primary roads proposed by the Department of the City Engineer for this part of the system.

¹⁵⁹ *Afskrift efter Døllnors referat vedrørende: diskussionsmøde om Amager-konkurrencens 1. præmie projekt. 1. februar 1966. BP3, F.T. 15.02.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)*

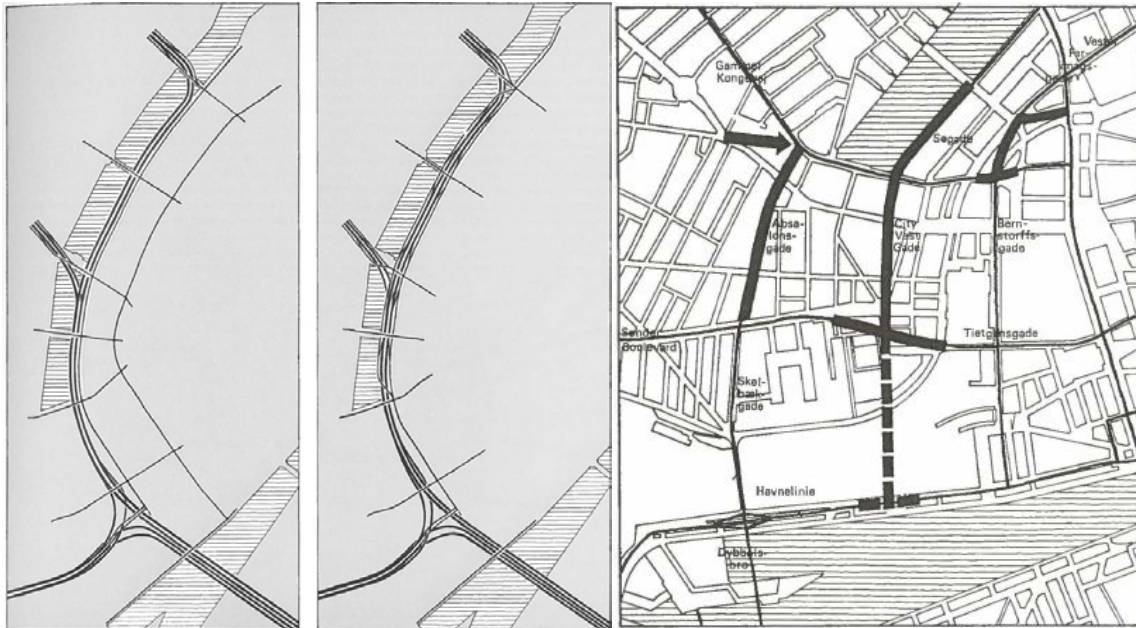


Figure 10.15: On the left: the Lake-ring designed with segregation of the of through and city-oriented traffic
 In the middle: the Lake-ring designed without segregation of the of through and city-oriented traffic
 On the right: the trace of the proposed harbor crossing, Dybbølsbro, south of a Lake-ring crossing (Lyager, 1968)

Hence, the forecast rendered traffic knowable in a new manner, which problematized the design of the primary road network that had been assumed appropriate by the Department of the City Engineer. Moreover, because it was the increase in through traffic which constituted the problem of the Lake-ring, the forecast also implicitly problematized development on Amager.

10.6.3 Re-opening of the land-use alternatives

This subsection explores how the land-use alternatives were shaped by the re-emergence of the spatial policy controversy and the movement in the sticking point towards Amager.

In the end of September 1965, just after the architectural completion was settled, Ottesen made a note on the awarded and purchased projects in regard to the forecasting programme. Ottesen argued that because the respective proposals' engagement with aspects of regional planning was based on such diverse principles, they had contributed to further opening regional planning rather than bringing closure. Ottesen also argued that the winning project contained a number of weaknesses, implying that it was unacceptable as a basis for an Amager development in its current form. The project seemed oversized with regard to transit and undersized in respect to road capacity. Ottesen was also reserved about establishing the first of the larger developments before the primary road system on Amager was implemented. The strong concentrations of development on Amager also deviated decisively from the prevailing spatial order, but in that respect, the winning project was not a special case. Many of the incoming proposals were based on principles which hitherto had not formed part of the planning practice within the Metropolitan area. Therefore, it was told by Ottesen that a decision should only be made in respect to the basis of future planning when the various proposals had been tested based on traffic economic criteria. In the forecasting group, the work with the preliminary forecast had progressed to the point that establishment of the geographical distribution of jobs and housing for 1960 was soon to be completed. However, the work with preparing the long-term land-use scenarios was not yet conducted, and therefore it was possible to include alternatives from the

Amager competition.¹⁶⁰ Hence, the re-opening of the policy controversy about future spatial order, which Copenhagen's Amager plans had caused, meant that the computerized transport model was reopened for change to come about.

In the beginning of 1966, the Mayor of Urban Planning, Wassard Jørgensen, set up an internal "Amager Committee" with the purpose of preparing an update of the Master Plan in respect to a number of problems associated with development on Amager (Stadsingeniørens Direktorat, 1967c). Wassard chaired the Committee, which also contained Urban Hansen, the Chief City Engineer and the new head of the Urban Planning Office, Kai Lemberg, among others. A number of high-ranking officials within the office had resigned due to dissatisfaction, e.g. Lyager and Thomasen. Kai Lemberg, who came from a position in the Ministry of Public work, was therefore hired at a two-year secondment as the new head of the Urban Planning Office (Lyager, 1996). The winning team from the Amager competition was hired as consultants and participated in the committee meetings.

In June of 1966, an agreement was made between the Amager Committee, the winning team and the forecasting group to include increased development on Amager as a land-use alternative in the forecast, both for 1980 and 2000. In the preliminary forecast for 1980, Amager was now given priority over evaluation of the alternatives to the 2nd stage development plan. In fact, for 1980, it was decided that only a basic alternative and an Amager variant should be evaluated. The basic alternative (alternative 80.01) resembled the development which the forecasting group considered most likely. Within the central municipalities, the number of workplaces was assumed to stagnate between 1960-80. In respect to Amager, in addition to approx. 7000 designated dwellings, this alternative contained 10.000 new dwellings on West Amager. The Amager variant (alternative 80.02) was similar to the basic alternative, but contained increased development on West Amager and correspondingly less evenly distributed over the rest of the forecasting area. It was prepared in collaboration with the Amager Committee and Anders Nyvig A/S. However, distinct from the 1st prize project, the Amager variant did not contain a full development, but only the amount of housing assumed realistic in 1980 (see figure 10.16), which was estimated to be 30.000 smaller apartments on West Amager in addition to the 7000 dwellings.¹⁶¹ In respect to workplaces, it was assumed that construction of the city belt was initiated but not finalized in 1980. Therefore, the alternative only contained around 26.000 additional workplaces (see figure 10.16). In mid-October, it was decided to include yet another Amager alternative. This so called "minimum alternative" did not contain any further development on Amager beyond the 7000 (Alternative 80.03) (see figure 10.16).^{162, 163} In the next chapter, we will explore whether the development assumed in this alternative was actually the minimum development.

¹⁶⁰ *Notat om resultaterne af Amager konkurrencen og trafikprognosearbejdet*, BP3, K.A.O, 28.09.1965 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁶¹ *Notat vedrørende fordelingen af boligbyggeriet i hovedstadsområdet frem til 1980 under forudsætning af en udbygning på Vestamager*, BP3, F.L. 01.08.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata-analyser og tællinger, Box 1)

¹⁶² *På foranledning af forespørgsel fra Vestamagerudvalget skal bemærkes:*, BP3, K.K. & A. J. 10.11.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata, Box 1,)

¹⁶³ *Referat af møde om arbejdsopgaver*, BP3, B.E./M.F. 19.10.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata, Box 1,)

	Residing employees on Amager	Workplaces on Amager
1960	98.100	87.500
Minimum alternative 1980.01	94.500	98.000
Basic Alternative 1980.02	109.800	102.700
Maximum alternative 198.03	139.200	112.900

Figure 10.16: Amount of residing employees and workplaces on Amager

Although Amager was prioritized in the 1980 forecast, the group still planned to evaluate the three land-use scenarios resembling continuations of the 2nd stage development plans in the forecast for 2000 (see section xxx). However, alternative C was now to contain even further development on Amager (see section 10.3.4).^{164, 165}

Hence, Copenhagen still needed truths to reify the mono-centric finger structure in the long term, but now truth was also needed in the short term to reify the legitimacy of an Amager development. This need for facts served as a mechanism for opening up the land-use alternatives of the computerized forecast.

10.6.4 Re-opening of the infrastructure alternatives

This sub-section explores how the opening up of spatial planning contributed to shaping the infrastructure alternatives.

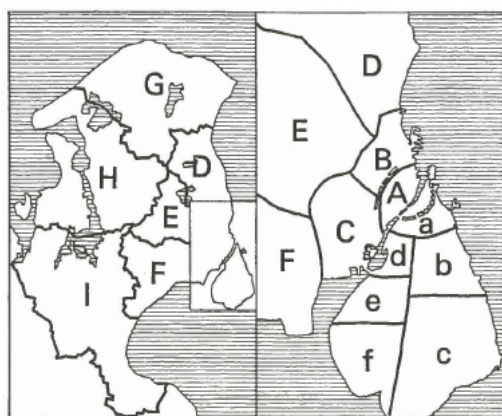


Figure 10.17: Division of zones assumed in the forecast of the City Plan West Office (Lyager 1968)

As argued in the above section, the forecast prepared by the City Plan West Office raised to discursive consciousness problematic aspects of the design of the primary road system which the Department of the City Engineer had sketched out. Moreover, as it was through traffic which constituted the particular problems of the Lake-ring design, the forecast also implicitly problematized a large Amager development. However, it remained to be seen whether these critical issues would be acknowledged by the Department of the City Engineer.

In beginning of 1966, Ottesen made a memo in which he discussed the assumptions, the results and the implications of the forecast.¹⁶⁶ He did not find the forecast to be directly erroneous. In fact, he accepted the assumption about stagnation in city employment. Nevertheless, Ottesen held that the forecast was prepared on a rather simplified basis. For instance, the entire Greater Copenhagen area was only divided into nine zones (see figure 10.17). Moreover, the forecast

¹⁶⁴ *Forslag til Storbymodeller*, BP3, F.T., April 1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1967-1967, Storbymodeller og zonedata, Box 1,)

¹⁶⁵ *Udkast til arbejdsprogram for storbymodeller* (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁶⁶ *Notat vedrørende City Plan Vest-rapport nr. 65/12, Fremtidige Trafikstrømme omkring City Plan Vest (jfr. Møde den 13.januar 1966 hos Stadsingeniøren)*, BP3, V.E, 20.01.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

was based on a sequential structure where modal split had been executed before trip distribution (see chapter 2) (Lyager 1968).

He did also find some of the assumptions of the forecast to be problematic. For instance, compared to the result of the 1956 travel survey, the estimated share of transit was too high. Moreover, distance dependency was neglected and traffic between neighbouring zones was assumed not to load the primary road network. It was also found unrealistic that of traffic between zones D and F (see figure 10.17), 100% of transit and 30% of private motoring was assumed to load the Lake-ring, which was too high according to Ottesen. Nevertheless, as the assumptions tended to be biased in opposite directions, the main results of the forecast could be accepted, namely that a large development of Amager could be expected to increase harbour crossing traffic and that through traffic constituted a larger part of the total Lake-ring traffic than previously assumed. Therefore, the Department of the City Engineer could, according to Ottesen, accept the forecast served as the underlying basis for the further work of the City Plan West Office until the results of the preliminary computerized forecast were available.

On the basis of the forecast, the City Plan West Office had drawn the following implications:

1. The Goods-ring must be designed with a very large capacity in order to divert as much traffic as possible away from the Lake-ring
2. The Lake-ring must be designed to segregate through traffic from city-oriented traffic (see figure 10.15)
3. The future traffic load in the City Plan West area will be so great that the capacity of the Department of the City Engineer's proposed design of the primary road system for this area will be too small to handle the traffic.

However, on the surface, it was only the first of these conclusions which the Department of the City Engineer could accept. The proposed segregation of Lake-ring traffic was considered to be an unsuitable design solution, as it would make the intersections between the radial roads and the Lake-ring very complicated and implied an uneconomic utilization of the road system's lane capacity. Moreover, it was feared that this design would encourage through traffic to use the Lake-ring. However, the spatial logic of segregating the city-oriented and through traffic was obviously correct according to Ottesen. Instead of segregating traffic in the Lake-ring, Ottesen suggested that an additional harbour crossing be established south of the City Plan West area and prolonged as a new, primary semi-circular road between the Lake-ring and the Goods-ring. By preventing the through traffic from being pulled all the way into the Lake-ring, the capacity of this critical link could be reduced. It would thereby be possible to give the Lake-ring its original function back, namely that of a circulation road serving the city-oriented traffic.¹⁶⁷ In the below sub-section, it will be discussed that it was not only Ottesen who came up with this implication of an Amager development. In a more elaborate version of his first paper, dated approximately a week later, Ottesen proposed placing the layout of the new semi-circular road in prolongation of the Dybbølsbro line, which was originally meant as a crossing for local traffic between Vesterbro and Amager. Yet, it appears that problems of establishing such a semi-circular primary road now had been realized. Ottesen acknowledged that this line could not be upgraded to a primary road,

¹⁶⁷ *Notat vedrørende "Fremtidige Trafikstrømme omkring City Plan Vest" Oktober 1965*, BP3, K.A.O, 21.01.1966, (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

but it was still assumed to divert through traffic away from the Lake-ring.¹⁶⁸ He argued that these corrective suggestions ought to be included in the City Plan West Office's further planning, as well as in further work of the Urban Planning Offices' traffic forecast and road planning.¹⁶⁹ Even though only some of the implications of the forecast were met with acceptance from the Department of the City Engineer, it still contributed to opening the Lake-Ring's design as well as the forecast up for change.

At a meeting in the beginning of February 1966 at the Chief City Engineer's office, the implications of the forecast were discussed. The Chief City Engineer also accepted that the forecast could form the basis of the City Plan West Office's further work until the results of the computerized forecast were available. Moreover, he accepted that the implications of the forecast could be that development on Amager Fællede had to be constrained. According to Egebæk from the Department's Road Office, either the number of dwellings had to be reduced or the additional ring had to be established.¹⁷⁰ Hence, the problematic aspects which the forecast had raised, namely that a considerable Amager development would have implications for the design of the primary road network in the inner city areas, were also accepted by the Chief City Engineer. However, the Chief City Engineer did not accept that these implications were issues within the general public. We will return to this in the sub-section below.

At a meeting in March of 1966 between representatives from Nyvig A/S, the City Plan West Office and the Department of the City Engineer, Lyager presented the results of the forecast prepared by the City Plan West Office and its perceived implications for the primary road system. The Nyvig team was critical towards some of forecast's assumptions. In accordance with Ottesen, the Nyvig team problematized neglect of distance dependency and the proposal to design the Lake-ring for segregating through and city-oriented traffic. This gave rise to a discussion about the layout and capacity of the primary road network, and on that ground, Nyvig wished to have the different road proposals evaluated by the forecast of the Department of the City Engineer. He could not understand that important links of the primary road network were decided upon so soon before the preliminary forecast was to be finalized.¹⁷¹

Hence, the transport model-based knowledge production stemming from both the planning of Amager and the City Plan West Area contributed to problematizing the Department of the City Engineer's proposed Lake-ring design, causing two alternatives to be advanced, one with less capacity and one with more. Although these alternatives were not accepted uncritically by the Department of the City Engineer, they nevertheless contributed to opening the issue on the Lake-ring design for change. In fact, this also contributed to opening up the possibility of change to the infrastructure alternatives of the computerized transport model, and it was decided to include both Nyvig's and the City Plan West Office's alternatives in the model evaluations.

¹⁶⁸ *Notat vedrørende City Plan Vest-rapport nr. 65/12, Fremtidige Trafikstrømme omkring City Plan Vest (jfr. Møde den 13. januar 1966 hos Stadsingeniøren). 2.2.1966* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁶⁹ *"Notat vedrørende "Fremtidige Trafikstrømme omkring City Plan Vest" Oktober 1965"* BP3, K.A.O., 21.01.1966 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁷⁰ *"Møde om City Plan Vest-program, 02.02.1966* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁷¹ *Nyvigmøde I CPV 2. Marts 1966, BP3, K.A.O., 09.03.1966.* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

10.6.5 Only the computer should be allowed to speak truth

Even though the preliminary forecast was not yet finalized, there was already knowledge on the implications of Copenhagen's plans for expanding its structural position, produced on the basis of transport-modelling, and some problematic aspects of these plans were therefore already known. However, it was not only the Nyvig team and the City Plan West Office which produced transport model-based knowledge claims expressing criticism of Copenhagen's plans. Yet, these critical knowledge claims were marginalized in favour of the knowledge produced on the basis of the computerized transport model.

In addition to the Municipality of Copenhagen and its consultancies, the Regional Planning Secretariat had also found it important to evaluate the traffic impacts of an Amager development, and had prepared a small report investigating this to do so. The report was titled *"Amager and development in car traffic"* and consisted of a small booklet of seven pages. In accordance with the report of the City Plan West Office, it was originally ready to be issued in 1965. In the report, the traffic impacts of developing Amager were elucidated in respect to:

1. The size, type and location of new settlements on Amager
2. Localization of urban growth in the rest of the region, concentrated either in the Western sector or more evenly distributed
3. The design and development pace of the regional transport system

These issues were evaluated based on three different scenarios for development until around 1985 (see figure 10.18). The report stated neither how the results were derived nor which data was used as its base. It presented only the following results and conclusions.

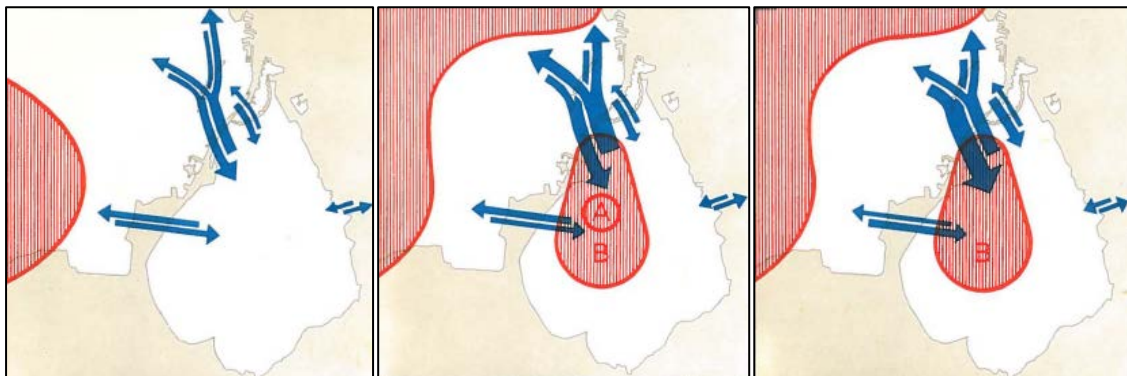


Figure 10.18: The three alternatives evaluated in the Regional Planning Secretariat's Amager report. To the left: alternative 1 with no further development on Amager. In the middle: Alternative 2, with assumed doubling of dwellings and workplaces on Amager. To the right: Alternative 3. With assumed doubling of dwellings.

In the 1st alternative, further development on Amager was assumed to be brought to a halt. Instead, the major part of the regional development was placed in the Western sector. Still, compared to 1960, the load of the harbour crossing traffic was assumed to double due to an increase in motoring and traffic to the airport and an Oresund crossing. Based on these conditions, the capacity of the existing crossings and the planned semi-circular lake-road harbour crossings would be adequate to accommodate traffic in 1985 (see figure 10.18).

In the 2nd alternative, doubling in houses and workplaces on Amager¹⁷² (approximately 70.000 homes and 90.000 workplaces) was assumed in combination with a development on the Zealand-side, equally distributed between the Northern, Southern and Western sectors. Under these assumptions, the load of the harbour crossing traffic was assumed to quadruple, and due to the equal distribution of housing in the region, most of the traffic would cross the harbour section in the central area. Therefore, two new urban expressways crossing the harbour would be necessary (see figure 10.18).

The 3rd alternative contained a doubling of housing on Amager, while an increase in workplaces was minimized to 25% of the 1960 situation. In accordance with the 2nd alternative, growth on the Zealand-side was evenly distributed across the region. This alternative also showed a fourfold increase in traffic and a demand for two new urban expressways crossing the harbour in the central parts (see figure 10.18).

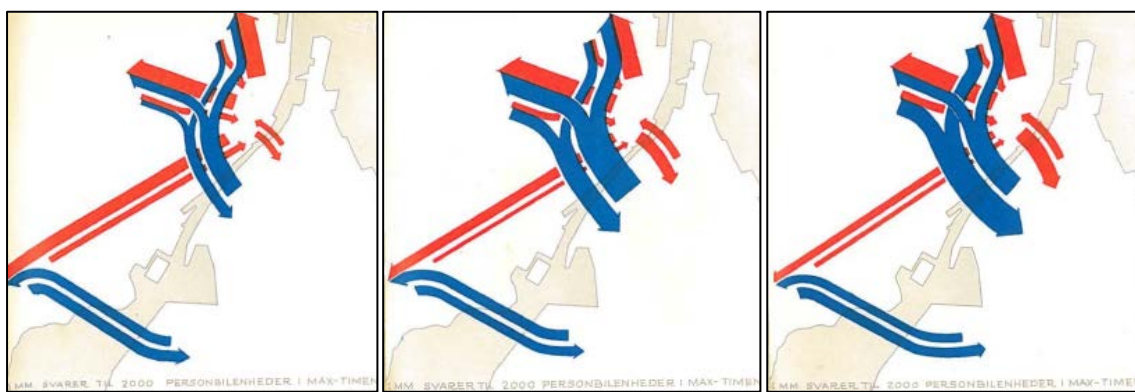


Figure 10.19: calculated traffic flows for the three alternatives. To the left: alternative 1. In the middle: Alternative 2. To the right: Alternative 3.

This forecast was hence based on a considerably larger development of housing than the maximum 30.000 assumed in the computerized forecast (see section 10.6.3). Moreover, in accordance with the City Plan West Office's forecast, it was not only in the harbour crossing section that an Amager development was foreseen to cause traffic problems. The movement of traffic from Amager to the semi-circular roads of the inner-city areas and further on to the radial roads was foreseen to cause large problems in the peak hour, particularly in the 2nd alternative. Here, traffic from the workplaces on Amager would load the radial roads to an extent equal to the peak traffic from the city centre and would therefore cause a significant additional capacity demand in the primary road system at large (see figure 10.19). In the 3rd alternative, traffic was more evenly distributed in the two directions and would hence demand less capacity than the 2nd alternative, both on the radial roads and in the harbour crossing section (see figure 10.19).

¹⁷² It is not explained in the report how much a doubling of homes and workplaces squares to. The numbers are referenced from FAB (1967).

In the 3rd alternative, traffic was more evenly distributed in the two directions and would hence demand less capacity than the 2nd alternative, both on the radial roads and in the harbour crossing section (see figure 10.19). One implication of the forecast was, according to the Regional Planning Secretariat, that it would be necessary to establish two urban expressways in addition to the roads that were already planned, namely a new radial road in the north and a semi-circular road in the south (see figure 10.20), in accordance with Ottesen's suggestion (see section 10.6.4). In the following chapters, we will return to the semi-circular road, where it will be discussed under the name of the Forum-line or the Slum-ring. The Regional Planning Secretariat's report did point towards the same implications as the report of the City Plan West Office, namely that an Amager



Figure 10.20: Blue: road system necessary before 1985. Red: supplementary road systems in consequence of development on Amager in 1985, namely an urban expressway towards the east for the traffic coming from the north, and an additional inner-circular road, the Forum-line (to the left)

development would cause large traffic problems in the inner-city area and that it was necessary to establish a new primary semi-circular road between the Lake-ring and the Goods-ring. However, as it was impossible to provide the capacity needed to accommodate predicted traffic in the inner city areas without considerable clearance, these additional roads were undesired. They not only degraded living conditions in the affected areas, but they were also extremely costly to establish (Egnsplan sekretariatet, 1965). The conclusion of the report was unambiguous; development of Amager would be very costly compared to development in other parts of the region and should only be considered in relation to renewal of the inner districts. This conclusion was, however, not issued publicly.

The report was submitted to the Urban Planning Board, under which the Regional Planning Secretariat functioned at the time. However, at a meeting in April of 1966, it was decided to postpone the report's release because there were some corrections that needed to be made. This work was undertaken by Poul Vedel and the Regional Planning Secretariat in collaboration. In the summer, the corrected version, which showed even larger costs of an Amager development, was ready (Korgh, 1967d), but the Copenhagen Urban Planning Major, Wassard Jørgensen, did not accept that this version was issued (Nilson, 1967a). He was unhappy with the front cover of the report, which contained a picture of long tailbacks on the harbour crossing, Langebro, caused by the leaf of the bridge being open. Moreover, Wassard was dissatisfied with the conclusions drawn in the report, which warned against a development on West Amager. To him, this "seemed like an attack on the Municipality of Copenhagen" (Nilson, 1967b; Own translation). According to him, the reason why the report was withheld was because Copenhagen also was in the process of preparing a report which investigated the same problems. He therefore recommended that its release be postponed until the report of the Department of the City Engineer was available, and this recommendation was accepted by the Urban Planning Board (Korgh, 1967d).

This was not the only critical transport model-based knowledge production which was withheld. At a meeting in the Amager Committee, the Chief City Engineer made it clear that he did not accept that the critical issues which the City Plan West Office's forecast had brought to attention were disclosed to the general public. According to Vedel, the reason was that the City Plan West Office's calculations were relatively crude, and therefore, one should wait for the results of the more detailed traffic forecasting that the Copenhagen municipality was preparing and planned to complete within a year (Krogh 1967b; 1967c). However, according to Lyager (1996), the reason why Vedel wanted to withhold the report was because new ideas would disturb the on-going planning of the Lake-ring's design and would confuse the politicians.

Copenhagen had therefore managed to marginalize the critical truth claims which more or less directly warned against the implications of a large Amager Development, and the two reports were kept secret from the general public, including both the Copenhagen City Council and the National Parliament. Instead, the problems which they raised would be included in the Copenhagen forecasting programme and evaluated against the Department of the City Engineer's alternative. According to the Urban Planning Mayor and the Chief City Engineer, it was only acceptable that one voice delivered information to the general public, and this was to be the voice of the computer.

10.7 Completing the preliminary computerized forecast

This section explores the final stage of producing the first preliminary results. First, the calibration of the gravity model will be investigated, with a special focus on induced traffic. Next, the considerations about conducting a transport economic analysis will be elucidated. Hereafter, the further work on initiating a new transportation study is investigated, followed by the discussion of a new process for finalizing the forecasting programme and the presentation of the first partial results.

10.7.1 Calibrating the gravity model and induced traffic

Induced traffic was both part of discursive consciousness and transport project evaluation practice in the 1960s (see section 7.3). Moreover, when the 1956 travel study was prepared, acceptance of the gravity model for the purpose of forecasting was conditioned on the distance dependency being lowered for the future forecasting year due to improved travel conditions (see section 10.4.3). However, this previously unacceptable simplification was now found acceptable, not because induced traffic was no longer accepted as a real phenomenon, but because the results of the test calculations for 1960 compared to the results from 1945 did not show the lowering of the distance exponent to be as significant as expected (see figure 10.21). Therefore, it was acceptable to apply the same distance exponent for 1980 as the one found for 1960, implying that the travel-inducing effect of improved travel conditions was not included in the preliminary forecast (Stadsingeniørens Direktorat, 1967b).

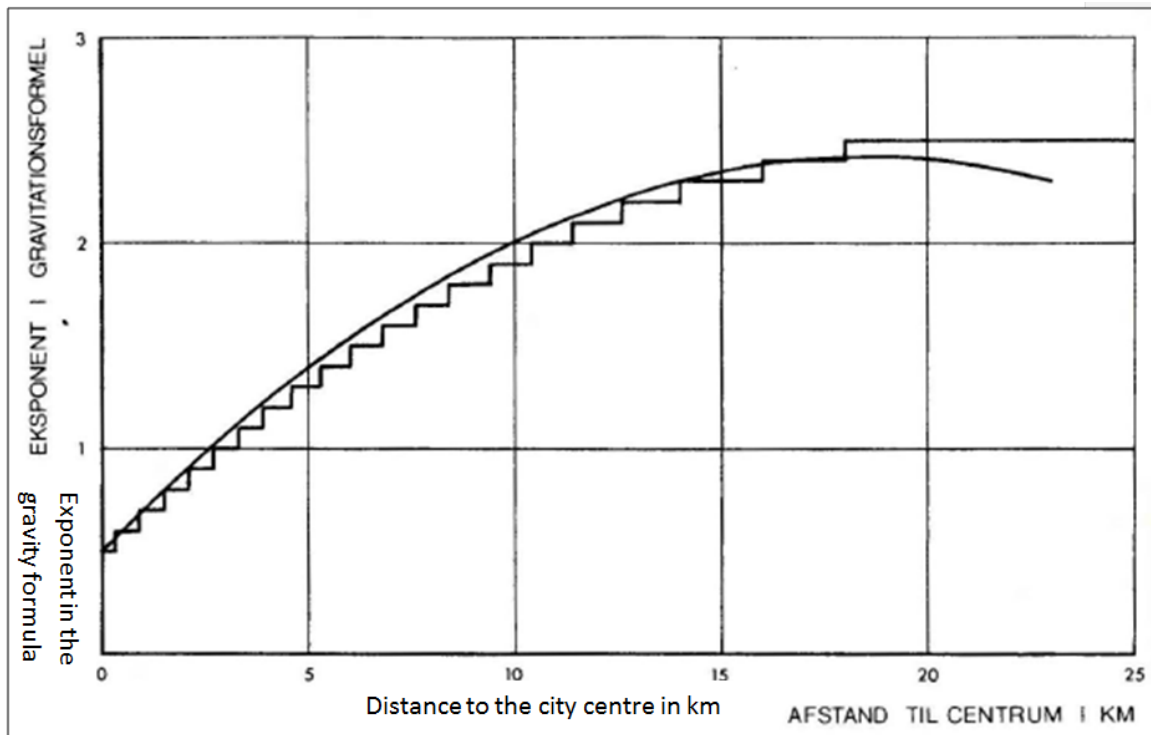


Figure 10.21: Smooth curve: exponent 1960 and 1980. Stepped curve: Exponent 1945 (Stadsingeniørens Direktorat 1967b, p. 41)

However, while the simplification of neglecting induced traffic was accepted, it was also accepted that this simplification was most likely biased. Progress report 2 states:

“It should also be noted that the estimated traffic volumes in 1980 must generally be considered as the lower limit for the home-work traffic under the given assumptions about resident employees and workplaces. [...]. The implementation of a convenient and ample-sized transport system will probably give people greater freedom to choose residences and/or work places, and thus the traffic volume will grow. The pre-assumptions of the traffic calculations can be said to be, by and large, that the current level of service is maintained”. (Stadsingeniørens Direktorat 1967b, p. 52; Own translation)

Yet, even though induced traffic in general was ignored in the preliminary forecast, it was actually included in regard to Amager. According to the progress report, the 1960 calculation of the home-work traffic had shown a relatively good fit compared to traffic counts at most of the screenlines. However, for screenlines B and E, the calculations showed greater traffic than counted (see figure 10.22).

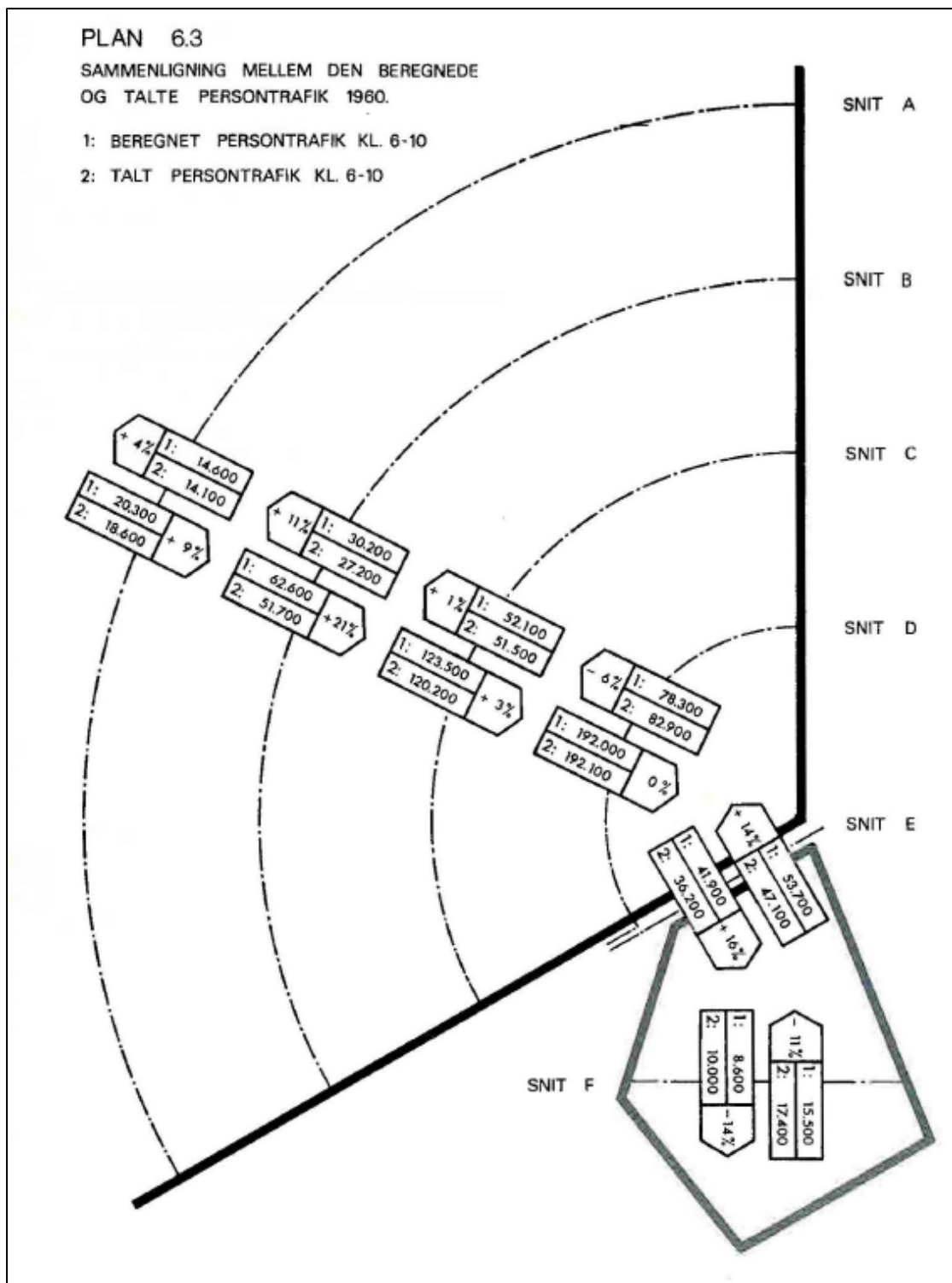


Figure 10.22: Comparison between counted traffic and calculated traffic in 1960 (Stadsingeniørens Direktorat 1967b, p. 48)

The deviation in screenline B was explained by the fact that traffic on important roads in this section was not included in the traffic census. In respect to overestimation of traffic passing through screenline E, the harbour section, the deviation was explained as follows:

“This Amager-deviation can be explained by the harbours’ bascule bridges being perceived as a bottleneck in the traffic system, among other reasons. (Stadsingeniørens Direktorat 1967c, p. 38; Own translation)

The overestimation of the 1960 calculation compared to previous counts was hence explained by restrained traffic growth, caused by capacity problems in the harbour crossing section. It had been observed that people residing on Amager were largely locally employed. Both the survey of 1945 and the results from 1956 showed a higher distance dependency for people residing on Amager than for those in corresponding areas within the metropolitan region. Therefore, in regard to Amager, it was chosen to use a lower distance exponent in the gravitational model for 1980 than in the 1960 calculations. As it is stated in Progress report two:

“...the exponent for the Amager zones has been determined by the same law as is used for the other sectors, as it has been desired to calculate home-work trips to and from Amager, under the condition of ample capacity having been provided for harbour crossing traffic, so that distance dependency for residents and employees at Amager in 1980 will be at the same level as in other districts with similar distance from the Centre.” (Stadsingeniørens Direktorat 1967b, p. 45; Own translation)

Hence, although the effect of improved travel conditions on increase in traveling distance was not generally included, this effect was included in respect to Amager.

10.7.2 Transport economic evaluations

While the objective was originally to subject the different urban development alternatives to a transport economic evaluation, this part of the work had not yet been given a lot of attention. This did not, however, mean that a transport economic analysis was no longer desired. According to Ottesen, a possible transport economic evaluation should contain construction costs, maintenance costs, operation costs, time savings and potential accidents. While the cost benefit analyses conducted in American transportation studies had been criticized for not discounting future benefits and costs (Beesly 1963), Ottesen planned to calculate net present value, or the “objective function,” as he termed it. However, Ottesen was doubtful whether a transport economic analysis could be conducted satisfactorily. The transformation in the forecasting programme from total traffic to home-work travel meant that the preliminary forecast was less suitable as input to a cost-benefit analysis than initially assumed. Moreover, the preliminary forecast was based on incomplete data and hence associated with considerable uncertainty, and there were no certified index numbers which could be used to convert the different components of the cost-benefit analysis into a common unit; this had to be done on a rudimentary basis, involving a large number of subjective judgements which were of a political nature. Therefore, valuation of the components had to be handed over to a committee of politicians and technical experts. Yet, because Ottesen regarded it to be beneficial for the future work with the actual forecast, in spite the insufficiencies and difficulties, he desired to initiate the work based on the preliminary forecast. He proposed that an economist be hired and that work with estimating construction and compulsory purchase costs was commenced. Whether an economist actually was hired is unknown to me, but Bjarne Eir, who was part of the forecasting group, was assigned a sojourn for purposes of study at the Norwegian Transport Economic Institute (TØI) in May-December of 1967. The primary purpose of the study trip was to gain insight into the profession of transport economics both in respect to the problem area and in respect to methodology (Eir, 1967).

10.7.3 Transportation study 1967/68?

In March of 1967, the transportation study was taken up for consideration again (see section 10.5). This time, the group remembered to submit an application for carrying through the grant amounted to the transportation study for 1966/67 to the following accounting year.¹⁷³ However, due to the practical difficulties the forecasting group had previously faced with organizing the large transportation study, the option of basing the actual forecast on a gradually improved dataset was now considered as an alternative to a comprehensive transportation study. Nevertheless, the traffic forecast was regarded as decisive for the political decisions regarding investments in the Copenhagen transport infrastructure which had to be made in the near future. The forecasting group was therefore of the opinion that the forecast ought to be based on material that was as well-established as possible.¹⁷⁴ Gradual improvements would also imply that the actual forecast would come to be based on an inconsistent dataset. Therefore, this option was not preferred.¹⁷⁵ Due to a shortage on labour, it was, however, not found realistic that the Department of the City Engineer would be able to execute the transportation study in the autumn on its own. If the travel study was to be executed that year, other agencies had to be enrolled in the data collection. In that respect, three possible pathways were drawn up:

- 1) The transportation study was managed by a working group composed of representatives from the involved governmental authorities and institutions.
- 2) The transportation study was to be managed by one or more Danish consultancy firms
- 3) The transportation study was to be managed by a foreign consultancy firm

No matter which of the solutions was chosen, it would be necessary to involve a large number of governmental authorities and institutions in the organization and execution of the travel study.¹⁷⁶ In respect to the second option, hiring Danish consultancies, two firms had been considered. The largest of these firms had, however, put up unacceptable conditions for its assistance, and the other was too small to take on the task on its own. It was decided that if these first two options continued into dead ends, then the third option of hiring a foreign consultancy firm should seriously be considered. However, if this option was to be chosen, urgent action was required on establishing contact and defining the tasks.¹⁷⁷

Soon after, it was acknowledged that it would be impossible to carry out the transportation study in the autumn of 1967 unless a foreign firm was engaged. Therefore, the joint British/American venture Freeman, Fox, Wilbur, Smith and Associates (hereinafter FFWS) was approached by the Department of the City Engineer with an invitation to submit tenders.¹⁷⁸ This firm was internationally renowned (see section 2.2.3). In addition to allowing the transportation

¹⁷³ *Vedrørende budeget forslag for 1967/68*, Magistratens 4. afdeling, 23.01.1967 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁷⁴ *Notat vedrørende prognosearbejdet*, Stadsingeniørens Direktorat, 28.04.1967 (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1967, Økonomi m.m., Box 1)

¹⁷⁵ *Mulighederne for at gennemføre en trafikanalyse og –prognose i København*, BP3, K.A.O. Marts 1967 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹⁷⁶ *Problemer ved organisationen af trafikanalyse- og prognosearbejdet i hovedstadsregionen*, BP3, K.A.O., 30.03.1967 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

¹⁷⁷ *Mulighederne for at gennemføre en trafikanalyse og –prognose i København*, BP3, K.A.O. Marts 1967 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

¹⁷⁸ (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Generelt, Box 1)

study to be executed in the fall, a major advantage of engaging the firm was that the subsequent data processing and analyses could be completed promptly. Moreover, the Department of the City Engineer would come into possession of the transport modelling software pack developed by FFWS.¹⁷⁹ However, hiring FFWS would not be a cheap solution; it cost just under 3 million DKK, and only 1 million had been granted for the transportation study. As the work would equally benefit the Ministry of Public Works and the three metropolitan counties, it was questioned whether it was fair that Copenhagen should defray all the expenses. Therefore, it was suggested to initiate collaboration with other relevant planning authorities. The newly established Regional Planning Council was regarded as an obvious body for organizing such collaboration. Both the Road Directorate and the counties showed interest in the collaboration and promised to contribute 1.000.000 DKK. In May, the Department of the City Engineer accepted the offer from FFWS.¹⁸⁰ According to the contract, the work of FFWS consisted of the following tasks:

- 1) Organize and oversee the execution of a comprehensive transportation study in autumn of 1967
- 2) Analyse the incoming results
- 3) Develop and calibrate the necessary computer programs on the basis of the collected data

After the contract was signed, it was, however, decided that the Regional Planning Council should overtake the contract with FFWS and head the further preparation of the forecast. FFWS established an office in Copenhagen and the transportation study was executed in the fall of 1967, as planned (FFWS 1968b; 1968b). The work with preparing the actual forecast was subsequently initiated.

We will return to this later. For now, we will elaborate on the implications for the further use of the transport model developed by the Department of the City Engineer (see section 12.5.3). However, in the last two chapters, the focus will be on the forecasting results, how they were used and whether they gained acceptance. However, before elaborating on this, a conclusion will be drawn on the sub-question addressed in this chapter.

10.7.4 A work programme for finalizing the forecast

According to the original schedule, the forecast should have been completed in 1965. However, despite several attempts to simplify the work, even preliminary results had been delayed past the beginning of 1966 and were not expected to become available before 1967. It appears that due to the continued slip of deadlines, Vedel was getting impatient with the forecasting group and wanted to hasten the new transportations study, suggesting imposing a more strict control on completion of the work tasks.¹⁸¹ Arne Stæremose from the forecasting team was also asked to spy on Ottesen by one of the higher ranked officials. However, this attempt at direct

¹⁷⁹ *Notat vedrørende prognosearbejdet*, Stadsingeniørens Direktorat, 28.04.1967 (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1967, Økonomi m.m., Box 1)

¹⁸⁰ Letter to: *Freeman, Fox, Wilbur Smith and Associated*, Stadsingeniørens Direktorat, Poul Vedel, 19.06.1967 (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1967, Økonomi m.m., Box 1)

¹⁸¹ *Kommentar til PERT-plan*, BP3, B.E., 08.07.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

behavioural control was not accepted by Stæremose, who declined the request (Interview 2012). There was therefore a pressure on the group to produce results quickly. Decisions had to be made rapidly with regard to both an Amager development and the need for additional harbour crossing capacity, as well as on the Lake-ring.

The first test runs for 1960 were conducted in the summer of 1966.¹⁸² In August/September, a new work programme for completing the preliminary forecast was drawn up.¹⁸³

1. Trip frequencies 1980
 - Home-work trips for Basic alternative and Amager alternative
 - Performance report 1 & 2 August 1966
2. The Department of the City Engineer's proposal to a primary road system
 - Home-work trips 2000 basic alternative
 - Modal split 1980 and 2000 basic alternative
 - Assignment of road traffic on the Department of the City Engineer's proposal to a primary road system
 - Preliminary working paper
 - Revision of the Department of the City Engineer's proposal to a primary road system
 - Performance report 3 March 1967
3. Alternative urban development plans
 - Home-work trips for alternative land-use and infrastructure scenarios 1980 & 2000
 - Modal split 1980 & 2000
 - Assignment of car traffic on alternative road systems 1980 & 2000
 - Transport economic assessment of alternatives
 - Performance report 4, traffic on road system 1980. September 1967
 - Performance report 5, traffic on road system 2000. December 1967

The alternatives with respect to land use, modal split and road systems which should be evaluated in the first and second stages, can be seen at figure 10.23 and those evaluated in third stage, can be seen at figure 10.24.¹⁸⁴

The results of the calculated trip distribution were available in the fall of 1966 (Ottesen & Eir 1967). However, the first progress report was not issued until April of 1967. It contained a description of the methodological framework of the computer models. Soon after, the 2nd progress report was also issued, containing a description of data and assumptions in respect to distribution of residents and workplaces, which underlie the base and the maximum Amager alternatives, respectively. The calculated trip frequencies between the different zones for 1980 were also presented for the two land-use alternatives. These results, how they were used and

¹⁸² *De særlige problemer vedrørende Amagertrafikken* (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁸³ *Foreløbig trafikprognose for København*, BP3, 10.08.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

¹⁸⁴ *Alternative udbygningsprogrammer*, BP3, B.E./A.A. 01.08.1966 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, Prognosearbejdet, Box 1)

whether they gained acceptance will be explored further in the next chapter. However, before doing so, a conclusion to the sub-question addressed in this chapter will be drawn.

Land use 1980	Traffic solutions and corresponding modal split 1980	Road system 1980
Basic alternative	Individual emphasized transport system	The Department of the City Engineer's proposal
Maximum alternative	Amager Transit system emphasized transport	Nyvig's proposal
Minimum alternative	Amager Interim solution	The City Plan Vest Office's proposal
Revision of alternatives		Revision of proposals

Figure 10.23: Alternatives in respect to land use, modal split and road systems for 1980

Land use 2000	Traffic solutions and corresponding modal split 2000	Road system 2000
Model A	Individual emphasized transport system	The Department of the City Engineer's proposal
Model B	Transit emphasized transport system	Nyvig's proposal
Model C		The City Plan Vest Office's proposal
Revision of proposals		Revision of proposals

Figure 10.24: Alternatives in respect to land use, modal split and road systems for 2000

10.8 Sum up

In this chapter, the process of the developing the computerized transport model and the mechanisms shaping the model development were explored. Even though American methods were accepted as the best practice, these methods were not accepted unconditionally. Instead they were modified to fit into the prevailing transport project evaluation practice. Meaning was also found to shape the model development. The objectives assigned to the model were essential for understanding its development path. However, the desire to inscribe meaning into the model was constrained by limited data availability, and that this meant that the original objective assigned to the model was not fully inscribed. In order to circumvent the problem of data, a number of detours were made, which generated a number of changes in the objectives of the forecasting programme, resulting in a more simplified approach than originally envisioned. In fact, such detours also generated a shift in the organizational context of the forecasting programme, as enrolment of the international consultancy firm resulted in the Regional Planning Council taking over responsibility. The development of the model was also shaped by the spatial policy controversy regarding the future spatial order of the Greater Copenhagen area. The outbreak of the policy controversy meant that Copenhagen was once again in need of truth, but this time, truth was needed in order to expand the spatial capital tied up to its structural position. In fact, the forecast was re-opened as a reaction to re-politicization of the future spatial order of the Greater Copenhagen Area, and the forecasting programme was transformed in accordance with the transformations in the policy controversy. Even though some of the alternative infrastructure designs were included in the forecasting programme, which problematized the design of the Department of the City Engineer's proposed primary road

network, the critical, transport model-based knowledge claims were withheld from the general public. Instead, as part of Copenhagen's truth-seeking strategy, a position was created for the computerized traffic forecasts, where it monopolized the certified knowledge production and thereby became the uncontested voice of truth. However, at this stage of the story, the forecasting programme is not yet finalized. Therefore, even though this chapter addressed the question concerning which mechanisms shaped the development of the transport model, this subject will be explored further in the subsequent two chapters.

11 The partial results and the battle of Amager - a battle of truth

This chapter elaborates on the results of a preliminary forecast which was prepared on the basis of calculated trip frequencies, exploring how the results were put to use and whether they gained acceptance. The planning context to which the forecast related was development on the island of Amager and the demand for additional harbour crossing capacity. The chapter is structured as follows. First, the preliminary forecast prepared for the harbour crossing capacity will be explained, followed by an exploration of how the transport model-based knowledge production was used to reify the legitimacy of Copenhagen's plans for expanding its spatial capital. Next, the disclosure of the withheld reports will be investigated. Hereafter, whether the forecast results concerning the legitimacy of Copenhagen's expansion plans on Amager were accepted will be investigated, first in regard to planning peers and then in regard to local politicians on the Copenhagen City Council. The Amager plans' battle for acceptance in the National Parliament will be explored in Chapter 12.

11.1 A forecast for the harbour crossing traffic

Even though it was only the calculations of trip frequencies between zones which were completed, and not yet modal split and assignment, the partial results were nevertheless applied to illuminating pressing planning problems concerning Amager. It had been agreed to postpone the decision on a long-term development of the island until a forecast based on new data was completed, but in regard to the short-term development on West Amager, it was assumed that a decision could not wait until the large transportation study was finalized. Therefore, in order to obtain a basis for the next year's decisions, the forecasting group was assigned the special task of preparing a forecast for harbour crossing traffic on the basis of the partial results, with the objective of estimating total capacity demand in 1980 (Stadsingeniørens Direktorat 1967c, p.33).

As part of preparing the forecast, the base situation was first investigated. On the basis of traffic censuses taken during both 1960 and 1965 at the harbour crossings at the peak hour of 16-17, it was observed that more people travelled towards Amager than from Amager, implying that more people residing on Amager worked on the Zealand-side than vice versa. However, it was also observed that the share of road users travelling by car and motorcycle was much greater from Amager towards Zealand than from Zealand to Amager (see table 11.1).

Table 11.1: Modal split in the harbour crossing section at the peak-hour, in directions both towards and from Amager in 1960, 1965 and 1980 (Ottesen & Eir 1967).

	Towards Amager 1960	From Amager 1960	Towards Amager 1965	From Amager 1965	Towards Amager 1980	From Amager 1980
Transit riders	40%	28%	33%	22%	30%	20%
Motorized road users	19%	28%	40%	51%	55%	65%
Cyclists, moped riders	41%	44%	27%	27%	15%	15%

This implied that when the travel was converted in to passenger car units, the capacity load of traffic in the direction of Zealand was higher, even though the number of road users was lower (see figure 11.1).



Figure 11.1: In the afternoon peak-hour, 1960, the harbour was crossed by most people in the direction towards Amager (1). The load on the bridges, measured in passenger car units (PU), however, was greatest in the direction from Amager, because private cars accounted for a greater share of traffic in this direction than in the opposite direction (2) (Stadsingeniørens Direktorat 1967c).

The observed difference in mode share between the two directions was explained by commuters travelling from jobs on Amager to dwellings on Zealand having poor transit connections, but fairly good parking conditions at the workplace, while commuters residing on Amager largely came from workplaces in the central business district, which had poor parking opportunities but fairly good public transport connections.

After the current conditions were illuminated, the forecast was prepared on the basis of the following procedures. First, the total home-work trips between zones were calculated. This was based on the finalized step of the computer model. Next, the portion of the total home-work traffic carried out at the peak hour was estimated. Hereafter, a given percentage was added for passenger traffic with purposes other than commuting (e.g. shopping, visits). On the basis of the observed development in modal split in the harbour crossing section 1960-1965, the estimated total traffic was then distributed on modes (see table 11.2) and converted into an equivalent street load measured in passenger car units (PU). In the end, supplements for traffic to the airport and for commercial traffic were added. The forecast was prepared for both the basic alternative as well as the minimum and maximum Amager alternatives.

Table 11.2: Peak-hour traffic in the harbour crossing section in 1960 and 1980 in the directions towards and from Amager. The forecast is prepared on the basis of the basic alternative, the minimum Amager alternative and the maximum Amager alternative (Adopted from Ottensen & Eir 1967)

Peak-hour traffic from 16-17 in the harbour crossing section	Road users towards Amager	Road users from Amager
1960		
Work-home traffic in persons	47.000	36.000
Work-home traffic in PU	6.000	6.400
Minimum alternative 1980		
Work-home traffic in persons	52.700	54.700
Work-home traffic in PU	14.800	18.400
Basic alternative 1980		
Work-home traffic in persons	61.800	54.700
Work-home traffic in PU	17.200	18.400
Maximum alternative 1980		
Work-home traffic in persons	80.300	54.000
Work-home traffic in PU	21.400	18.200

The results of the forecast showed a great increase in traffic. Even in the minimum alternative, the capacity load in the harbour crossing section would rise considerably due to the following conditions:

1. Increased traffic to the airport, implied by growth in number of employees and passengers
2. Increase in motoring
3. Planned development
4. Induced traffic due to capacity improvements in the harbour crossing section

In the model calculations, the distance exponent for the Amager traffic had been lowered in the 1980 calculations in order to resemble a situation with unrestrained harbour crossing capacity (see section 10.7.1). This unrestricted traffic was assumed to be approximately 25% above the level of restraint present at the time (Ottensen & Eir 1967). Hence, if the harbour crossing capacity was not expanded in accordance with the predicted unrestricted demand, this implied that the results of the forecast should be lowered. In respect to the minimum Amager alternative, it was stated that:

“If similar [traffic constraining] conditions will be in effect in 1980, the future traffic will be, instead of the calculated figures of 33.200, approximately 26.600 passenger car units. This implies that the development of the Amager traffic will, to a significant extent, come to depend on future expansion of the harbour crossings, and calculations suggest that the quality of the traffic conditions will be one of the decisive factors.” (Stadsingeniørens Direktorat 1967c, p. 38; Own translation)

Hence, even though bias against the zero alternative, due to the neglect of the induced traffic factor, is taken for granted by some within contemporary practice (see section 6.3), the restraining effect on traffic growth due to capacity limits was, in fact, discussed in regard to the minimum Amager alternative. Hence, in regard to a do-nothing alternative, the first Danish

computerized traffic forecast was based on more valid assumptions than those which prevail within contemporary practice. However, as will be explained in this chapter, this does not imply that the partial forecast was not biased in other regards.

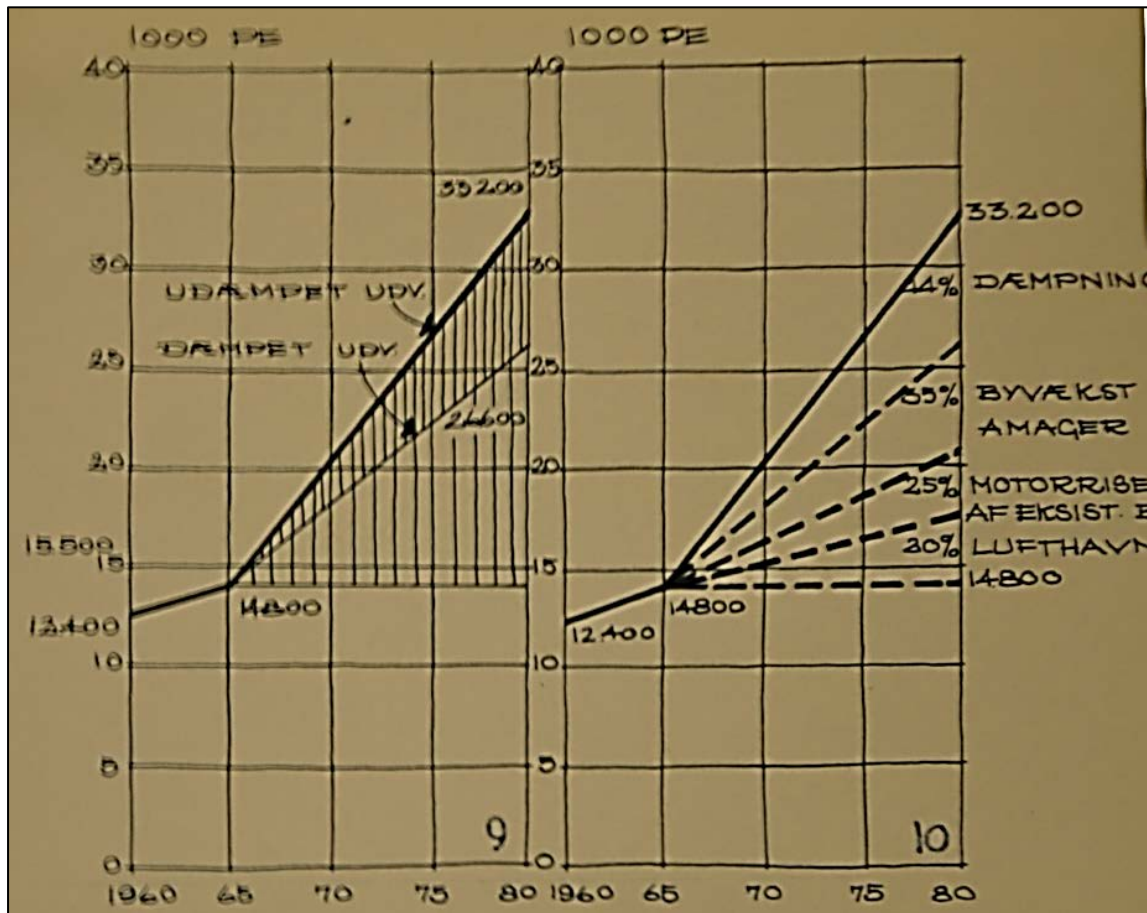


Figure 1: Different components of traffic growth on Amager, measured in passenger car units. The narrowly hatched area on the graph to the left represents induced traffic due to capacity extensions in the harbour section (trafikanalyse 1960-69 p. 63)

The Amager Committee used the forecast as a basis for drawing up the report “Amager and the Master Plan,” which was issued in March of 1967. This report discussed the perspectives of an Amager development in regard to urban structure, traffic and the locations of the airport and the harbours, as well as Amager’s role within the Greater Copenhagen Area. Jørgen Vedel, who was employed at the City Plan West Office, reviewed the plan in the journal *Byplan*. He states:

“The report is primarily intended for the National Parliament and the Regional Planning Council, as an appeal to these agencies to awaken the Copenhagen Sleeping Beauty from its long sleep via billions in investment in the harbour the airport, subways, urban expressways, etc.” (Vedel 1967, 67; Own translation)

The report was essentially a cry for help; Copenhagen was in need of investments to reverse the negative development. The following paragraphs will elaborate on the part of the report which was concerned with investments in traffic and urban development as well as how the transport model-based knowledge production was used to reify the legitimacy of Copenhagen’s plans for expanding its spatial capital beyond what the city was legitimately conferred.

While induced traffic around this period of time was apparently framed as having a positive contribution to transport project evaluation, this opinion was apparently more ambiguous in regard to Amager. From a regional planning perspective, one of the major concerns against further development on Amager was that increased traffic would generate a demand for costly capacity extensions in the harbour crossing section. Because induced traffic would increase the demand for harbour crossing capacity, it could hence serve as an argument against expanding the harbour crossing capacity and therefore discourage development on Amager. However, the Amager Committee actually used induced traffic as an argument to support capacity enlargements. The Amager report states:

“The Amager Committee considers that on the present basis, it cannot judge whether it is possible to eliminate the current restraints within a period of 15 years. On the other hand, it must be considered desirable to aim for Amager obtaining such an equality of status with the other sectors of the metropolitan area that a cancellation of the restraint can be achieved. Expansion of the traffic connections is the most important countermove against the restraint”

“These considerations lead more concretely into the desire of adapting the capacity of the harbour crossings to an ‘unrestrained’ development trend from the present traffic volume of 7.700 PU up to 18.400 PU. They are, at the same time, stressing that it would be irresponsible to allow capacity expansion to take place at a slower pace than corresponding to a ‘restrained’ development trend from the current level of 7,700 PU up to 14.700 PU, since this deterioration of quality would cause an additional damping” (Stadsingeniørens Direktorat 1967c, p. 42; Own translation).

Hence, it was found undesirable that traffic on Amager should be suppressed, and it was a stated objective to release it through provision of ample capacity to accommodate unrestricted demand. This signifies a change in the interpretation horizon underlining planning practice. When the travel study of 1956 was prepared, one of the objectives was to obtain knowledge on how to restrict unnecessary traffic (see section 9.1.4). Now, capacity enlargements were to be used as a means to set traffic free. It seems that a shift in the system of thought from “predict-and-prevent” to “predict-and-provide” had occurred within the planning programmes where the forecast was put to use. In accordance with the findings from Chapter 8, it can be seen that there is no link between the predict-and-provide horizon and non-acceptance of induced traffic as a real phenomenon. On the contrary, induced traffic was accepted within this interpretation frame. However, suppressing of demand due to capacity restraint was not accepted within this interpretation horizon. In fact, it can be seen that suppression of demand was problematized and it was desirable to release the latent travel demand. Hence, because induced traffic was a token of suppressed demand, it served as an argument for and not against road construction within the predict-and-provide paradigm. This will be returned to in section 11.3, where it will be explored whether induced traffic, and the predict-and-provide framing of the policy implications, was also accepted by project opponents.

11.1.1 10.000 free dwellings on Amager

This section explores how the forecasting results were used to reify that Copenhagen could expand the spatial capital of its structural position beyond what it was legitimately conferred.

In 1966, the maximum capacity per hour in one direction of the three existing crossings constituted 7.200 PU, but already planned and on-going enlargements would increase capacity to 10.200 PU in 1970. However, according to the forecast, even in the Minimum alternative where no dwellings were assumed built on Amager beyond those designated, the harbour crossing traffic would still increase to an extent where capacity expansions would be needed (see figure 11.2). In order to keep in step with the current level of restraint on traffic development (dotted line), additional harbour crossing capacity amounting to 4.500 PU (A) was needed in 1970-80. However, in order to eliminate the capacity constraining effect on traffic growth (bold line), further capacity of 3,700 PU had to be constructed (B). In order to provide for the predicted unrestricted capacity demand, two new road crossings were proposed to be constructed before 1980, namely a Dybbølsbro in 1972 for local traffic and a partly enlarged lake-road crossing in 1976, with two lanes in each direction, for through traffic.

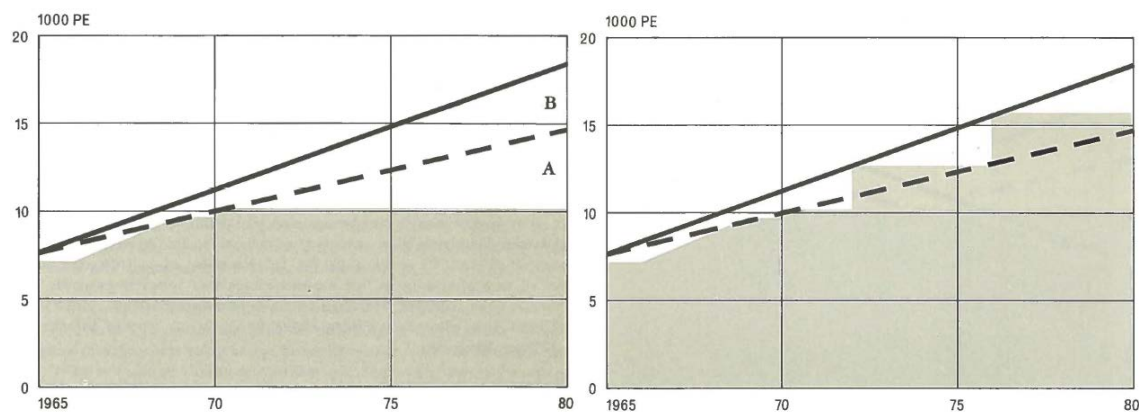


Figure 11.2: On the left: forecasted harbour crossing capacity demand, under conditions of unrestrained traffic growth (B/bold line), forecasted capacity demand under current level of restraint (A/dotted line) and capacity supply (grey area). On the right: forecasted capacity demand under conditions of restrained (dotted line) and unrestrained traffic growth (bold line), with establishment of a Dybbølsbro in 1972 and the prolongation of the Lake-ring to Amager in 1976 (Stadsingeniørens Direktorat 1967c)

In accordance with the situation in 1960 and 1965, the forecast for the minimum alternative of 1980 also showed that even though the fewest people travelled in a direction heading away from Amager at the peak hour of 16-17, traffic in this direction demanded more capacity than traffic towards Amager (see table 11.2). As it was the larger of the two directions' peak-flow which should serve as the basis for sizing the capacity of the harbour crossings, this meant that there was spare capacity in the direction towards Amager.

In respect to the maximum Amager alternative, the additional urban development on Amager implied that the peak flow in the direction towards Amager would now consume more capacity than traffic from Amager (see table 11.2). The additional 30.000 dwellings on West Amager would hence require that the capacity in the harbour crossing section be further expanded compared to the minimum alternative. If the semi-circular Lake-ring crossing were fully enlarged in 1978 (four lanes in each direction), sufficient capacity would be procured to accommodate a restrained traffic development. Alternatively, if a subway to Amager were established in 1978,

this would procure sufficient capacity to accommodate unrestricted traffic demand. However, in order to accommodate traffic growth after 1980, it would still necessary establish a fully enlarged semi-circular lake-road crossing around 1983-84.

Because traffic towards Amager at the peak-hour of 16-17 was less space-consuming than traffic in the other direction, the 10.000 dwellings beyond those designated on West Amager assumed in the basic alternative would, according to the forecast, imply that a balance would be reached in the load of the two directions' traffic flow. On the basis of these calculations, the following conclusion was drawn up in the Amager report:

"It has hence been found that there, in addition to the previously described, unavoidable "minimum development," can be built 10,000 homes on West Amager before 1980 without danger of extra traffic loads at the entrance to the harbour" (Stadsingeniørens Direktorat 1967c, p. 40; Own translation)

Therefore, based on the partial results of the forecast, a truth claim was advanced which reified that Copenhagen could expand its spatial capital by building new housing on Amager, moving beyond what was legitimately conferred upon the municipality by the prevailing regional plan. Whether this attempt to reify the Copenhagen Amager plans was met with acceptance or non-acceptance will be elaborated on in sections 11.3 and 11.4. Next, the framing of this truth claim will be critically scrutinized.

11.1.2 From a comprehensive to an incomprehensive approach to planning

While the discourse on comprehensive planning has been shown to serve as an important mechanism shaping the transport model-based knowledge production, the truth claim concerning that 10.000 dwellings on West-Amager could be established for free was inferred from an incomprehensive basis. In this sub-section, the partial result of the preliminary forecast will be critically analysed.

In the partial forecast, it was only traffic crossing the harbour section which was evaluated. However, according to the results of the two withheld reports, it was when traffic was assigned on the road network that the most critical problems stemming from an Amager development became evident, the most prominent of these being increased through traffic in the inner-city areas. This issue was, however, hardly touched upon in the Amager report. The only discussion of the problem was the following lines:

"The task in respect to city must be ... to divert as much as possible of the through traffic around the city area and the inner city districts, ... by leading motorists on the primary roads to fast driving beyond the city area without mixing them with the city-oriented traffic." (Stadsingeniørens Direktorat 1967c, p. 29)

Even though the principle of diverting through traffic away from the Central Business District was accepted, it was never explained that a large Amager development could imply that the Lake-ring had to be redesigned, as concluded by City Plan West Office, nor that an additional semi-circular primary road would be necessary, as both of the withheld reports had claimed. Moreover, the Amager report did not discuss how traffic crossing the Dybbølsbro line should

continue on the Zealand-side, where it had to pass through the narrow streets of the inner district of Vesterbro. This was in spite of the report stating as follows:

“In recent years, significant capacity extensions on the two old bridges and their access roads have been implemented, but this has, to a certain extent, moved the problems onto new parts of the inner, narrow road system.” (Stadsingeniørens Direktorat 1967c, p. 31)

Another shortcoming of the Amager forecast was that it only was prepared for 1980. However, the large growth in jobs on Amager, following from implementation of the 1st prize project's city belt (see section 10.6.1), was expected to take effect after 1980. This meant that if the city belt was implemented, a considerable increase in commuting to Amager could be expected after 1980, occurring in the direction that consumed the most capacity. This effect was not, however, elaborated on in the report. The size of the capital investments in the required infrastructure projects was not discussed, and neither was whether the proposed harbour crossings signified an appropriate order of prioritizing compared to other planned infrastructure investments. “Amager and the Master Plan” hence contained a systematic bias, ignoring some of the most critical issues related to an Amager development. Not only were the inconvenient truth claims advanced by the Regional Planning Secretariat and the City Plan West Office withheld, but their implications were also largely excluded from the agenda drawn up in “Amager and the Master Plan.” However, this systematic bias can partly be explained by technical constraints. The calculated trip frequencies could only serve to illuminate the problem of harbour crossing capacity and not assignment of traffic in the inner city areas. Moreover, neglect of these critical issues from “Amager and the Master Plan” did not imply that Copenhagen intended to ignore them completely. According to the work schedule, they were to be investigated in the last two stages of the forecasting programme (see section 10.7.4). However, as the neglect cannot be completely explained by ignorance (see section 10.6), the technical constraints cannot completely explain why the critical issues raised to discursive consciousness in the two withheld reports were not explained qualitatively in the Amager report. In fact, just as the critical issues excluded from Amager and the Master Plan seem to pull in a uniform direction, the partial framing of traffic problems also seems to have political undertones. If the comprehensive planning discourse had previously held such a strong position within the Department of the City Engineer, why was publication of the report not postponed until the preliminary forecast was finalized? Was the unavoidable demand for additional harbour crossing capacity so great that submitting an application for road reimbursement could not have waited for the result of the comprehensive forecast? If this is so, why were the results of the withheld reports not drawn upon? They might not have been prepared on an equally sophisticated basis as the computerized forecast, but they did provide an analysis of these wider effects, which the partial forecast failed to do. It appears that the knowledge produced on the basis of the partial results was shaped by a mixture of technical constraints and political motives. This will be elaborated on later in this chapter.

11.2 Bringing the secrecy to light

The truth claim advanced in “Amager and the Master Plan,” which argued that 10.000 houses on West-Amager could be developed for “free,” did not stand uncontested for long. Soon after

“Amager and the Master Plan” was issued, the counter truth claims contained in the withheld reports were brought to the light. In the 1st of April of 1967, the duty of regional planning within the Greater Copenhagen area was transferred from the Ministry of Housing to the newly established Regional Planning Council. The Regional Planning Secretariat now came to serve under this new planning body, which consisted of collaboration between the municipalities within the counties of Copenhagen, Frederiksberg and Roskilde and took over the task of preparing a regional forecast based on data from a new transportation study (see section 10.7.3).

In late April, the editor and member of the Social-Liberal party, Svend Skovmand, wrote a feature article on Copenhagen’s Amager plans, which he termed *“the most insane urban-plan drawn up in this century”* (Skovmand 1967a; Own translation). With a point of departure in a socio-economic point of view, he criticized Copenhagen’s Amager plans for being unprofitable. According to him, implementation of the Amager plans would imply that other plans, other more needed investments, would have to be postponed. He also criticized that no impartial government agencies had investigated the costs of an Amager development. This criticism was levelled at the Regional Planning Secretariat in particular. Skovmand states:

“In fact, one must wonder why this Secretariat [the Regional Planning Secretariat], which has not been on its own initiative for a long time, has started to investigate the problems related to a development of Amager. The secretariat has now had six-eight years to draw up plans for the Greater Copenhagen area’s growth. Is it not aware of the consequences the Amager-projects can pose for these plans?” (Skovmand 1967; Own translation)

The article must have been provocative reading to those planners who knew that such work had, in fact, been carried out, but was withheld. Only a few days later, the existence of a secret Amager report was leaked to the press. According to the press, rumours had it that the report documented that an Amager development required an additional urban expressway running through the inner city area of Nørrebro and considerable additional investments in the harbour crossing capacity. The possible existence of the report was, however, shrouded in secrecy. Even the Minister of Traffic was not familiar with the report (Nielson 1967a). The Regional Planning Secretariat’s staff members were gagged on the case and could not confirm the report’s existence. However, an anonymous source did confirm it (Krogh 1967d; Nielson 1967a). The media now demanded that the report be released, but Wassard was of another opinion. He states:

“I believe that the Municipality of Copenhagen’s report is grounded on a better basis, so there is no reason to publish the Regional Planning Secretariat’s report. Moreover, there are no principle inconsistencies between the two reports. The Regional Planning Secretariat’s report must be considered as skimmed work not suitable to serve as a basis for a public debate, which I would appreciate seeing on the metropolitan area’s future development.” (Information 1967c; Own translation)

He further states:

"Copenhagen's report is based on investigations. The other is more a number of assertions." (Aktuelt 1967; Own translation)

Hence, Wassard attempted to de-reify the Regional Planning Secretariat's report and, on that basis, justify its withholding. Moreover, according to Wassard, the Regional Planning Council, under which the Regional Planning Secretariat now functioned, was not obliged to publish the report:

"The Regional Planning Secretariat has never had a special power to issue its frank and considered opinions. We can therefore not be obliged to publish a report no one has asked for, but which the Secretariat has prepared on its own initiative." (Information 1967a; Own translation)

The withholding of the report fuelled a reaction among those in opposition to the Amager-plans. The Social-Liberal member of the Copenhagen City Council, von Rosen, stated that if the report had been withheld because the conclusions were politically inconvenient, this was outrageous, but he found it even more outrageous that officials had intended to initiate a development on Amager before the results of the forecast based on new home interviews was available. This was likely to cause costly poor investments. Wassard had announced that the home-interview survey would be executed in the fall, with the assistance of the Social Research Institute. Von Rosen, however, preferred to spend millions more on hiring Canadian or American consultancies, as had been done in some other cities. He feared that lack of practical experience among the technical staff would result in a piece of homespun work (Krogh 1967a). The transformation in the forecasting programme, resulting from the enrolment of FFWS (see section 10.7.3), was hence also facilitated by political project opponents' non-acceptance of the Copenhagen forecasting programme.

Approximately two weeks after the report of the Regional Planning Secretariat was brought to the light, the City Plan West Office's secret forecast also emerged (Krogh 1967b). Jørgen Vedel, who had prepared the forecast, had quit his job and leaked the report (Lyager 1996). According to the press, the withholding of this report was even more scandalous, as it concluded that the Lake-ring ought to be redesigned (Krogh 1967c). While the report was withheld based on the argument that one had to await the more detailed results of Copenhagen's forecast, there was much criticism of the fact that the report had not been released after the delay of the computerized forecast. While it was Wassard who came under fire as the man responsible for the withholding of the Regional Planning Secretariat's report, it was the Chief City Engineer, Poul Vedel, who was held responsible for the withholding of the City Plan West Office's forecast. Poul Vedel, however, spoke up for himself. He argued that at the time the forecast was prepared, it was impossible to establish a proper data set. The forecast could therefore only be regarded as an interim result. Now that the calculations, on the basis of the computerized transport model, had been conducted, the City Plan West Office's forecast was already obsolete in some regards. Moreover, the forecasting groups were soon to issue the result of the preliminary forecast, which was based on a more certain foundation than the City Plan West Office's forecast. According to the Chief City Engineer, there was nothing unnatural about awaiting these results. Hence, in order to legitimize the withholding of the forecast, he attempted to de-reify the base of the City Plan West Office's forecast, while simultaneously trying to reify the forecast

of the Department of the City Engineer. As will be shown in the section below, this truth-seeking strategy was by no means exclusively applied by Poul Vedel. It was widely used by both by proponents and opponents of Copenhagen's Amager plans^{002E}

11.3 War on the knife: The battle among planning peers

This section explores whether planning peers accepted the truth claims regarding the inevitable demand for additional harbour crossing capacity and the claim of free development on Amager. On May 10, 1967, shortly after the Regional Planning Secretariat's secret report was released, but before the leak of the City Plan West forecast, the Association of Urban Planners arranged a panel discussion regarding Copenhagen's Amager plans. The participants in the panel discussion came from relevant planning authorities, including the Department of the City Engineer and the Regional Planning Secretariat, as well as officials from the harbour and the airport, among others. At the meeting, the scene was set for a discussion of the Regional Planning Secretariat's Amager report vs. the report of the Department of the City Engineer. As Lemberg stated to the press a few days before the meeting: *"Now there will seriously be war over Amager"* (Aktuelt 1967; Own translation). In the following section, the discussions of the panel participants will be explored in respect to how the truth was used, either to reify or de-reify the reasonableness of an Amager development and the related traffic impacts.

11.3.1 A claim to scientific truth

The new head of the Urban Planning Office, Kai Lemberg, was the first panellist to give a talk. He started by outlining how the Amager plans divided the waters between opponents and proponents. He states:

"Some have looked at the Amager plans as a chance, on green fields without old buildings and other obstacles, to create a district with unprecedented qualities, while others have described it as the most insane plan that will cost untold additional expenses in transport facilities. Under the aroused passion, it can be difficult to assess what is proper planning and what is municipal selfish madness. This applies perhaps particularly after Politiken [a newspaper] has mentioned the 'secret plan' of the Regional Planning Secretariat from 1965, which warns against a large-scale Amager development because it allegedly would necessitate much larger traffic investments than development elsewhere." (Foreningen af Byplanlæggere 1967, p. 2; Own translation)

The appearance of the secret report had made the policy controversy even more complex. Now, two opposing truth claims existed, which respectively reified and de-reified the appropriateness of an Amager development. However, in the media, it was the secret report which had gained acceptance as truth. Lemberg states:

"From the last few days' newspaper debate, the uninitiated could get the impression that the Amager report's investigations and conclusions are now undermined by the Regional Planning Secretariat's report on 'Amager and development in car traffic.' There is therefore reason to try to drag the discussion down to Earth again." (Foreningen af Byplanlæggere 1967, p. 5; Own translation)

According to Lemberg, the media's acceptance of the Regional Planning Secretariat's truth claim concerning the gigantic infrastructure investments necessitated by an Amager development could not be validated. On the contrary, in respect to capacity needs, Lemberg argued, with reference to the forecasting group's partial forecast, that the only difference between the basic and the maximum Amager alternative was that a subway to Amager would be necessary 3-5 years earlier in the latter alternative. Lemberg states:

"This is for the harbour crossings, the consequences of a construction of up to 30.000 homes on West Amager until 1980. No one who retains his objectivity can claim that this has 'enormous and disastrous traffic consequences.'" (Foreningen af Byplanlæggere 1967, p. 5; Own translation)

According to Lemberg, it was nonsense that a 4th and 5th motorway crossing would be necessary, as claimed in the secret report. However, even though the forecasting group's transport model results could serve to de-reify the need for additional capacity investments, the model calculations could not be used to de-reify the secret report's conclusion concerning traffic problems in the inner-city areas. Due to the ignorance of "Amager and the Master Plan," the secret report had the upper hand in this matter. The inner city traffic problems hence constituted a vulnerable flank, and in order to repel an attack, Lemberg argued that Copenhagen was not ignorant towards these problems. In fact, work had already been initiated to illuminate them. He puts it as follows:

"Of course, the harbour crossings are not the whole problem, and work must continue in respect to the traffic problems on the additional road system. In this regard, the traffic analysis and forecast in the Municipality of Copenhagen will be able to deliver the figures which can provide firm ground. We expect to improve the preliminary forecast figures which have been produced through a comprehensive interview analysis in the autumn. I think it is money very well spent." (Foreningen af Byplanlæggere 1967, p. 5; Own translation)

Hence, although the partial results of the preliminary forecast did not assess the traffic impacts for a comprehensive point of view, the further work to be carried out by the forecasting group would allow the Municipality to speak truth about the Amager traffic's further move into the inner city areas. Hence, the real truth about the inner city impacts was long in coming. Yet, the truth claim advanced in the secret report regarding inner city traffic problems could still not be accepted in the interim. Lemberg problematized the assumptions underlining the secret report's assessment of the inner city traffic impacts and attempted to render them arbitrary. He states:

"The Regional Planning Secretariat's report from 1965 is a booklet of 6 pages (7 with a summary), in the form of short texts to a series of illustrations of traffic increases through the city centre and the inner city areas as a result of a doubling in the number of dwellings and in the number of jobs on Amager (i.e. around 70.000 more dwelling and 90.000 more jobs!), operating under the assumptions of predominant car traffic and all the through traffic running through the city and the dense inner areas. There are no documented traffic calculations, and at that time, there was still no information from the comprehensive Copenhagen traffic analysis." (Foreningen af Byplanlæggere 1967, p. 6; Own translation)

Hence, according to Lemberg, the assumptions of the secret plan were exaggerated and biased. Moreover, the traffic calculations were without a scientific basis. Distinct from this arbitrary approach, Lemberg postulated that the Department of the City Engineer's Amager report was grounded in thoroughly scientific analyses and was therefore able to speak the real truth in respect to the impacts stemming from an Amager development. Lemberg states:

"The Amager report from Department of the City Engineer 1967 is a report of 140 pages with an extensive and thorough documentation. It is based on the latest available figures from the municipality's forecast group, which has enabled detailed calculations of traffic across the harbour. I will dare say that it is the Amager report [the one prepared by Copenhagen] that is currently the most reliable testimony about what problems and what possibilities are contained in the development plans for West Amager." (Foreningen af Byplanlæggere 1967, p. 6; Own translation)

Lemberg used a truth-seeking strategy where he attempted to de-reify the base of the Regional Planning Secretariat's claims to truth while simultaneously self-proclaiming scientific truth. The question now becomes whether Lemberg's plea for scientific truth led to the opponents accepting the transport model results in order to avoid being portrayed as irrational (see section 4.1.5), or rather, prompted them to attempt to render the model results unacceptable on other grounds.

From the minutes of the panel discussion, it is evident that the claimed scientific rigidity was insufficient to convert the opponents into accepting the status of the forecasting results as truth. In the following, it will be analysed how opponents attempted to render the model calculations arbitrary, as well as how the panel participants affiliated with "Amager and the Master Plan" replied to this.

11.3.2 Incommensurable with a comprehensive system of thought

While Lemberg called upon science as part of his truth-seeking strategy, science was not the only system of thought with which an act of structuration had to comply in order to gain acceptance; it also had to be commensurable with a comprehensive approach to planning. On that ground, Kristan Larsen and Gert Moltke from the Regional Planning Secretariat attempted to de-reify the model calculations contained in "Amager and the Master Plan." Kristian Larsen problematized that the assumed housing growth in the so-called maximum alternative corresponded to less than a quarter of the long-term objective. If full development of the island was the goal, why then were the implications not investigated? This shortcoming was not accepted by Moltke from the Regional Planning Secretariat. He states:

"If one takes decisions now and begins a full development, without having examined the impacts which a full development will have and what demands it requires - and this has not been examined in the report, ... - then it is, from a planner's point of view, unacceptable to cut the first turf." (Foreningen af Byplanlæggere 1967, p. 20; Own translation)

Anders Nyvig declared his agreement with the unacceptability of this, and replied that he had tried to get these figures into the report. However, the politicians had opposed it because they felt that the idea of full development first had to be launched. Moltke replied that the partial view was insufficient to determine the design of a Lake-Ring crossing and a Dybbølsbro crossing, as it was possible that it should be designed differently under assumptions of full development (Foreningen af Byplanlæggere 1967, p. 20).

It was not only the assumed development in the maximum alternative which was incommensurable with a comprehensive planning approach; the narrow framing of traffic problems contained in “Amager and the Master Plan” had the same issue. The harbour crossing capacity only constituted one part of the problem, and according to Kristian Larsen, this was not the major one. He argued as follows:

“with the increasing car ownership, it will first and foremost be the traffic problems in the inner districts which will become the dominant, and not so much the question of a few harbour crossings, more or less. It is therefore surprising that ‘Amager and the Master Plan’ not with so much as a syllable refers to the traffic problems a housing development on Amager will create, particularly in the inner city areas; in fact, it has not even so much as been rendered probable that the first bridge, Dybbølsbrolinien, can get rid of its car traffic in the narrow streets of Vesterbro, which are already overcrowded with traffic. To us, this is the problem and not, as in the present material from the City Engineer’s Department, the issue of the harbour crossing capacity. Why you have not touched on this, the main problem of an Amager development, in fact, we must hope is because you did not know of our memo because of the confidentiality. But, if that is the conclusion, which is what I hope for your sakes, then the case shows in no uncertain terms that when you are playing around with each other in this way, this not only slows down our own time, but wastes the politicians time, and most of all, sacrifices a stock of unnecessary money on parallel work that is not coordinated.” (Foreningen af Byplanlæggere 1967, p. 7; Own translation)

Kristian Larsen hence tried to render the partial framing of traffic problems contained in “Amager and the Master Plan” unacceptable because it was inconsistent with a systematic approach to planning and failed to put the real problem on the agenda. Larsen even indicated that the partial framing of traffic problems in “Amager and the Master Plan” was, if not due to ignorance, a strategic misrepresentation.

In response, Anders Nyvig stated that he was, in fact, familiar with the Regional Planning Secretariat’s report, but he regarded it to be inadequate. To Nyvig, the secret report was nothing more than the regional planning’s *Fanny Hill*.¹⁸⁵ He phrased it as follows:

¹⁸⁵ *Fanny Hill* is an erotic novel originally from 1748. The book was banned soon after its release due to its perceived sexually immoral content, but the novel still flourished underground. In Denmark, the book was banned for obscenity in 1957, but the ban was lifted again in 1965. The prohibition of the novel created much attention around it, but when it was released, its content did not give rise to much offence.

“It is a ‘Fanny Hill’ in the sense that it has been of more use by pointing out that there exists secrecy than by its literary or individual forecasting qualities.”
(Foreningen af Byplanlæggere 1967, p. 19; Own translation)

By this, Nyvig implied that the professional standard of the secret report was insufficient and that it had created a lot of fuss about nothing. Its content had already been disclosed at a meeting in the Engineering Association in 1965. Nyvig had known about the report since the previous spring when he was approached by the Urban Planning Board, which had consulted him in respect to its publication. Nyvig, however, advised against its release, but:

“not because it could overturn the Amager report and the competition which came later, but because it as ‘Fanny Hill’ could not contain anything new. Its definition of problems was exceedingly primitive; the outcome could almost be guessed without making the forecast.” (Foreningen af Byplanlæggere 1967, p. 19; Own translation)

In accordance with Lemberg, Nyvig also attempted to render the conclusions of the Regional Planning Secretariat’s report arbitrary. He stated:

“Furthermore, it was such that it [the secret report] had only dealt with traffic across the harbour screenline. If it had taken more screenlines into account, e.g. a north-south screenline, it would have shown great traffic due to large development in the west. It is a platitude that where one builds, comes the traffic load, and it is not an argument just to establish one screenline and say that this will be very expensive.”(Foreningen af Byplanlæggere 1967, p. 19; Own translation)

Hence, in accordance with Larsen and Moltke, who attempted to render “Amager and the Master Plan” arbitrary because it did not correspond with a comprehensive planning view, Nyvig attempted to de-reify the conclusion of the secret report, arguing that it too was incomprehensive and therefore unacceptable. Conversely, the traffic forecast being prepared by the Department of the City Engineer’s forecasting group was truly comprehensive, and Nyvig found this work more suitable than the Regional Planning Secretariat’s report. The preliminary forecast accounted for the whole metropolitan region, illuminated the situation until 2000 and contained several alternatives, the planning of which being a project in which the Regional Planning Secretariat was intended to participate in and draw up. Nyvig had assumed that the results of the preliminary forecast would be available soon, and had therefore discouraged the release of the Regional Planning Secretariat’s Amager report. Instead, he had offered the Regional Planning Secretariat a chance to participate in a joint cooperation concerning the drawing up of “*the real*” report. However, the Urban Planning Board had declined Nyvig’s offer and recommended publication of the report. Now that the report was released, Nyvig felt he had to point out its insufficiencies. However, Nyvig’s attempt to counter the critique by rendering the assumptions of the secret report arbitrary was not accepted by Moltke. He replied that if the conclusions of the secret report were so trivial and so easy to disprove, he could not comprehend why they were not addressed on a single page in “Amager and the Master Plan.”

11.3.3 Too uncertain to be certified with truth

The claimed reliability of the model's results was also countered at the meeting. Jørgen Vedel, who prepared the withheld City Plan West forecast and later leaked it to the press, took a critical position towards the accuracy of the preliminary forecast. Like Lemberg, Vedel also used a de-reifying strategy as part of his critique. However, while Lemberg attempted to reify the partial results of the preliminary forecast, arguing that they were grounded in scientific rationality, Vedel attempted to de-reify their scientific character. Jørgen Vedel states:

“The results of the preliminary traffic forecast are used to reason that it will be ‘free’ to build up to 10.000 new homes on West Amager. With the uncertainty that rests on such a preliminary forecast, which as a result shows that traffic crossing the harbour will increase by 225% in the course of 15 years, among other things, I would have rather preferred that some maximum and minimum thresholds were outlined, within which traffic development will proceed. With such an approach, the conclusion could be reached that there perhaps should be removed 10.000 homes on Amager, or that there perhaps should be built 20.000 new homes, in order to equal the flows of the harbour crossing traffic in both directions; in short, the preliminary traffic forecast is not sufficiently certain to be able to predicate something real about what type of expansion can be recommended on Amager, and it must solely be a political responsibility to initiate development on West Amager.” (Foreningen af Byplanlæggere 1967, p. 9; Own translation)

Hence, due to uncertainty of the preliminary forecast, it was, according to Vedel, unacceptable that it was certified with truth. Vedel also contested the design of the planned Dybbølsbro crossing, which was supposed to serve local traffic between Vesterbro and Amager. According to Vedel, only around 20% of the traffic would be local, while the remaining was through traffic. What should happen with this traffic when it crossed the bridge from Amager? Should it be diverted through the narrow streets of Vesterbro? Would this not be unacceptable? (Information 1967d). Also, Knud Rasmussen¹⁸⁶ attempted to de-reify the basis of the computerized forecast. He put it as follows:

“Forecasts must, in fact, be considered as prophecies. And just as prophecies neither get worse nor better dependent on whether they are told by tea leaves or by gazing into a crystal ball, then the forecast results neither become more nor less certain whether they are calculated by the electron brain [the computer] or by hand.” (Quoted in information 1967b; Own translation)

Hence, to Knud Rasmussen, the use of modern computing technology did not reify the results of the forecast in and of itself.

¹⁸⁶ Knud Rasmussen had prepared the 2nd prize winning project in the Amager competition and also worked at the City Plan West Office. He later resigned in protest. The quote by him is not taken from the round-table discussion, but from a newspaper article.

11.3.4 Non-acceptance of predict-and-provide

Gert Moltke also implicitly contested the predict-and-provide interpretation horizon underpinning the framing of the partial forecast's policy implications, namely the incontrovertible necessity of providing capacity enlargements in the harbour crossing sections. He states:

“All in all, there is reason to expect a worsening of Amager’s traffic conditions, and development on West Amager will further aggravate the situation. Oppositely, it could be considered whether one could limit the number of jobs on Amager, as it is, according to the report, traffic to and from the workplaces on Amager, which in a situation where there are restraints on building on West Amager, occupies most of the roads and therefore determines how large transport facilities need to be.” (Foreningen af Byplanlæggere 1967, p. 13; Own translation)

Hence, distinct from the predict-and-provide rationality which underpinned the framing of the policy implications of the forecast, Moltke framed the implications of the forecast within a predict-and-prevent interpretation horizon. In fact, Moltke attempted to render arbitrary the so-called inevitable traffic increase assumed in the minimum alternative. He puts it as follows:

“Fortunately, there is something which seems to indicate that a reduction of jobs at Amager is occurring by itself and that the report overestimates when it stipulates the inevitable increase in jobs to 10.500. The last year's radical decline in industrial jobs within the Municipality of Copenhagen has also set its mark on Amager, and nothing indicates that this development will stop, on the contrary ... Perhaps we should, for 1960-1980, have assumed a net decrease of 5.000 and not a net increase of 10.500. Then traffic flows on the harbour crossings from the jobs on Amager would virtually not fill more than traffic home to dwellings on Amager. Requirements for capacity of the traffic facilities would be significantly less and therefore somewhat easier to meet.” (Foreningen af Byplanlæggere 1967, p. 13; Own translation)

Hence, the truths claim about unavoidable capacity enlargements were rendered arbitrary in respect to the actual development trend. On that ground, the predict-and-provide rationality which underpinned the interpretative framing of the model results could not be accepted. As a response to the critiques, Nyvig stated as follows:

“The question is whether these figures are valid [the forecast]. Jørgen Vedel and Gert Moltke have made a great deal of this and so there should be. The increase which ‘the engineer group-Anders Nyvig’ has assumed in the calculations in respect to the number of jobs for Amager has been given by the ‘forecast team by Bent P. Jørgensen.’ We have been told that it is consistent with what the Regional Planning Secretariat assumes for the Copenhagen region as a whole. It assumes decline in the inner parts of Amager and an increase in jobs in the outer parts which belong to the airport. Employment growth is measured zone for zone...” (Foreningen af Byplanlæggere 1967, p. 18; Own translation)

Hence, as response to Vedel's and Moltke's attempt to de-reify the assumptions of the forecast, Nyvig tried to re-reify them. Nyvig referred the opponents to Bent Jørgensen, the consultant mainly responsible for drawing up the geographical distribution of homes and workplaces. According to Nyvig, Jørgensen was the guarantee on the accuracy of the figures and their correspondence to the Regional Planning Secretariat's perception of them.

Bent Jørgensen, did not, however, confirm the accuracy of the figures. On the contrary, he argued that through a reduction of workplaces in the central districts and by accepting some degree of restraint on the Amager traffic, only one of the two proposed crossings, Dybbølsbro, was needed, even if 10.000 additional dwellings were constructed on West Amager.

Lemberg responded regretfully to Bent Jørgensen's statement claiming that the so-called unavoidable development was, in fact, preventable. The Amager Committee had asked the municipality's forecasting group how many workplaces were designated on Amager. Lemberg therefore found it disappointing that Bent Jørgensen had not previously reported that growth in employment did not need to be as large as assumed in the Amager Committee. From the minutes, it is not evident why the forecasting group had provided the Amager committee with overestimated figures in respect to the prejudiced development. If one believes Bent Jørgensen, then the results of the forecast were certainly misrepresented. The question now becomes whether they were strategically misrepresented. Based on my material, I cannot give a firm answer to this question. However, there was certainly a political incentive to deliberately exaggerate the demand for harbour crossing capacity, as it would make acceptance, and therefore funding, from the state more likely. Second, construction of extra harbour crossing capacity was a precondition for the development of Amager. Conversely, I can, in fact, see from my material that the Amager Committee did ask the forecasting group why traffic in the minimum alternative increased when the number of workplaces in the central part was reduced. Hence, it does not appear that the Amager Committee directly put pressure on the forecasting group in respect to misrepresenting the designated development. It might be that it was realized only after that the model had been run that the assumed development was mistaken. Ultimately, the actual reason is unknown.

From the above, it can be seen that the truth claims regarding the inevitable demand for harbour crossing capacity and "free" development of Amager, advanced on the basis of the partial forecast, did not manage to obtain acceptance among planning peers. In fact, the partial results were nearly de-reified due to their incomprehensiveness, uncertainty, issues of validity in land-use assumptions and the predict-and-provide interpretation horizon through which their policy implications were framed. However, although the opponents problematized and attempted to render the assumptions of the partial forecast arbitrary, inclusion of induced traffic was not contested. Yet, the policy implications were questioned. Within the predict-and-provide interpretation horizon, suppression of traffic demand was rendered unacceptable, and in order to set traffic free, capacity had to be enlarged. Distinctly, within the predict-and-prevent interpretation horizon, induced traffic was seemingly also accepted as an empirical phenomenon, but suppression of demand was perceived to be acceptable. Hence, in accordance with the findings from Chapter 7, the above does not lend support to the link between predict-and-provide and non-acceptance of induced traffic. On the contrary, it seems to support the

conclusion of Chapter 8, namely that induced traffic signified a positive effect. However, in Chapter 12, it will be shown that induced traffic did not signify a benefit to all.

11.4 The Copenhagen City Council

The Copenhagen truth claims about incontrovertible demand for harbour crossing capacity did not gain acceptance among planning peers. However, this was not catastrophic. After all, it was within the political domain that the proposal had to be approved. This section explores whether the truth claims about incontrovertible demand for additional harbour crossing capacity gained acceptance in the Copenhagen City Council.

In March of 1967, the Municipal Corporation had requested the City Council to make a decision of principle on the two proposed road crossings found necessary in order to accommodate predicted demand, namely the Dybbølsbro-line and the prolongation of Lake-ring to Amager. In regard to the Dybbølsbro-line, this decision of principle was needed in order to apply the Road Reimbursement Fund. If the decision was not made then, the Dybbølsbro-line could not be completed in 1972. The Municipal Corporation also applied to the City Council for authorization to request the Ministry of Public Work to seek implementing a law on prolongation of the Lake-ring to West-Amager. As the prolongation was part of the Primary Road network, this investment would be fully covered by the state (Københavns Borgerrepræsentation 1968, p. 137).

In April of 1967, the case was submitted for arbitration in the City Council's Urban Planning and Traffic Committee. However, due to the Municipal Corporation's upcoming summer vacation, the Urban Planning and Traffic Committee did not have much time to deliberate the large issues, which included considerations of Amager, specifically West-Amager's future role within the metropolitan area, among others. Nevertheless, as the proposed harbour crossings were considered necessary, independent of a further Amager-development, the majority of the Committee members recommended that the Municipal Corporation be authorized to approach the Ministry of Public Works in respect to the two harbour crossings (Københavns Borgerrepræsentation 1968, p. 664-706). The case was therefore put on the agenda for the meeting of the City Council in June. The majority recommended approval of both crossings. However, because several issues of concern had been insufficiently elucidated, particularly in respect to the prolongation of the Lake-ring, the minority, which consisted of the Socialist People's Party and the Social-Liberals, recommended against the prolongation to Amager. According to the minority, the Municipal Corporation did not possess sufficient knowledge on the technical and economic implications of the proposal. The following issues were of particular concern:

- The construction costs were unknown and its implementation could imply that other plans, and perhaps more needed infrastructures, were postponed, e.g. the Goods-ring.
- It was not assessed whether extension and improvement of the bus-system from Amager could reduce the number of car users and hence capacity demand.
- How the future development of the South Harbour would influence the design of the crossing.

- There was no assessment of the economic and technical feasibility of implementing the City Plan West project before 1976, which was a precondition for the prolongation of the Lake-ring
- It was feared that the prolongation of the Lake-ring to Amager as a motorway would demand a redesign of the Lake-ring, in a manner colliding with the City Council's decision of principle in 1963 on the Lake-ring as a one-level road (Københavns Borgerrepræsentation 1968, p. 670f).

The minority did not problematize inclusion of induced traffic as an arbitrary and illegitimate effect overstating the demand for capacity in harbour crossing section. It was, in fact, not so much the issues contained in the partial forecast which the minority problematized, but the wider impacts not assessed in partial forecast; its system biases were problematized. Due to the interconnected degree of the many large planning projects on which the City Council had to take a position in the near future, the minority feared that decisions made on a partial basis would now prejudice later decisions. It was therefore necessary first to make a decision in principle on, e.g. an Amager development, before a position on the problem of harbour crossing capacity could be taken. The minority did not accept the proposed prolongation of the Lake-ring because it was incomprehensively assessed, so they requested that the case be referred back to the committee. Hence, in accordance with the planning peers, the minority rendered the forecast results unacceptable due to their incomprehensive character. They argued that it was necessary to postpone the decision on the prolongation of the Lake-ring and await the finalization of the preliminary forecast so that the complex interrelations between the many large planning projects could be illuminated. Von Rosen states:

“I can also add that it would be natural that the traffic studies, which had already been initiated around 1963 by the Department of the City Engineer, and to which we already have granted a few million - these traffic studies, on which we, just during this joint council, were informed by the municipal corporation's side that it was attempted to see them accelerated, or we can say lead up to a kind of finalization by possibly engaging foreign consultants for assistance – it would be natural that these traffic studies are included in this entire mess of questions, which we might come to solve wrongly if we do not have the necessary basis in such studies.” (Københavns Borgerrepræsentation 1968, 679f; Own translation)

While von Rosen argued that the decision on the prolongation of the Lake-ring to Amager should be postponed because the decision-support on harbour crossing capacity was incomprehensive, Wassard was of another opinion. According to him, the decision was already well grounded. He states:

“Mr. v. Rosen did also touch on the issue of traffic forecasts. It is, of course, something that has been mentioned many times from up here. In this respect, I should like to say that the Department of the City Engineer works with all these issues, both in respect to long-term solutions of traffic connections between Amager and Zealand, south of Langebro, and in respect to the most appropriate priority. And we make use of all the information about the current and future traffic flows contained in the preliminary

forecast for 1980-traffic, which is currently being prepared by the Department of the City Engineer.” (Københavns Borgerrepræsentation, p. 692f; Own translation)

Hence, both the project proponents and opponents used the computerized forecast to underpin their arguments. While the proponents referred to the results of the partial forecast, arguing that it was necessary to make a rapid decision on the harbour crossing capacity in order to avoid the predicted capacity problems, the opponents used the partial basis of the forecast as an argument for postponing the decision until the finalized results of the preliminary forecast were available, so that decisions could be made on a comprehensive basis. Hence, in accordance with the findings of Sager and Ravlum (2005), it seems that the project opponents used a strategy in which they pointed out the shortcomings of the decision base and argued that more knowledge was needed before a rational decision could be made. However, in this case, the project opponents constituted the minority, and the proposal to recommit the case was rejected by the majority. Hereafter, the Dybbølsbro-line was carried unanimously, while the prolongation of the Lake-ring was passed by a vote of 34 to 13 (Københavns Borgerrepræsentation 1968, p. 706). In this case, non-acceptance of the transport model-based knowledge production did not contribute to opening it up for change to come about. Instead, the knowledge production concerning the unavoidable demand for enlargement of road capacity in the harbour crossing section gained acceptance from the majority within the Copenhagen City Council. This was, however, not sufficient; acceptance also had to be obtained from the Road Directorate and the national politicians. Whether the results gained acceptance at the State level will be explored at the end of the next chapter.

11.5 Sum up

In this chapter, the basis of the partial results of the computerized forecast was scrutinized, along with how the results were used to support the planning of an Amager development and whether they gained acceptance among planning peers and local politicians. It was shown that although the problem of harbour crossing capacity was framed within a predict-and-provide interpretation horizon, induced traffic was actually included in the partial forecast. In fact, in the base alternative, it was even discussed that absence of capacity enlargements would increase the capacity restraining effect on traffic growth. Hence, while neglect of induced traffic within contemporary planning practice is associated with bias against the zero alternative, this bias was not evident in the partial forecast generated on the basis of the first Danish computerized traffic model. This was in spite of that the forecast was prepared within a predict and provide horizon. However, within this horizon the capacity restraining effect was perceived to be unacceptable and served as an argument for pro-capacity enlargements as a means to set traffic demand free.

In the chapter, it was also shown that the transport model-based knowledge production was used to reify the fact that there was an inevitable demand for two new harbour crossings in the near future. A truth claim was further advanced concerning that if these two crossings were established, 10.000 new dwellings could be constructed on Amager for free. These truth claims were, however, produced on a partial basis, containing a system bias framing the knowledge production in a reductive manner, which excluded the most critical issues from the planning agenda. The system bias embedded in the transport model can partly be explained by technical constraints. Yet, while technical constraints alone cannot explain why the excluded critical issues

were not deliberated on in a non-technical basis in the planning report, neither can ignorance. As the critical issues pulled in a uniform direction, the partial framing of traffic problems appeared to be political, and it was also shown that the so-called incontrovertible demand for two new harbour crossings was actually preventable, meaning that the knowledge claims that were levelled based on the transport model results were misrepresented. However, even though there was clearly a political motivation to strategically misrepresent the results, this accusation cannot be firmly concluded. Ultimately, it appears that the transport model-based knowledge production was shaped by a mix of technical constraints and political motives.

The chapter also explored whether the model results gained acceptance among the audience. Although the transport model results were nearly reified as a result of them having been framed as corresponding to scientific truth, the model results were still met with non-acceptance among planning peers. The partial results were then almost de-reified on the basis of their uncertainty, with the opposition claiming that they were incomprehensible and incommensurable with a systematic approach to planning. It was also shown that despite inclusion of induced traffic being accepted among planning peers, the predict-and-provide framing of capacity restraining effects on traffic growth as unacceptable was not accepted within a predict-and-prevent horizon. Among the local politicians, the minority attempted to render arbitrary the knowledge base of the decision for being incomprehensible and non-acceptable, problematizing its system biases. In the political debate, both the project proponents and opponents used the computerized forecast to support their arguments, arguing either that, with reference to the results of the partial forecast, it was necessary to make a rapid decision on the harbour crossing capacity, or that it was important to postpone the decision until the finalized results of the preliminary forecast were available so that decisions could be made on a comprehensive basis. In this situation, non-acceptance did not generate a second round of knowledge production, as both the Dybbølsbro-line and prolongation of the Lake-ring gained political acceptance among the majority in the Copenhagen City Council in the first round.

12 Finalizing the preliminary forecast and the decision on the Lake-ring

In this final chapter of the second embedded case, the process of finalizing the computerized forecast and the mechanisms shaping this process will be explored. However, the focus of the chapter is also particularly on how the finalized forecasting results were put to use and whether they gained acceptance among their audience. While the planning and decision-making context of the partial forecast was an Amager development, the finalized results were used as support for the political decision on the Lake-ring. In that respect, it will be investigated how the model results were put to use in the political debate in the Copenhagen City Council, and whether they gained political acceptance. Next, it will be explored how attempts to render the results of the computerized forecast unacceptable subsequently influenced the transport model-based knowledge production. As it was, the State which had to provide the major part of the financing of the transport projects and which the transport model was used to evaluate, their implementation did not only depend on acceptance among local politicians, but also among national politicians. The issue about whether the Amager projects described in the former chapter, as well as the Lake-ring, which is elaborated on in this chapter, managed to gain acceptance at the national level will therefore also be explored. This is followed by an elaboration on different reasons for why the results of computerized forecast did not materialize. Lastly, a conclusion is provided to synthesise the findings from this embedded case and provide an answer to the sub-question addressed in this chapter.

12.1 The third progress report

Although a new transportation study and the subsequent development of a new model had been planned and initiated under the management of the Regional Planning Council, the preliminary forecast was still brought to some kind of finalization. In fact, its finalization was rushed. After the harbour crossings had been approved in principle, one of the following major infrastructure projects on which the City Council had to make a decision was the Lake-ring. In October of 1967, the Municipal Corporation submitted a proposal to the City Council on constructing the Lake-ring, after which the project was sent into committee. In order to provide the Committee with decision support, finalization of the computerized forecast was urgent. In fact, the forecasting team did succeed in producing results carried all the way through to the last iteration in the assignment model, but not before the Committee issued its report. We will return to this in the section below. This section elaborates on the process of finalizing the forecast.

The finalized results were prepared on the basis of the basic land-use alternative for 1980 and the Department of the City Engineer's proposed primary road network.¹⁸⁷

The results of the forecast showed that the future development in car traffic would largely continue the trend seen in the past 10-15 years (see figure 12.1). However, in the screenline of the municipal border, in the direction towards the city, the results were below the trend. This

¹⁸⁷ *Udkast til arbejdsrapport 3, kapital 2, oversigt over forudsætninger og fremgangsmåde. 2. redaktion.* GPD, K.A.O, 17.06.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

was assumed to be caused by an error in the forecast, but it was not possible to locate it. In the screenline of the Lake-ring, future traffic also deviated from the trend, but in the upper direction. This was not due to an error but was primarily caused by increased through traffic, particularly stemming from expansion of the airport and the planned development on Amager.¹⁸⁸

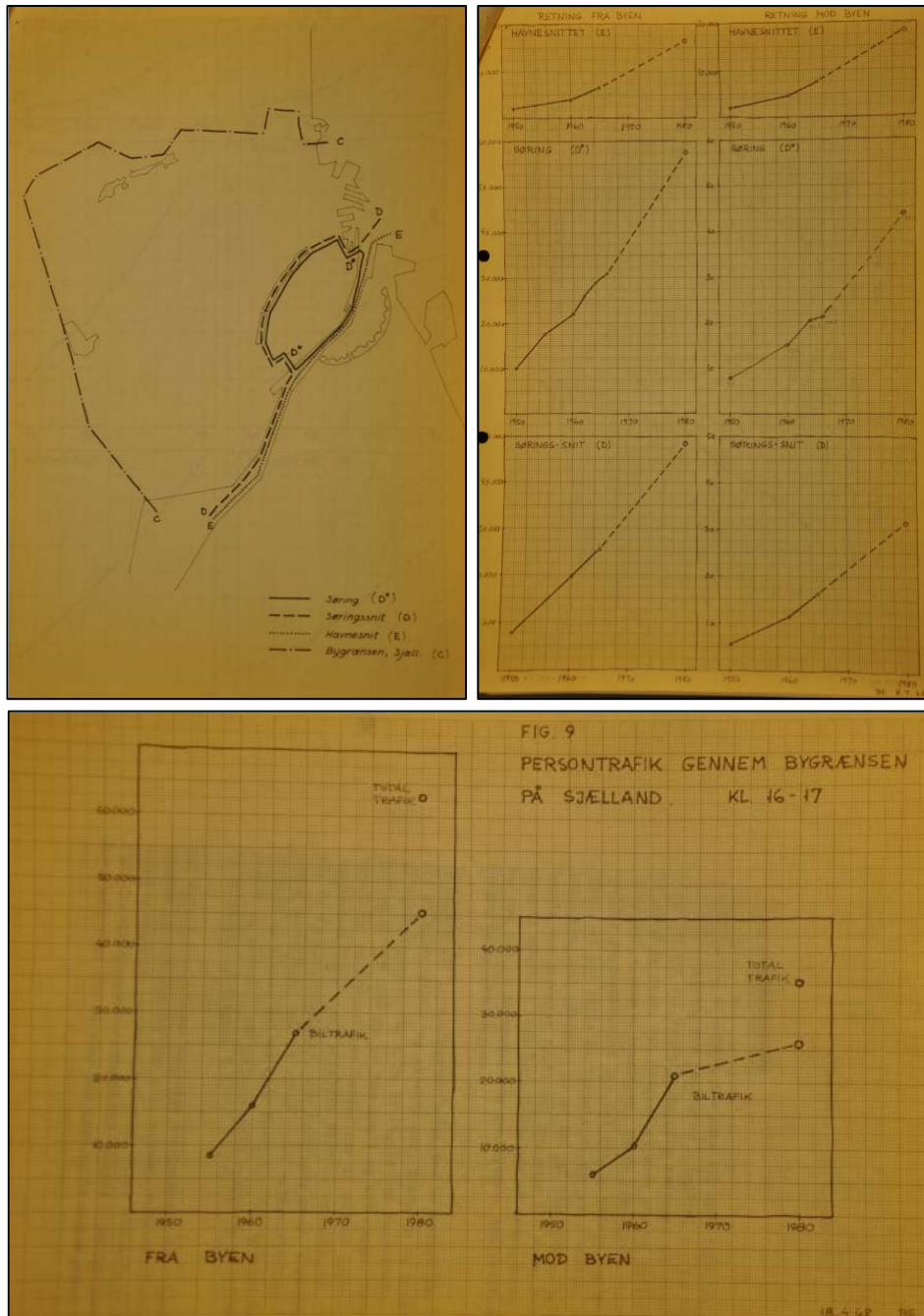


Figure 12.1: Above to the left: screen-lines in the Lake-ring (D*), the Lake-ring section (D), the harbor section (E) and the municipal boarder. The other figures show the results of forecasted traffic crossing these screenlines in both directions.¹⁸⁹

¹⁸⁸ Arbejdsrapport 3, kapital 5, prognose resultater vedr. biltrafikken i maxtimen. 1. udkast. BPD, B.E./H.P., 21.10.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

¹⁸⁹ Arbejdsrapport 3, kapital 5, prognose resultater vedr. biltrafikken i maxtimen. 1. udkast. BPD, B.E./H.P., 21.10.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

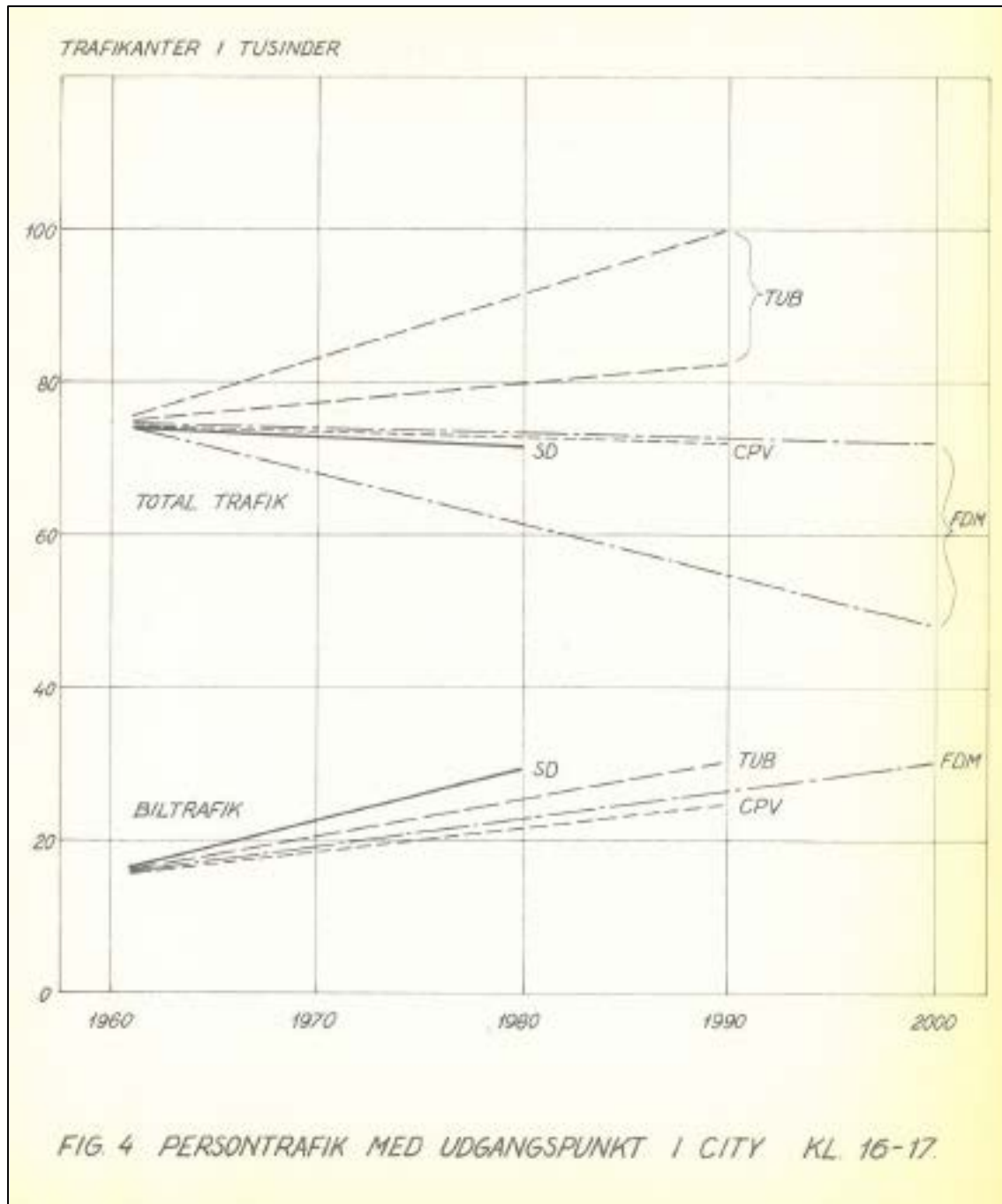


Figure 12.2: Comparison between the result of the Department of the City Engineer's forecast and a number of other available forecasts. Above: total traffic. Below: Car traffic.

SD = Department of the City Engineer; TUB = Subway Committee; CPV = City Plan West Office; FDM = Federation of Danish Motorists.¹⁹⁰

In comparison with a number of other available forecasts for total city traffic produced around the same period of time, the result of the computerized forecast was somewhere in the middle in regard to total traffic (see figure 12.2). However, in spite of the considerable differences between forecasted total traffic amounts, the forecasts produced rather similar results in regard to car traffic. The Department of the City Engineer's forecasted car volumes were higher compared with the other forecasts, though not to any extreme (see figure 12.2). Nevertheless,

¹⁹⁰ Redaktionsstof til Arbejdsrapport 3. Kapitel 4: Modal split. BP3 B.E., 18.04.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

the modal-split model used to produce the car forecast did not meet the standard of quality for which the committee originally aimed. In view of the urgency of the matter, it seems that finalization of the preliminary forecast was carried through at the expense of its scientific grounding. In a working paper from February of 1968, titled *“Reflections over the traffic forecast work in last half of 1967, etc. from a computer running point of view,”* it is stated that:

“Since we as quickly as possible and for any price wanted to go through with an assignment calculation for traffic in 1980, between 16.00-17.00, it was decided that the only bonds put on the methods used were that they should be tested on a 1960 basis model and produce results not differing significantly from the traffic counted through certain screenlines. I took on the task of completing the calculations, though I disclaim any responsibility for the conceptual foundation of the methods used” (Own translation)¹⁹¹

This disclaim of responsibility for the methods used was particularly directed at the modal split model. Due to the problems of data availability, it had not been possible to test the three considered modal split models and select the most suited on that basis. Moreover, due to problems of data availability and lack of knowledge, the forecasting group had not been able to include biking, even though this was desired. Due to these problems, development of the modal split model had been postponed until new data was available (see sections 10.4.2 & 10.5). As this was not yet the case, a new and more simplified forecasting method was applied instead. In fact, in spite of the original objective being to prepare a comprehensive and multi-modal forecast, it turned out to be a primarily car traffic forecast, which only differentiated between private motorized traffic (including motor cycles, private cars and motorized vehicles used for commercial purposes) and other traffic (transit and biking). This other traffic was not assigned to the infrastructure system. In the applied modal split model, it was assumed that motorists who own cars choose to use them, but parking restrictions and the level of transit service could counteract the use (see figure 12.3. It was also assumed that parking restrictions in the area within the Lakes meant that only about 1/3 of peak-hour traffic was by car. The choice of mode was further determined by the car ownership in the origin zone (see figure 12.3. The car ownership forecast was based on a minimum forecast produced by the Federation of Danish Motorists for the nation as a whole. However, car ownership was not applied uniformly throughout the forecasting area, but varied geographically, being lowest in the inner areas and highest in the outer zones, as well as the wealthier areas north of Copenhagen. The level of transit service was assumed to have only limited influence on car-use under normal parking conditions, but a significant effect under poor parking conditions, particularly in the City. In situations where transit service was poor and parking conditions likewise, the effect on modal split was small.¹⁹²

¹⁹¹ *Betragtninger over trafikprognosearbejdet i sidste halvdel af 1967 m.v. fra et kørselssynspunkt*, B.M., Februar 1968 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

¹⁹² *Kapitel 4. Fordeling på trafikmidler*, GPD, B.E., 21.08.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

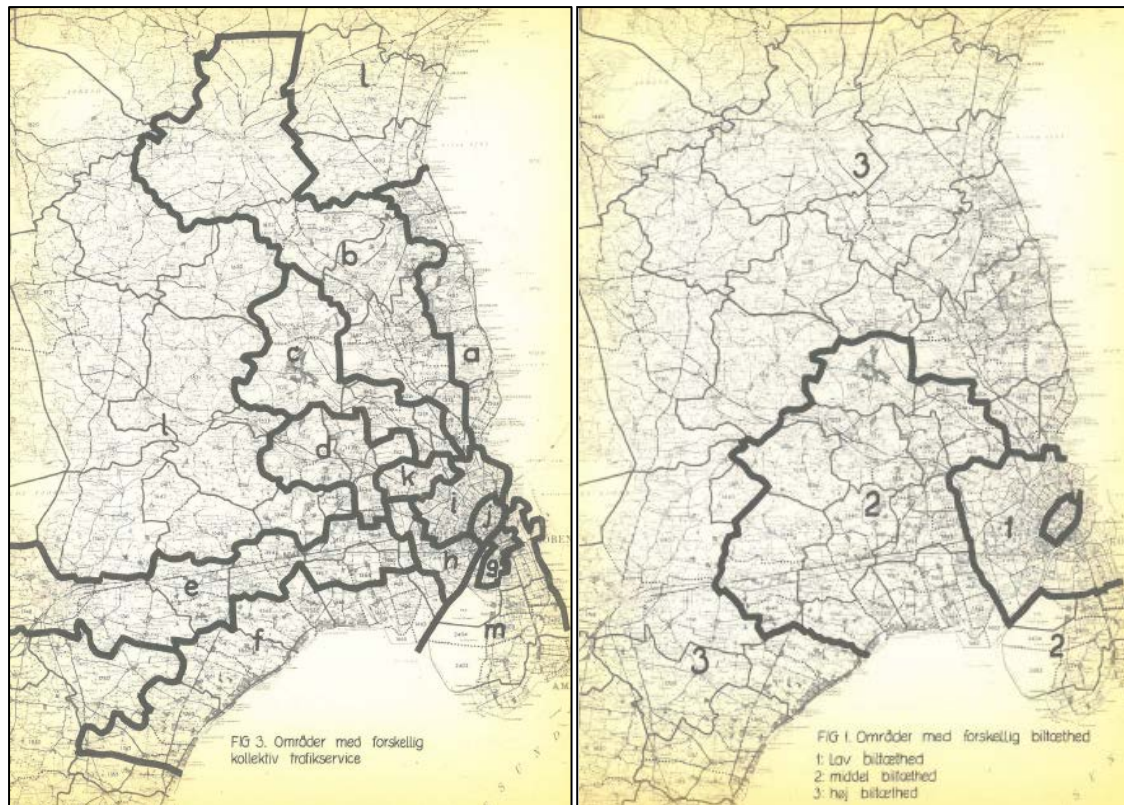


Figure 12.3: To the left: areas with different level service in regard to transit. To the right: Areas with different levels of car ownership. 1 = low car density, 2 middle car density, 3 high car density¹⁹³

Although forecasted car traffic was not radically high compared to the other available forecasts, it was produced on a problematic basis. The method had seemingly been selected as a method of last resort to circumvent the problem of data availability. In the paper titled “Reflections over the traffic forecast work in last half of 1967, etc. from a computer running point of view,” it is stated that:

“... it was hoped that the inspiration and the good ideas would emerge when the trouble was the greatest. The result was a new calculation method for distribution traffic on modes and it is noteworthy that it is not tested on the 1960 situation; one can wonder about whether some dare to run a similar calculation for 1960, whereby we would risk demonstrating potential shortcomings of the method.” (Own translation)¹⁹⁴

Hence, while modal split was initially considered vital for a comprehensive forecast, this sub-model came to constitute the weakest step in the model. The assignment calculations were, however, carried through all the way to the 10th iteration. The outputs of these calculations were available in the form of tables, containing information about traffic volumes on the individual stretches, specifying travel time and speed, capacity utilization, vehicle hours and vehicle kilometres travelled. These tables could therefore serve as the basis for making capacity

¹⁹³ Redaktionsstof til Arbejdsrapport 3. Kapitel 4: Modal split. BP3 B.E., 18.04.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

¹⁹⁴ Betragtninger over trafikprognosearbejdet i sidste halvdel af 1967 m.v. fra et kørselssynspunkt, B.M., Februar 1968, p.15. (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1960?-1969?, Trafikanalyser -, Box 1)

diagrams (see figure 12.4) and traffic-economic analyses. Hence, the work with defining capacity curves and seep/flow relations, which was originally initiated in 1956 with the objective of enabling traffic economic evaluations, was now so advanced that this objective could actually be fulfilled.¹⁹⁵

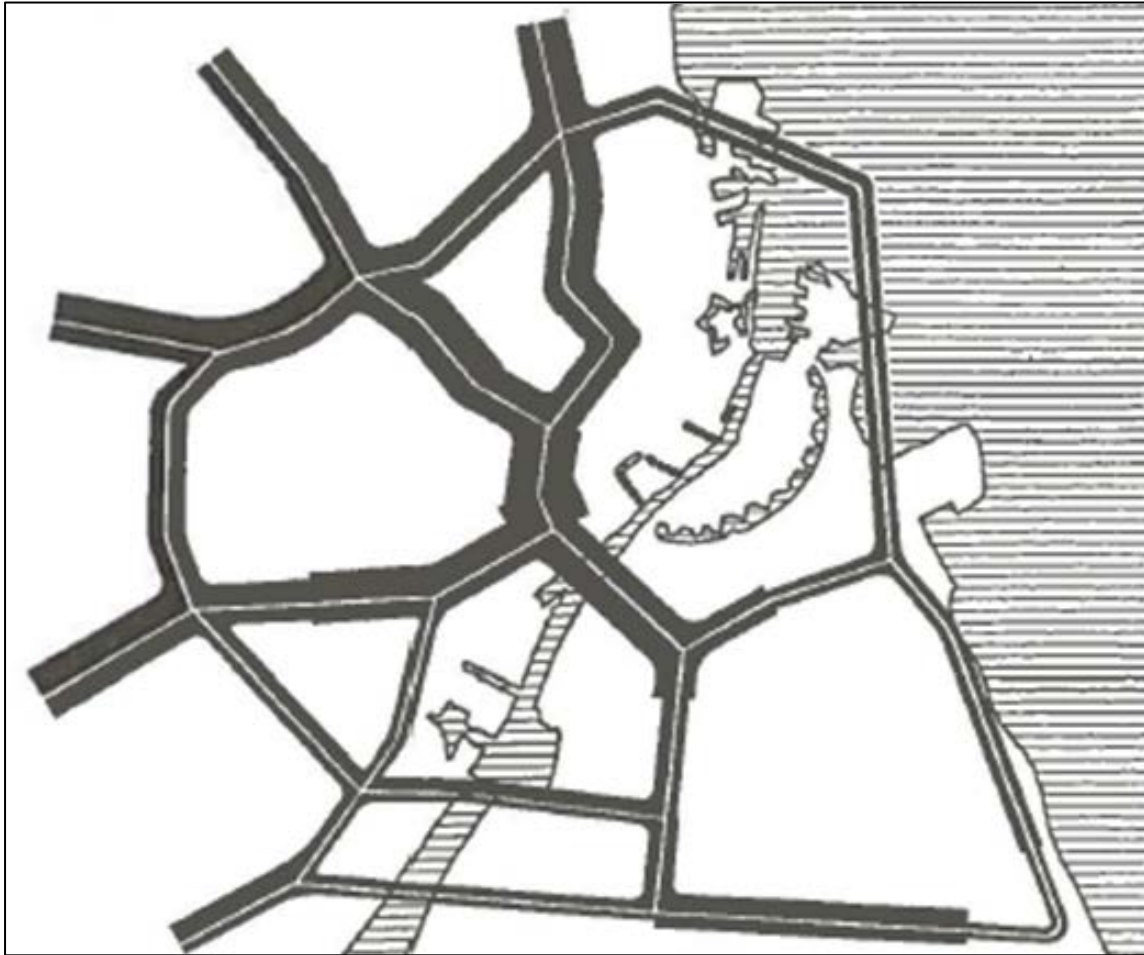


Figure 12.4: Calculated traffic load in the peak-hour 1980, assigned to the road network (Lyager 1968, 33.)

Though the forecasting programme now was in its final stage and there was a rush for producing results to support the decision on the Lake-ring, an opportunity for change to the framework of the computerized transport model was still created in the spring of 1968. While it has thus far been shown how both transformations in systems of thought and spatial order have contributed to reopening forecasting practice, this time, the opportunity for change to come about was generated by technological transformations. The occasion was that the Data Centre had installed a new IBM-360 computer which was incompatible with other IBM computers (Heide 1996), and in order to be able to run on the new computer,¹⁹⁶ the transport modelling software programs

¹⁹⁵ Udkast til arbejdsrapport 3, kapital 2, oversigt over forudsætninger og fremgangsmåde. 2. redaktion. GPD, K.A.O, 17.06.1968 (Plandirektoratets arkiv, Trafik, diverse, 1968-1968, Forarbejder til arbejdsrapport 3, Box 1)

¹⁹⁶ Notat om fremstilling af et forbedret programsystem for behandling af trafikanalyser og beregning af fremtidig trafik. Karl Arnold Ottesen, 25.3.1968

had to be rewritten before the end of 1969.¹⁹⁷ This raised the question of whether it was desirable to preserve the modelling system in its present form, as well as whether it was desirable to make modifications in the individual programs so that they could be retained in the new modelling system. Nevertheless, from the empirical material, it does not appear that radical changes in the framework of the model occurred.

In the beginning of 1968, it was decided to start reporting the new results, and the work with preparing the third progress report was initiated. Instead of five progress reports, as contained in the work programme from the summer of 1966 (see section 10.7.4), the third progress report was now to be the final. The report described the home-work traffic in the peak-hour in terms of being distributed on modes and assigned to the road network. However, because the Regional Planning Council aimed at quickly producing forecast results based on new data, it became clear in late 1968 that there was no longer a need for an official report on the preliminary traffic forecast. Even though Progress Report 3 was almost finished, the results of the preliminary forecast were never officially issued. Instead, it was replaced with a description for internal use.

After having presented the more or less finalizing of preliminary forecast, the results will be discussed in respect to the City Council's decision on the Lake-ring.

12.2 The City Council's decision on the Lake-ring

Even though the forecasting team succeeded in producing forecast results to support the committee work on the Lake-ring, at the time of the committee stage, they had not managed to run the assignment model iteratively. There had only been a single assignment (see Chapter 2) prepared for the network at large, but the 4th iteration had been reached for some stretches. Moreover, only a single road infrastructure alternative was evaluated at the Committee stage, namely the Department of the City Engineer's proposed primary road network for 1980; no alternative existed for comparison.

In spite of these technical shortcomings, the Urban Planning and Traffic Committee issued its report on the Lake-ring on March 13, 1968, and the case was placed on the agenda for the meeting of City Council on March 21. However, the day before the meeting, Fritz Ingerslev, the Professor in sound at the Technical University, submitted an open letter to the City Council, warning that the Lake-ring would affect the surrounding areas negatively as a result of excessive noise, resulting in a serious deterioration of residential and recreational values. Therefore, he recommended that the decision be postponed until further investigations had been conducted. This was accepted and it was decided to withdraw the Lake-ring from the agenda and postpone the decision until the Professor had been given the opportunity to elaborate on his point of view. However, the professor was by no means the only one who problematized the Lake-ring, and noise was not the only reason. It was also strongly opposed due to its safety effect, air pollution and degradation of recreational areas. Although the Lake-ring was not a new project (see sections 9.1.2; 9.1.3; 9.2.1; 10.3.5), it was not until then that a strong resistance was put up. The decision on the Lake-ring was hence situated within a critical historical moment in respect to

¹⁹⁷ *Notat om fremstilling af et forbedret programsystem for behandling af trafikanalyser og beregning af fremtidig trafik*, BP3, K..A.O, 25.3.1968 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1)

Danish transport planning and project evaluation practice. It signifies a shift in the discourse on urban expressways, in which environmental concerns started to constitute an increased rationale for non-acceptance among road opponents.

The opponents of the Lake-ring project were very successful in mobilizing the media, planners, politicians and even the general public in the opposition, and a very negative smear campaign was launched. As some of the participants in the controversy also noted, the debate on the Lake-ring was played out between opposing views on the city. On one hand, it seems that the project proponents were tied to 1950s discourse on the benefits of increasing accessibility to the city centre through enlargements of road capacity and expanding of the mono-centric spatial order, while the opponents were arguing within a discourse based on protection of the urban environment, meaning that the traffic load on the inner city should be eased through urban decentralization, a notion which started to become strong in the 1970s. In addition to negative externalities, the Lake-ring was also problematized because only a single alternative had been prepared. The Minister of Traffic had declared in the press that he would personally approach the Road Directorate and make them draw up alternatives when Copenhagen did not (Københavns Borgerrepræsentation 1969, p. 226-357). He also declared that the State would not invest a penny before a realistic overall plan was prepared to cover the whole Greater Copenhagen Area (Rothenborg 2002). With all of these factors present, the decision on the Lake-ring was situated in a highly politically-charged context.

However, while an addendum which suggested that the Municipal Corporation investigate noise effects in the further work on the Lake-ring was added to the majority report, the Professor's talk to the Committee and the Municipal Corporation did, according to the majority, not give occasion to revise the original formulation of the majority report (Københavns Borgerrepræsentation 1969, p. 249). Neither did the many critical voices levelled in the public debate. The case was put on the agenda for a meeting in the City Council, which took place on May 2, 1968. The committee reports will be elaborated on in the following, after which the debate in the City Council on the Lake-ring will be explored, accompanied by analyses of how the project proponents and opponents made use of the computerized forecast in their respective arguments.

12.2.1 The committee reports

The committee report contained a technical deliberation of the forecast's methodology. It was acknowledged that the calculations were inaccurate because the forecast was based on peak traffic and not total traffic (Københavns Borgerrepræsentation 1969, 229). Also, the difference between an all-and-nothing assignment and an assignment with capacity restraint was expounded upon. In that regard, the Municipal Corporation pointed out that the results of first assignment step (0th iteration) had showed an overload of the Goods-ring, implying that the capacity on this stretch had to be enlarged by an extra lane compared to what was assumed in the calculations. Such a capacity enlargement had not yet been inscribed into the transport model, but it was expected to cause a diversion of road users from the Lake-ring to the Goods-ring (Københavns Borgerrepræsentation 1969, p. 233). This shows that the model was, to some extent, used in the manner originally envisioned, which was that of an iterative tool for evaluating and optimizing proposals. On the other hand, although Ottensen had proclaimed,

back when it was decided to develop the computerized model, that the effort of computerization was partly wasted if it was not applied to evaluating several alternatives (see section 9.3.3), only a single alternative had actually been evaluated. However, according to the report, other alternatives had been discussed in the committee. In one alternative, urban expressways should only be constructed in the Goods-ring and beyond, not within this ring. According to the Municipal Corporation, this would mean that the road network of the inner city would be overloaded with through traffic, but it had promised to conduct model calculations in order to illuminate these issues further (Københavns Borgerrepræsentation 1969, p. 238f). The Committee had asked the Municipal Corporation about whether the inner-ring could be removed from the Lakes and established further out in accordance with the line proposed by the Regional Planning Secretary, the so-called Forum-line (see section 10.6.4). However, this alternative was evaluated and declared to be unrealistic due to the massive clearance that it required. Though the City Council had not yet taken a position on an Amager development, the committee had still asked the Municipal Corporation about how an Amager development would impact the Lake-ring traffic. To this, the results from Amager and the Master Plan were repeated, namely that development of 10.000-15.000 dwellings would not have an appreciable effect, while 30.000 dwellings would require additional capacity enlargements in the harbour crossing section. It was, however, stated that this would not have an appreciable effect on the Lake-ring. From the above, it can be seen that while the Municipal Corporation did not try to black-box the methodology of the computerized transport model, neither did it hide that it had some shortcomings. Nevertheless, it was not disclosed that the validity of the modal split model seemed to have gone untested (see section 12.1). The majority in the Urban Planning Committee, which consisted of the Social Democrats, the Conservatives and the Liberal Party, recommended on the basis of the report that the Lake-ring be approved.

However, some committee members did not agree with the majority, resulting in two minority reports being drawn up. The first minority consisted of Boas Jensen, Jørgensen and von Rosen. They recommended that planning of the Lake-ring be suspended. According to them, it was unlikely that the State would increase its level of investments in the Copenhagen primary road system in accordance with the assumed costs. Therefore, it would be economically unfeasible to establish the Department of the City Engineer's proposed primary road network before 1980, as the model assumed. Instead, it would be necessary to prioritize between the many planned motorway investments. According to them, it would be more profitable only to establish motorways in the Goods-ring and the radial roads beyond this ring (Københavns Borgerrepræsentation 1969, p. 244f). As these issues were not evaluated in the traffic model, the minority found the basis of the decision insufficient. Their minority report states:

Thus, it is the minority's view that Municipal Corporations' traffic planning and forecasting-work should be revised. The forecast should be designed to, e.g. calculate different alternatives, clarifying ... which network is best under certain economic conditions ..." (Københavns Borgerrepræsentation 1969, p. 245; Own translation)

This minority did not accept the proposed Lake-ring because they believed it would worsen traffic in the inner-districts. The Minority Report states:

“... the Municipal Corporations’ proposals on major road investment can perhaps contribute to worsening the traffic situation in the central districts. The Municipal Corporations’ proposals can cause an increase in real estate and land values, which prevent a reduction in the too-dense building mass, and thus worsen the traffic situation.” (Københavns Borgerrepræsentation 1969, p. 245; Own translation)

Hence, according to this minority report, there was a risk that the Lake-ring would facilitate densification within the Central Business District, and thereby increase traffic as a result. This minority hence problematized the mono-centric spatial order because of the large traffic volumes attracted to this part of town. We will return to this below. Based on Professor Ingerslev’s memorandum, this minority also recommended that the Municipal Corporation be enjoined to produce an addendum containing investigations and assessments of the proposals’ noise impacts when introducing new large road projects (Københavns Borgerrepræsentation 1969, p. 245).

The second minority consisted of Ludvig Hansen and Børge Oløe from the Socialist People’s Party. In support of their view, they stated that:

“In principle, insertion of urban expressways so close to the Centre must be considered mistaken. Such facilities will draw additional car traffic toward the City. The Municipal Corporations’ forecast for car volumes rests, according to the view of the minority, on a schematic evaluation of development in the car traffic (extrapolation). While the urban expressways in themselves will attract additional car volumes in such a manner that road users who, under other circumstances, would not have used private motor vehicles for home– work travel will now be tempted to do so. The balance in the composition of traffic-modes will be shifted towards individual car travel. According to the minority’s opinion, the centre-directed traffic should primarily be facilitated by transit.” (Københavns Borgerrepræsentation 1969, p. 245f; Own translation)

Hence, this minority could not accept the results of the computerized forecast because induced traffic was not included. While induced traffic in the historical deliberations has signified only benefit thus far, induced traffic was, in this context, problematized as undesirable. Although induced traffic was not included, this minority generally supported that model calculations had been conducted. Yet, in accordance with the other minority, they problematized that no alternatives were evaluated. Their minority report states:

“The minority will consider a circular urban expressway in the Goods-ring, or maybe a little closer towards the lakes, as a much better solution to the problem of through traffic. The minority is satisfied with the work with the traffic forecast now being in progress, but warns against the preliminary results being used too mechanically as guidance for any future road project. The forecasting-work should also provide a basis for alternative solutions, whereupon the Municipal Corporation deliberately must set urban planning objectives and affect traffic in accordance, both in respect to type and direction. Calculation of traffic development (assignment from 0th to tth “iteration-step”) has, in fact, assumed the Lake-ring with the proposed capacity, as well as the inner circular-roads, being unmodified in principle. One has thereby set the scene for a circular

logic concerning the desired traffic distribution.” (Københavns Borgerrepræsentation 1969, p. 245-7; Own translation)

To this minority, it was hence unacceptable that any alternative which did not assume construction of the Lake-ring had been drawn up. As mentioned above, the Municipal Corporation had promised to evaluate the minority's alternative. In this case, non-acceptance also contributed to opening up the transport model-based knowledge protection for change to come about. We will return to this below.

12.2.2 The debate in the City Council

After having set the scene, we will now turn to the political debate on the Lake-ring and whether it gained acceptance in the City Council. In this debate, both the project proponents and opponents referred to the model results in their respective attempts to reify and de-reify the basis of the decision. The model results and the assumptions under which they were produced hence became a central contentious point in the debate. While it has been shown throughout this embedded case how the technical increasingly became interwoven with the political, it will be shown in the following how the political also became technical. In fact, it was not all of the politicians who understood the technical debate, and some chose not to take part in it as a result (Københavns Borgerrepræsentation 1969, p. 275).

The Chairman of the Committee, the Social Democrat Egon Widekamp, was the first in turn to speak. He started out by giving a long talk in which he expressed his indignation towards the press' treatment of the Lake-ring. To him, most of the critique was unreasonable. He puts it in the following emphatic terms:

“It is the sheer incarnate abuse of the free Word, and come close to prostitution of the concept of freedom of the press. They insinuate that municipal officials in bad faith have put forward proposals that deliberately are based on false assumptions. [...]. They insinuate that our technicians broke the neck on an attempt to do traffic research, which is why it had to be delegated to the Regional Planning Council” (Københavns Borgerrepræsentation 1969, p. 254; Own translation)

In order to counter the critique of the computerized forecast, and hence the basis of the decision, he argued as follows:

“... about this forecast, on which the future traffic-numbers are based, I must inform you that it has been prepared by experts in the Department of the City Engineer. [...] The traffic forecast, which the Regional Planning Council is now starting on the basis of this respective traffic analyses, can only be finished in a couple of years and will then be particularly designed to facilitate a choice between different regional land-use alternatives. We can expect that the present Copenhagen forecast will, for some time, be the forecast we have to work with in respect to the Copenhagen road network, but it should also be a very carefully prepared forecast” (Københavns Borgerrepræsentation 1969, 268-9; p. Own translation).

Weidekamp hence tried to reify the computerized forecast by arguing that the forecast was prepared by experts and was particularly well-researched. Moreover, it was framed as constituting the most valid basis of the decision available in the near future. With reference to the computerized forecast, Weidekamp also attempted to reify the proposed design of the Lake-ring, arguing that the model results had only given occasion to minor design changes. In this truth-seeking strategy, the fact that only an all-or-nothing assignment had been conducted at the Committee stage constituted an exposed flank. Weidekamp tried to protect this flank, arguing that from the road stretches for which the 4th iteration had been reached, it could be deduced how the traffic load would distribute in the following steps. According to Weidekamp, the calculations carried out subsequently confirmed these assumptions. Nevertheless, this attempt to cover the flank was not enough to repel an attack. Oløe directly used the all-or-nothing assignment to de-reify the claim that through traffic would not constitute a problem. He states:

"Another issue is that the forecasting technique used means that one cannot measure how much of the traffic will be through traffic, as through traffic is only measured in the starting position, the so-called 0th iteration. It will be speculation and not science" (Københavns Borgerrepræsentation 1969, p. 293; Own translation)

With this, Oløe tried to de-reify the model results, arguing that it was invalid to conclude on the basis of an all-and-nothing assignment that through traffic would not become a major problem in the Lake-ring section. Oløe also tried to de-reify the reliability of the forecast's data by stating that:

"We also lack traffic forecasts, inasmuch as those we have are based on outdated and uncertain data, as the Municipal Corporation has explained to us...." (Københavns Borgerrepræsentation 1969, p. 303; Own translation)

In accordance with the findings of Porter (1995), as well as Sager & Rvalum (2005) (see section 4.2.6), the minority hence attempted to de-reify the basis of the model results by pointing out shortcomings in the analytic techniques, and attempted to legitimize their non-use by requisitioning more valid decision support. Opposed to Weidekamp's argument concerning that the Department of the City Engineer's forecast would be the most advanced forecast available for some time, the minority wanted to postpone the decision on the Lake-ring until the results of the Regional Planning Council's new forecast were available. The Minority had also written a letter which they threatened to post to the Minister of Traffic if the Lake-ring was approved. The letter stated that the decision was made on an inadequate factual basis and it ought to be postponed until the results of the Regional Planning Council's forecast were available. There was no reason to bring about a speedier decision, as construction of the Lake-ring could not be initiated before the new results were available, (Københavns Borgerrepræsentation 1969, p. 289).

That only a single alternative had been prepared, namely the proposal of the Department of the City Engineer, also constituted an exposed flank. The lack of alternatives had been problematized in the minority reports, the public debate and even by the Minister of

Traffic. Weidekamp also attempted to protect this exposed flank by arguing that other alternatives had been discussed by the Committee in consultation with the Municipal Corporation (Københavns Borgerrepræsentation 1969, p. 273). Moreover, following after the Committee stage, in which Nyvig's proposed double Lake-ring (see section 10.6) had been evaluated in the model and at the City Council meeting, Weidekamp presented these results. They showed that Nyvig's proposal would attract an amount of traffic nearly equal to that in the Department of the Engineer's proposal. It was, however, more expansive, requiring capacity enlargements on both sides of the lakes. This alternative was therefore framed as unacceptable. Weidekamp also attempted to render arbitrary the proposal of the City Plan West Office. Although this proposal had not been evaluated by the model, he argued, on the basis of the evaluation of the Department of the Engineer's proposal, that the amount of traffic which the proposed thoroughfare would attract in the peak-hour corresponded to two lanes in each direction. Only one lane was needed during the rest of the day. On that ground, this alternative was also framed as unacceptable. It was both oversized in respect to capacity and more expensive than the Department of the Engineer's proposal (Københavns Borgerrepræsentation 1969, p. 235-7). According to Weidekamp, it was hence not true that other alternatives had not been assessed. In fact, the results of the computerized forecast reified that the Department of the City Engineer's proposal was the most optimal. However, Weidekamp's attempt to protect the flank was not sufficient for repelling an attack. According to Boas Jensen, the other alternatives had been rejected on the basis of inadequacy. He states:

"About the Municipal Corporation's motorway plans and the many other proposals which have now been suggested, I can say: it is not true, as it has been argued, that they have been sufficiently examined. If I may be allowed to be demagogic, I would say that if they were so, it would be nonsense to grant money to the Mayor of Urban Planning's forecasting-program. The many proposals promoted have, we must acknowledge, from time to time been mentioned here in the Council and in the Urban Planning Committee, and there have been discussions about the advantages and disadvantages. But they have never been systematically assessed or calculated, and in any case, the City Council has been presented with neither assessments nor calculations of them." (Københavns Borgerrepræsentation 1969, p. 288; Own translation)

Boas Jensen hence accepted that other alternatives had been discussed, but because they had not been systematically evaluated by the model, he did not accept the basis upon which they had been rejected. Hence, Boas Jensen also used a strategy where he pointed out shortcomings in the available basis of the decision and asked for additional support to overcome these shortcomings. Also, Oløe attempted to render the model calculations arbitrary on this basis. He states:

"It is the most beautiful circulus vitiosus one can imagine; it proves nothing about the Lake-ring, but rather a certain skill in mathematics." (Københavns Borgerrepræsentation 1969, p. 294; Own translation)

Because any alternative not presuming construction of the Lake-ring had been evaluated by the model, the forecast results did not show anything about the demand for the Lake-ring. The

forecast only showed that if it was constructed, people would use it. As mentioned above, Oløe had suggested an alternative where only the Goods-ring and the radial roads beyond this ring were established as urban expressways. Because the Municipal Corporation had accepted the minority's critique and had promised to make an evaluation of this alternative, Oløe argued that it would be natural to postpone the decision until these results were available (Københavns Borgerrepræsentation 1969, p. 350). However, the majority did not accept this suggestion. In the next section, we will return to this second round of transport model-based knowledge production generated by the minority's non-acceptance.

Throughout this embedded case study, it has been argued that the emergence and development of the computerized transport model were shaped by the spatial policy controversy surrounding the future spatial order of the Greater Copenhagen Area. In the following, it will be argued that practices of acceptance and non-acceptance of the model calculations among the political audience also were tied to this spatial policy controversy. In fact, the proponents' acceptance of the Lake-ring and their use of the model results to legitimize their acceptance were tied to a defence and reinforcement of the spatial capital attached to Copenhagen's structural position within the mono-centric spatial order, while the opponents' non-acceptance of the model results was tied to an attempt to undermine the mono-centric spatial order and thereby limit the spatial capital of Copenhagen. Both Weidekamp (Københavns Borgerrepræsentation 1969, p.267-68) and Flemming Grut from the Conservative Party (Københavns Borgerrepræsentation 1969, p. 275-283) emphasized in their respective speeches that the Lake-ring was an essential element in the Copenhagen plans to expand the Central Business District and thereby reinforce the mono-centric spatial order. On the other hand, according to Boas Jensen, the large concentrations of dwellings and particular workplaces within the municipal borders of Copenhagen were the cause of traffic problems. To him, the solution to the traffic problems was not capacity enlargements, but rather to "thin out" the inner city through slum clearance (Københavns Borgerrepræsentation 1969, p. 286). He states:

"Urban planning and transport planning are interrelated. It is imprudent to build roads where there will be no city development, and vice versa. And it is stupid not to thin out the city where road infrastructure capacity is limited". (Københavns Borgerrepræsentation 1969, p. 284; Own translation)

Flemming Grut was conscious of the fact that the strong opposition and great commotion that the Lake-ring had caused within planning circles was not only directed against the Lake-ring, but more generally against the Copenhagen plans to expand the mono-centric spatial order. He states:

"... but the Lake-ring is also, of course, in a manner, the crank in the machinery which shall keep city functions running. So, it is, perhaps, not surprising that divergences with regard to the planning perspectives, which completely unduly have harassed us, and which have long been a fact despite just now having been released in the crash which had to come sooner or later. [...] it is, in fact, chock-full of politics: professional politics and party politics, and precisely in that order" (Københavns Borgerrepræsentation 1969, p. 277; Own translation)

According to Grut, the battle of the Lake-ring was hence a battle between two different planning perspectives, namely the mono-centric vs. the poly-centric city, and he believed that the planners opposed to the mono-centric city held their opinions not on professional, but on political ground. As he states:

“What has triggered the campaign [against the Lake-ring] and cast a glow of objectivity over it, is an attack by some Planning groups, not only now, but after several attempts, and not on the basis of planning perspectives, but from purely ideological motives, which have launched their attack against the whole Copenhagen planning and against the objective that it is working according to [expansion of the mono-centric spatial order]. And now I come to the political. Why have they done it? Because the guidelines for city development which we have defined, and which are the crux of our planning, are simply abominable to them. They do not want that the centre of Copenhagen shall remain the absolute centre of gravity for administration, cultural life, business, and finance. They do not want that Copenhagen shall provide the setting for something that, with undeniable right, can be called primary functions. They shudder at the thought of one having to consolidate here the things that belong to a societal image, which in their eyes is hopelessly bound in tradition and authoritarianism. One is, of course, allowed to have this opinion as planner, but it has nothing to do with planning; it is politics.” (Københavns Borgerrepræsentation 1969, p. 281-282; Own translation)

According to Grut, the opponents' critique of the Lake-ring was an attack on the mono-centric spatial order from the political left-wing, cloaked in professional objectivity. Boas Jensen agreed with Grut in his observation that the debate on the Lake-ring was situated within a struggle over spatial order. He states:

“I think he [Flemming Grut] is right to a certain extent. What we are discussing tonight is not only the Lake-ring. The Lake-ring is a detail. What it is really about is two opposing views – or perhaps more views - of the city, how it shall function, how people should move in it. I also believe Mr Grut is right in saying that the perception we each represent, only to a very small extent, is based on knowledge, and to a large extent based on ideologies or prejudices. [...] I would just like to argue, whether we could go a bit further or whether Mr Grut might also agree with me, that we need debates and we need investigations which could extend our knowledge and may be able to remove some of our respective prejudices.” (Københavns Borgerrepræsentation 1969, p. 352f; Own translation)

In spite of the minority's attempt to de-reify the results of the computerized forecast as well as the request for additional decision-support, the proposal to refer the case back to committee was not accepted by the majority. It was not even accepted to postpone the decision until the Municipal Corporation had evaluated Børge Oløe's Alternative. Instead, the Lake-ring was passed by 34 to 17. The addendum report, which requested that the Municipal Corporation assess the project's noise impacts, was carried unanimously. The minority's proposal that the Municipal Corporation enclose assessments of noise impacts for every larger road project was

rejected by 34 to 17. However, even though noise was not institutionalized in this particular case, noise assessments did become so the 1970s. According to Overgaard, inclusion of noise was, in fact, facilitated by a response to non-acceptance among project opponents, who attempted to render the results arbitrary because this effect was not included (Interview 2012).

After the Lake-ring was accepted by the majority in the City Council, the Municipal Corporation approached the Ministry of Traffic in July of 1968, requesting that a construction law for the Lake-ring be prepared (Vejdirektoratet 1970a). Whether the Lake-ring and the model calculations underpinning its design were also accepted by the State will be explored in section 12.4.1. Next, we turn to the model calculations of the alternative advanced by City Councillor Børge Oløe, which the Municipal Corporation had accepted for evaluation as a reaction to the minority's non-acceptance of the fact that any alternative not presuming the Lake-ring had been evaluated.

12.3 The computerized forecast and de-reification of the Lake-ring

Even though the majority had approved the Lake-ring instead of postponing the decision until the results of the forecast which the Municipal Corporation had promised to prepare for the alternative proposed by City Councillor Børge Oløe, the alternative was actually evaluated following the meeting. Hence, distinct from the decision on the harbour crossings (see section 11.4), the minority's non-acceptance of the transport model-based knowledge production did, in this incidence, generate a second round of knowledge production. In this section, the transport model-based knowledge produced in this round will be explored.

Among the archive material from the Department of the City Engineer, a memorandum was found, titled "*Draft memo on traffic forecast for three different road networks*"¹⁹⁸ and dated December 13, 1968. The first of the networks evaluated was the Department of the City Engineer's 1980 proposal, containing full enlargement of the primary road network, both with the Lake-ring and the Goods-ring, as well as the radial roads as urban expressways (alternative 1). The second alternative resembles the alternative advanced by the City Councillor Børge Oløe, with the Goods-ring and the radial roads beyond constructed as urban expressways, but all urban expressways within the Goods-ring were omitted, including the prolongation of the Lake-ring to Amager (alternative 2). However, different from Oløe's proposal the southern insertion of the West motorway, was established as a urban expressway. The third alternative constituted a counterproposal to alternative 2, with urban expressways in the Lake-ring and the inner primary system, but without enlargements in the Goods-ring and the radial roads beyond (see figure 12.5).

The calculations of the three networks were carried all the way through to the 10th iteration step. On the basis of the assignment model, vehicle kilometres travelled and vehicle hours were calculated for the respective road networks. According to the results, the Department of the City Engineer's alternative preformed best in both respects. In regard to vehicle kilometres travelled, Alternative 3 performed better than Alternative 2, but in respect to vehicle hours, Alternative 2

¹⁹⁸ Udkast til notat vedrørende trafikprognose for tre forskellige vejnet, 13.12.68.

was better than alternative 3 (see table 12.1). In respect to construction costs, there was not prepared any detailed estimates for the three road network, only rough ones.

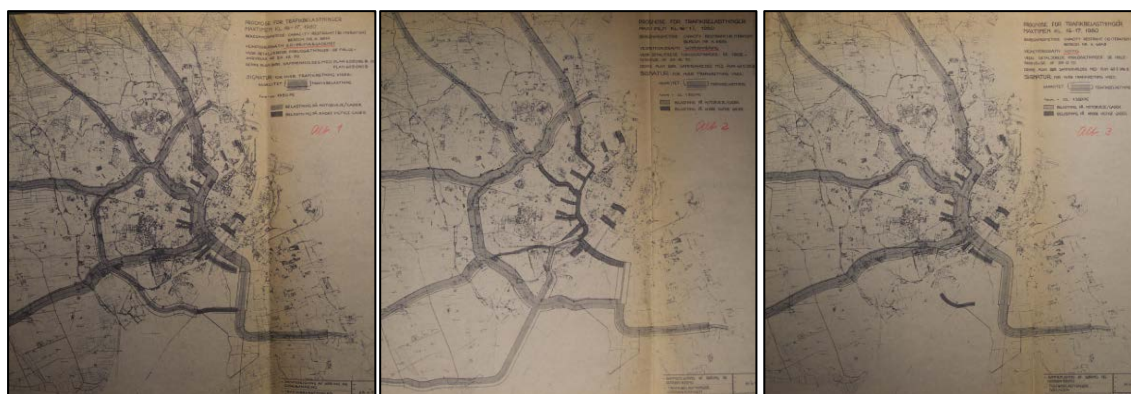


Figure 12.5: Calculated traffic load for the three alternative road networks. On the left: Alternative 1. In the middle: Alternative 2. On the right: Alternative 3.¹⁹⁹

As Alternative 1 was the most expensive (see table 12.1), it was as expected that this alternative proved superior both in regard to vehicle hours and kilometres travelled. It was, however, a bit surprising that Alternative 2, which was the cheapest, performed better than Alternative 3 in regard to vehicle hours.

Table 12.1: Calculated vehicle hours and vehicle kilometres travelled in the peak hour as well as roughly estimated construction cost for the three road networks

Road Network	Vehicle hours	Vehicle kilometres travelled	Estimated construction cost
Alternative 1	39,314 (1000)	2,044,693 (1000)	22,000 million DKK
Alternative 2	41,230 (1049)	2,067,349 (1011)	15,000 million DKK
Alternative 3	41,933 (1067)	2,057,233 (1006)	17,000 million DKK

In order to make an overall rating of the three road networks, a cost-benefit analysis was conducted. The calculated vehicle hours and kilometres travelled in the peak-hour were converted to annual traffic costs, and one vehicle hour in the peak-hour was put equal to 10 DKK, while one vehicle kilometre was 0.2 DKK. The yearly writing off and payment of interest for the construction costs was put equal to 10%. The results of the cost-benefit analysis appear in table 12.2.

Table 12.2: Calculated annual costs for the three road networks²⁰⁰

	Alternative 1	Alternative 2	Alternative 3
Total annual costs	1020 million DKK	975 million DKK	1000 million DKK

In the cost-benefit analysis, it was Alternative 2 which performed the best and Alternative 1 the poorest. In the conclusion of the memorandum, it was stated that the findings showing that Alternative 1 was the best traffic-wise were obvious; as it both was the largest and the most

¹⁹⁹ Udkast til notat vedrørende trafikprognose for tre forskellige vejnet GPD, A.S./H.P., 13.12.68. (Plandirektoratets arkiv, Trafik teori og metode, u.år- , Turanalyse af gl. Program – turfrekvensprogrammer, Box 1)

²⁰⁰ Udkast til notat vedrørende trafikprognose for tre forskellige vejnet GPD, A.S./H.P., 13.12.68. p. 7 (Plandirektoratets arkiv, Trafik teori og metode, u.år- , Turanalyse af gl. Program – turfrekvensprogrammer, Box 1)

expensive, these results were not significant. It was, however, of significance that neither Alternative 2 nor Alternative 3 were entirely unacceptable. In fact, in the conclusion of the memorandum, it is stated that:

“The most interesting result is that the smallest and cheapest road network, Alternative 2, in several respects, appeared to be Alternative 3’s superior. Even though Alternative 2, in the design assumed here, do not show completely satisfactory conditions for the handling of the calculated traffic, it cannot be rejected, and with some changes and local improvements, it can be made acceptable. In any case, if it is decided to adopt Alternative 1, it would hardly be practical to establish both the Lake-ring and the Outer-ring simultaneously. One of these facilities must therefore be constructed first, and it can, in any case, be said that with this assessment, justified doubt on the appropriateness of establishing the Lake-ring first has been raised. A more secure position on the project’s priority will, however, require new studies with other traffic loads than those calculated for 1980.” (Own translation)²⁰¹

While the computerized forecast served to reify the majority’s approval of the Lake-ring in the City Council, the new model calculations did, in fact, render the decision arbitrary. Instead, it was now the proposal of the minority which could call upon the model results and proclaim reification of its superiority. These new model calculations were hence very likely to increase non-acceptance and strengthen the opposition in the City Council, the State and general public. The results of this draft memorandum were hence extremely politically inconvenient for the dominating political powers within the City Council.

All of the contextual perspectives on the cause of inaccuracy and bias in travel forecasting, with the exception of selection bias, do in one way or another, demonstrate how transport modelling takes part in advancing the interest (either deliberately in the form of strategic misrepresentation, or tacitly in the form of optimism bias) and interpretation horizon (organizational perspectives) dominating within the its social operation environment (see Chapter 3). However, the results of the draft memo show that traffic models are, in fact, also used to produce knowledge claims which counter such dominating interests, interpretation horizons and optimistic views. In that sense, it can be argued that transport models not only speak truth for power, but also speak truth to power²⁰². Nevertheless, it does not appear that these critical knowledge claims were published. If the results had been released, it would have seized the headlines in the press. I have not, however, come across any mentioning whatsoever of the results around this period of time. In fact, it appears that in accordance with the two secret reports mentioned above, the traffic forecasts for the three different road networks were withheld. As the Member of the Danish Parliament, Per Dich, from the Socialist People's Party, stated in an approach to the Minister of Traffic in February of 1972:

²⁰¹ Udkast til notat vedrørende trafikprognose for tre forskellige vejnet GPD, A.S./H.P., 13.12.68. (Plandirektoratets arkiv, Trafik teori og metode, u.år- , Turanalyse af gl. Program – turfrekvensprogrammer, Box 1)

²⁰² This does not imply that transport models actually produce truth, only that they produce knowledge which can easily be reified due to their scientific nature

“From the press, it recently appeared that ... the Municipality of Copenhagen in the late 1960s ... has drawn up an analysis and plan, which not only seems to show that the Lyngbyvej’s insertion and the Lake-ring are adverse solutions, but in reality they are completely superfluous. This document has, for unknown reasons, not been published by the Municipality of Copenhagen; in fact, it has not even been submitted to the Copenhagen City Council.” (Folketingstidende 1972, column 2958; Own translation)

I have not managed to search press material from that specific period of time, but the above statement strongly indicates that it is the model results reported in the above draft memo to which the author refers. So despite truth being spoken to power, power was in a position to suppress and detain truth, but only for a while. Seemingly, the findings from the draft memo were eventually leaked to the press like the two other withheld reports. Hence, as before, power was not strong enough to keep the critical transport model-based knowledge production covert.

12.4 Did the State accept?

Even though the Lake-ring and its prolongation to Amager had gained acceptance among the majority of the City Council members, this was not enough for the projects to be approved and implemented. It was the State which had to finance the projects and which therefore had the final say in the matters. Moreover, even though the transport model was used to make a truth claim arguing that 10.000 dwellings could be developed for free on West-Amager, the State also had to accept the land-use plan which Copenhagen was about to provide. This section explores whether these projects, reified by the computer model, gained acceptance from the State and the Regional Planning Council. Acceptance of the Lake-ring by the State will be investigated first, followed by the issue of an Amager development.

12.4.1 The Lake-ring and its alternatives

Before the Lake-ring was approved in the City Council, the Minister had declared that he would personally make the Road Directorate draw up alternatives if Copenhagen did not (see section 12.2). After Lake-ring was approved by the City Council, he carried out his threat and refrained from introducing a law on the Lake-ring in the form drawn up by Copenhagen for the National Parliament, demanding the existence of an alternative. In the autumn of 1968, after the Road Directorate had screened various alternatives, one was selected in December, around the same time as the memorandum showing the superiority of the Goods-ring over the Lake-ring. The Goods-ring was not, however, the selected alternative; this was the so-called Forum-line, a semi-circular road more recessed than the Lake-ring and running through the inner districts (see section 10.6.1) (Vejdirektoratet 1970). The idea was to combine its establishment with complete clearance of the inner-city districts through which it ran (see figure 12.6).

Because results from the Regional Planning Council's on-going forecasting work had not yet been finalized, the Forum-line was, in terms of traffic, evaluated on the basis of the Department of the City Engineer's computerized traffic forecast for the base alternative of 1980. In addition to the main alternative and the Lake-ring, a secondary alternative, where the Forum-line was designed as an urban expressway, was also included in the evaluation (see figure 12.6).

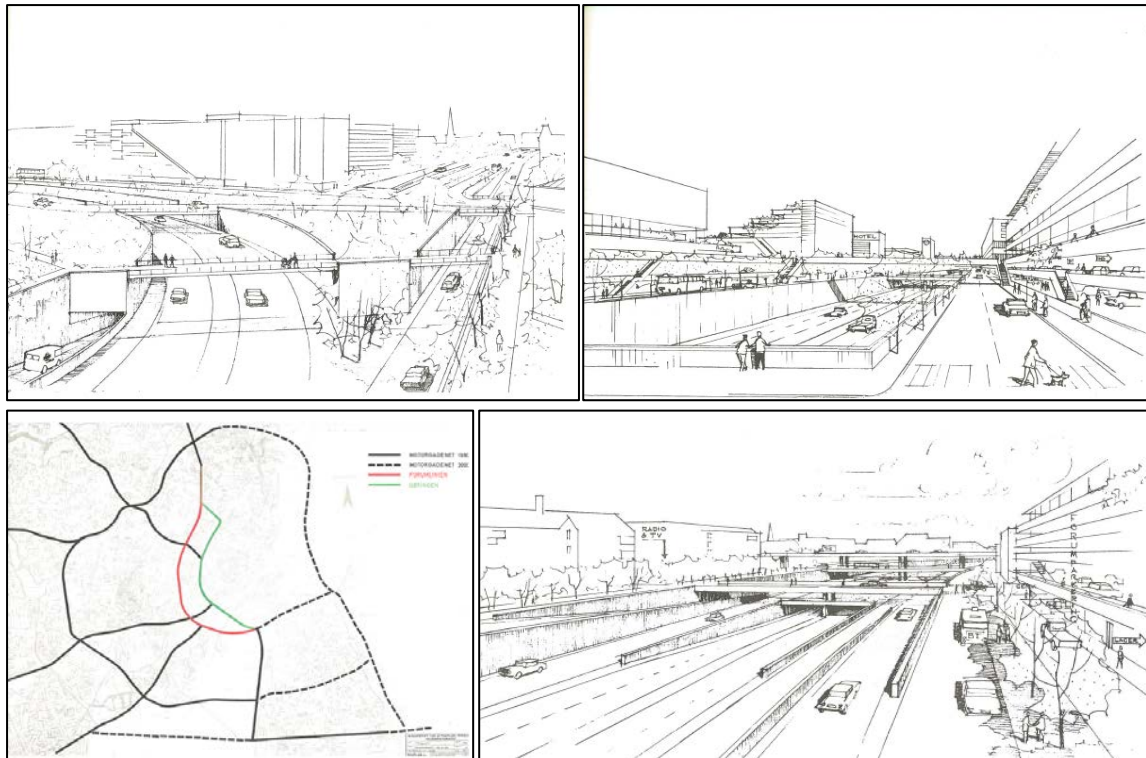


Figure 12.6: The left bottom: Sketch of the Forum-line (red) and the Lake-ring (green). The other sketches depict the designs of the forum line on different stretches (Vejdirektoratet 1970).

Non-acceptance by the Minister of Traffic hence resulted in the traffic model being reopened and used to evaluate new alternatives once again. Due to time pressure, the modal split was not calculated but estimated on the basis of subjective judgment. In the traffic assignment, capacity constraint was not included. Also, because the Forum-line likely could not be established before 1980, there had also been prepared a rather crude traffic forecast for 2000. This forecast was based on the assumed regional distribution of residences and jobs in 2000. Apart from this, the forecast for 2000 was almost a projection of the 1980 forecast's assumed growth in car ownership. The result showed that in both of the Forum-line alternatives, parts of the inner-city network would overload, but this occurrence was worse in the secondary alternative (see figure 12.7). However, in the Lake-ring alternative, overload would occur in the inner-districts. Hence, all of the alternatives were somehow substandard.

While the Lake-ring project seems absurd from a contemporary perspective, the same is definitely also the case for the Forum-line, which required massive clearance. In fact, the Forum-line was also perceived as economically unfeasible at the time by the City Council's Urban Planning Committee, which abandoned it during the committee stage (see section 12.2.1). The Minister of Traffic was of a similar opinion. Before the report on the Forum-line was published, he stated in the National Parliament that:

"I have the feeling that when this material is put on the table, it will show that if you approve the road, then the Municipality of Copenhagen and the State ... are faced with some tasks of a very considerable extent in terms of clearance, and one can therefore have doubts about whether such a solution can be implemented."
(Folketingstidende 1970, collum 1496)

The Road Directorate put the material on the table in 1970 (Vejdirektoratet 1970). As foreseen by the Minister of Traffic, the dramatic interventions in the existing built-up area, which the proposal required, lead to it being found politically unacceptable, so a construction law was never introduced (Gaardmand 1993; Jørgensen 2001).

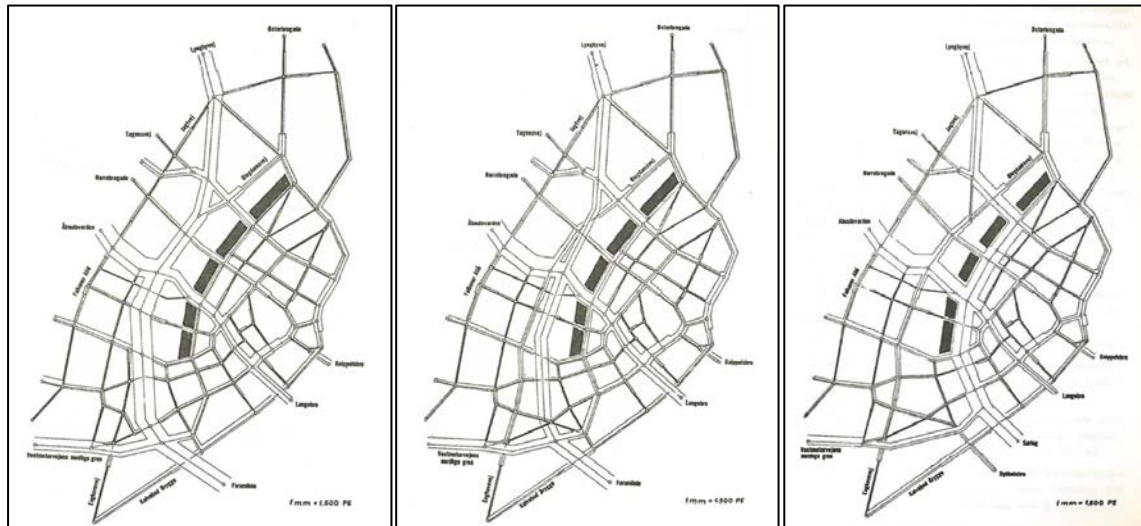


Figure 12.7: Calculated traffic load for the three investigated alternatives. On the left: the Forum-line, main alternative. In the middle: the Forum-line, secondary alternative. On the right: the Lake-ring (Vejdirektoratet 1970).

After the Forum-line was abandoned, a planning law for the Goods-ring was introduced in the Parliament during December of 1970. This law was passed in June of 1971. On that basis, the Road Directorate initiated investigations of several alternative layouts (see figure 12.8). This evaluation symbolized that the application of Copenhagen’s computerized traffic model was about to end.

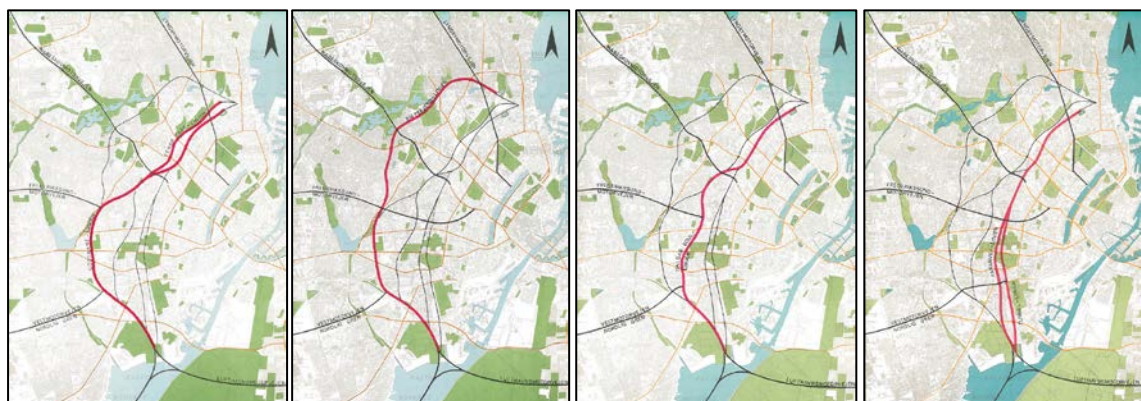


Figure 12.8: Goods-ring alternatives investigated by the Road Directorate (Vejdirektoratet 1972)

In the traffic evaluation of the Goods-ring, the transport model developed within the field of responsibility of the Regional Planning Council, with the assistance of FFWS, was applied instead of the Department of the City Engineer’s model (Vejdirektoratet 1972). The first results of the new regional forecast were issued in 1970. The forecast was for 1975 and showed an even higher increase in car traffic than had the forecast of the Department of the City Engineer. Car traffic was predicted to increase by 60% in the period from 1967-75, meaning that the capacity of the six lane West motorway, which opened between Hvidovre and Brøndbyerne in 1968, had to be doubled in 1975 (Egnsplanrådet 1970). A forecast for 1985 had not yet been finalized, but

because this was perceived as vital for dimensioning the capacity of the Goods-ring, it was decided to prepare one on the basis of a projection of the 1975 forecast. When the forecast for 1985 was prepared, the car ownership rate assumed in the original forecast was assessed as being too high. A private consultancy firm was therefore hired to make a revision, which formed the basis of the 1985 projection (Vejdirektoratet 1972). However, this was not the only revision of the Regional Planning Council's model conducted around this time. We will return to this in section 12.5.3.

The Road Directorate issued its evaluation of the Goods-ring alternatives in 1972 (Vejdirektoratet 1972), but this did not gain acceptance in the National Parliament and a construction law was never proposed (Elle 2004). From around 1970, indications started to show that the roaring 1960s and their constantly increasing prosperity was about to turn. A nail in the coffin of the Lake-ring was brought about in 1971, when the Minister of Traffic carried through a change in the Road-law reorganizing the Danish highway authorities. The authority of the public roads was split into arterial roads overseen by the State, country roads administered by the counties and municipal roads administered by the municipalities. According to the law, each of these authorities should now, on their own, bear the financial burden for construction, maintenance and operation of the roads under their respective administrations (Trafikministeriet 2000, p 35). At the same time, the automatic road reimbursement scheme was abolished in April of 1972 (Trafikministeriet 2000, 124). The new Road-bill also implied that the Road Directorate no longer should take part in the planning of urban expressways, and due to the high construction costs,²⁰³ the new Minister of Traffic, Jens Kampmann, officially renounced his support for the Lake-ring project in December of 1972 (Jørgensen 2001; Trafikministeriet 2000, 125). The political authority and liability for implementing the Lake-ring was now turned over to the Municipality of Copenhagen once again.

At first, this did not imply that Copenhagen decided to abandon implementing the Lake-ring on its own.²⁰⁴ The project was, however, still met with stubborn resistance from the general public, and this was one of the reasons why the Social Democrats suffered a crushing defeat in the municipal election of 1974. That same year, the final deathblow was dealt to the Lake-ring. Both the Major of Urban Planning, Wassard, and Egon Weidekamp,²⁰⁵ declared that the project had been given up. This was perhaps more due to Copenhagen's financial problems rather than the general public's non-acceptance. The initiating economic recession, intensified by the first oil crisis in 1973, further deteriorated Copenhagen's economy, and the Municipality was therefore incapable of bearing the large investment alone (Lyager 1996; Jørgensen 2001; Rothenborg 2002). The cancelling of the Lake-ring meant that the prolongation of the Lake-ring to Amager and the Dybbølsbro crossing were also given up. The basis of the City Plan West project thereby also eroded, and the Municipality decided to abandon it too (Lyager 1996). Hence, although the Lake-ring alternative which the Copenhagen City Council approved was misrepresented in the sense that the alternative suggested by City Councillor Oløe was withheld, this did not imply that the project was ultimately accepted politically and implemented.

²⁰³ The insertion of the Lyngbyvej and construction of the Lake-ring would add up to more than a billion DKK, excluding the stretches running in the tunnel from the Skt. Jørgens Lake, beneath the district of inner Vesterbro, and its prolongation to Amager (Trafikministeriet 2000, 125).

²⁰⁴ Demolition was, in fact, initiated in order to make way for the Lyngbyvej's insertion into the Lake-ring

²⁰⁵ Egon Weidekamp soon after replaced Urban Hansen as the Lord Major of Copenhagen.

12.4.2 The state's non-acceptance of an Amager development

This section explores whether Copenhagen's plans for developing on Amager, were accepted by the Regional Planning Council and the State respectively.

Even though that the State had accepted development on Amager as part of the co-ownership agreement, the State was disenchanted with the large scale development plans, which the 1st prize winning project contained (Krogh 1967e). The appearance of the Regional Planning Secretariat banned report also generated a critical political response, from the Governmental parties. The Social Democratic Minister of Traffic, Svend Horn, stated that:

"It should never have happened that Copenhagen Municipality launched this plan [development on West-Amager], but now it might be too late to stop it. I do not think Ministry of Traffic can do it. We are forced to try to establish traffic facilities for the many thousands of people who Urban Hansen will place on Amager."
(Quoted in Nilson 1967b; Own translation)

Hence, Copenhagen's plans for developing Amager, was only accepted reluctantly by the Minister of Traffic. He feared that an Amager development would take up large parts of the funds available for infrastructure investments within the Greater Copenhagen Area and thereby makes it necessary to postpone the investments, planned for the following period, particular in the Western sector.

However, in spite of the State's scepticism, the City Council decided in 1968, that "Amager and the Master Plan" (see Chapter 11) should underlie the drawing up of the development plan for West-Amager, as the co-ownership agreement had instructed Copenhagen to prepare and which the State and now also the Regional Planning Council had to accept before construction could begin. In 1970 Copenhagen issued a proposal to the development plan for West-Amager and a revised version in 1973. Both contained 25,000 dwellings on the Copenhagen part of West-Amager (Direktoratet for Københavns Kommunes Generalplanlægning 1970; 1973). Because Copenhagen constituted a minority in the Regional Planning Council it was unable to force through the large scale development as assumed in the 1st prize winning project. Nevertheless, the Regional Planning Council accepted the 25.000 dwellings on West-Amager. In fact, this was assumed in all of the four alternatives to the new regional plan. The Regional Planning Council's acceptance was however not self-imposed, but the 25,000 dwellings was a condition which Copenhagen had set up for accepting the Regional Plan (Illeris 2010; Rasmussen 1994). The development on West-Amager was however conditioned on the Air Port's relocation to the island of Saltholm. This hurdle was overcome in 1973, where the National Parliament approved the relocation by law. However, the outbreak of the first oil crisis changed the conditions of the law and it was later abolished again. Even though that the Regional Planning Council had accepted 25.000 dwelling and that Minister of Traffic had declared that the Ministry of Traffic could not put a stop to Copenhagen's Amager plans, the National Parliament's Committee on Spatial Planning did in fact do so in 1975, where it prohibited development of more than 400 dwellings on West-Amager (Gaardmand 1993; Illeris 2010; Rasmussen 1994; Thomassen 1980). Hence, the truth claim advanced on basis of the model about 10,000 free dwellings on Amager

did neither gain acceptance from the State. In accordance with the Lake-ring, this shows that even though the results seemingly was misrepresented this did not equal project approval.

12.5 Epilogue

This section constitutes the ending of the second embedded case. First, we will discuss some of the model input variables which contributed to generating the inaccurate forecast. Next, an answer to the question of what caused the inaccurate forecast will be given. Lastly, it will be discussed how the pioneering work on developing the first computerized forecast came to shape Danish transport planning practice.

12.5.1 Inaccurate inputs

This sub-section discusses the accuracy of some of the model's input variables. Although the road infrastructure network and land use on Amager were not implemented as assumed in the model (see section 12.4), another reason why the forecast never came to pass as expected was due to a severe and unforeseen decline of the mono-centric spatial order. In the computerized forecast, employment within the municipality of Copenhagen was assumed to stagnate. Distinct from forecasts prepared in the late 1950s and early 1960s, which assumed a 25%-50% employment increase within the inner city, it was hence presupposed in the computerized forecast that the mono-centric order would lose ground, even if only relatively. This assumption, however, turned out to be overestimated. The actual number of workplaces within the Municipality of Copenhagen did actually decline, particularly in the inner city. In 1945, there were 170.000 jobs in the central part of Copenhagen.²⁰⁶ This constituted one third of all jobs within the entire Greater Copenhagen area and one half of all jobs within the municipal border. However, from 1950 to 1975, the number of industrial firms within the municipality declined by two thirds. Half of this decline took place in the central districts. Since then, the number of workplaces has continued to decline, mostly in the inner city (Jensen, 2004).²⁰⁷ The forecasting group was not aware of these decentralization trends. As Arne Stærmose puts it:

"I had some diagrams with curves of both the counted and the predicted traffic. At one point, the two curves started to diverge. And why did they diverge? Our forecasts did not hold; traffic did not increase as anticipated. We found out that it was simply because the number of jobs in Copenhagen declined; despite the fact that the amount of business floorage actually increased, the number of square meters per employee increased dramatically. ... Therefore, the traffic did not continue to increase. We did not discover this until after we had made the forecasts." (Interview Stærmose 2012; Own translation)

It was hence unknown to the forecasting group that in spite of that business floorage in the municipality increasing by 1% a year from 1955-1973, the increased production machinery per employee combined with more stringent working environment regulations generated a 2% yearly increase in space requirement per employee during the same period (Jensen 2004). Neither was the forecasted population for the Municipality of Copenhagen fulfilled. From 1950

²⁰⁶ The area between the harbour and the lakes.

²⁰⁷ Since 1954, the number of jobs in the inner city has declined by almost 50% (Jensen, 2004).

to the early 1990s, the number of inhabitants declined by almost 300.000, and it was not until the mid-1990s that this trend started to reverse again (Nielsen 2006; Sander et al 2006). The decline of the mono-centric spatial order put an unforeseen damper on the traffic originating and departing within the inner city.

Additionally, the forecast for the overall population of the study area turned out to be overestimated. In the forecast, the population of Copenhagen and the three metropolitan Counties was estimated to be at almost 2 million in 1980 and 2,4 million in 2000. In 1980, however, the actual number was only 1.7 million (Indenrigsministeriet 1995) and in 2000 the number had only increased to 1.8 million (Økonomi & Indenrigsministeriet 2013). One of the reasons the forecast did not come to pass was due to a general decline in the fertility rate, generated by the extended schooling in the 1950s and women's entrance to the labour market in the 1960s. The result of this was many women choosing to postpone having children. Furthermore, the release of the contraceptive pill in 1967 and introduction of free abortion in 1973 made it easier to plan pregnancies (Sander et al 2006, 86).

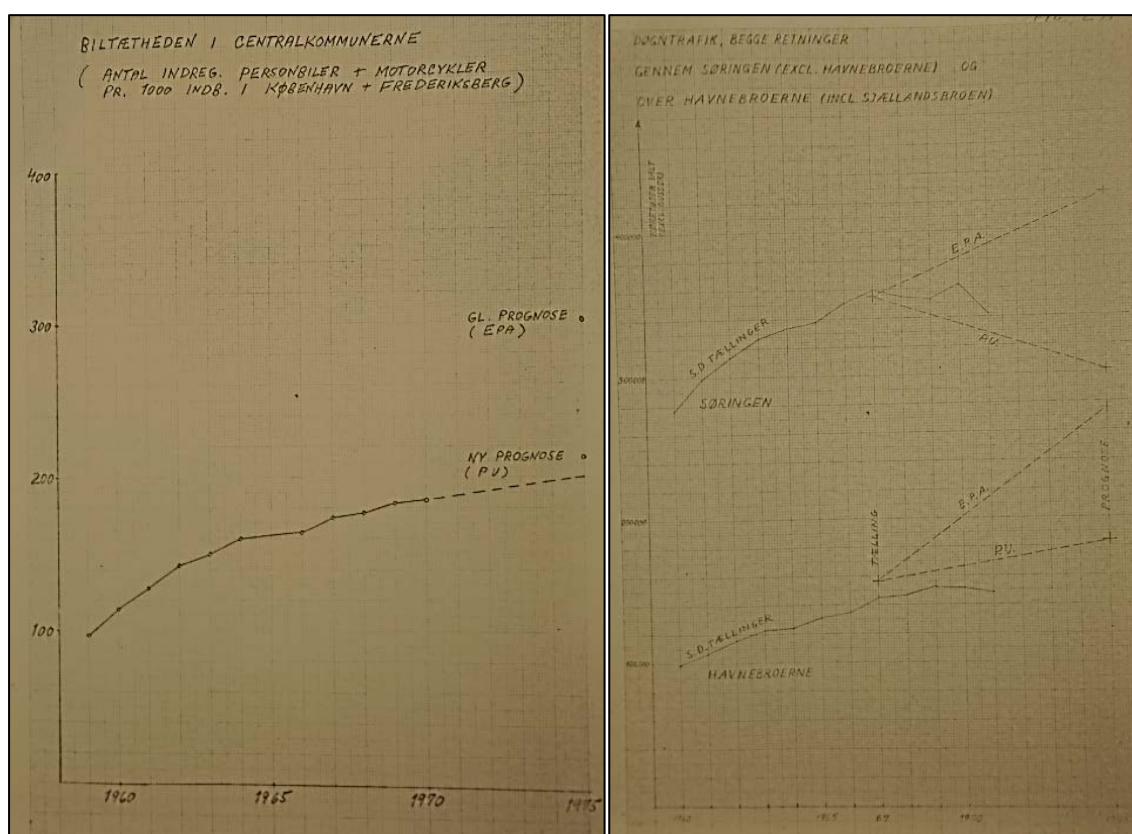


Figure 12.9: On the left: Graph of the development in car ownership within the central municipalities of Copenhagen and Frederiksberg. The dotted line is the new forecast proposed by Ottesen. The dot above shows the Regional Planning Office's original forecast.²⁰⁸ On the Right: Graph of the development in traffic crossing the screenlines of the Lake-ring (the above graph) and the harbour crossings (the below graph). In both graphs, the new forecast is depicted through the area below the dotted lines. In the Lake-ring, traffic is predicted to decline, while it only increases slightly in the harbour crossing section.²⁰⁹

²⁰⁸ Foreløbigt notat om ny trafikprognose for hovedstadsregionen 1975, GPD, K.A.O./E.A, 07.08.72 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)

²⁰⁹ Foreløbigt notat om ny trafikprognose for hovedstadsregionen 1975, GPD, K.A.O./E.A, 07.08.72 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)

However, it was not only in Copenhagen's transport model that the decline of the mono-centric spatial order was not predicted accurately. In the Regional Planning Council's original forecast for 1975, it was assumed that the population within the central municipalities would increase by 6.000, while the workplaces increased by 4.500. It was not until 1970 that a decline in the mono-centric spatial order was inscribed into this model as part of a larger revision (see section 12.5.3). According to the new assumptions, the population would decline by 50.000 and the number of workplaces by 15.000.²¹⁰ In spite of the population at the regional scale being adjusted downwards only slightly, the combination of these revised assumptions lead to the new forecast predicting a decline in traffic crossing the screenline of the Lake-ring, in accordance with the actual development (see figure 12.9). This was the first time that an absolute decline in the mono-centric spatial order was assumed in the certified transport model-based knowledge production concerning traffic in the Greater Copenhagen Area.

12.5.2 The causes of the forecast's inaccuracy

In this sub-section, we return to the question raised in the introduction to this embedded case, that of whether the observed overestimation of the forecast was due to ontological, technical, psychological, political-economic or organizational/institutional causes. Each of these theoretical perspectives will be discussed in turn.

The ontological perspective constituted a relevant cause of the forecast's inaccuracies. The outbreak of the oil supply crises in the 1970s as well as the decline in birth rate due to release of the contraceptive pill and free abortion both contributed to the inaccuracy of the forecast. Neither of these factors was predictable when the forecast was finalized in 1968. However, in spite of the relevance of the ontological perspective, it was also found that this perspective alone cannot fully explain the cause of the forecast's inaccuracy.

Also, the technical perspective was found highly relevant. Development of the computerized model was subjected to a number of technical constraints, including the application of a more simplified model approach, which caused delays and resulted in the model being finalized in a rush. Data availability was one of the larger technical constraints and ended in the forecast only being for peak-hour traffic, while the modal split model ended up being based on a simplified and untested approach. It also meant that it was not possible to include biking, as had been originally intended. The inaccurate estimate of development within the inner city can also be argued to be somehow technical. The lack of data on workplaces within the inner city meant that it was difficult to estimate this issue correctly. However, while the floorage survey showed an increase, traffic counts showed stagnation in traffic to the Central Business District, beginning around 1960 (Kryger 1962). Data was therefore ambiguous on the issue of business development within the Central Business District, and in addition to the technical aspects, social explanations are seemingly also needed in order to understand the inaccurate estimate of the mono-centric spatial order's decline. This will be elaborated on further below. Technical constraints also constituted a contributing cause for why the forecast for the harbour crossing capacity was evaluated on an incomprehensive basis, as well as for the fact that only a single

²¹⁰ *Foreløbigt notat om ny trafikprognose for hovedstadsregionen 1975*. Generalplan Direktoratet. KAO/EA. 7.8.1972 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe - , Box 1)

Lake-ring alternative was evaluated during its committee stage. However, these insufficiencies cannot be explained by mere technical issues in this case. While technical content is important in order to understand the cause of the inaccuracy, it was shown that it is also important to account for the social context of the model. This will be considered next.

The political-economic perspective was also found to be relevant. In regard to the forecast prepared for the harbour crossing capacity between Copenhagen and Amager, the technical insufficiencies were used politically to exclude critical issues from the planning agenda. Moreover, the incontrovertible demand for capacity enlargement in the so-called minimum alternative was seemingly misrepresented. Even though these incidences do not provide conclusive evidence to the theory of strategic misrepresentation, the withholding of the three critical reports certainly does. This shows that one should not dismiss strategic misrepresentation as a relevant explanation.

The organizational perspective was also relevant. The system of thought which prevailed within the Department of the City Engineer, namely comprehensive planning in the form of systematic and rational-comprehensive approaches, had a great influence on the selection of forecasting methodology. Moreover, even though the original objective was to prepare a multi-modal forecast, technical and time constraints lead to the group deciding, in accordance with the Department's field of responsibility, to prepare a car forecast instead. Moreover, the spatial policy controversy about the future spatial order was also a battle between different organizational frames. The Department of the City Engineer and the Regional Planning Secretariat were tied to different frames of spatial order, and these organizational frames had a great influence on the drawing up of the land-use alternatives. In fact, contrary to the frame of the mono-centric spatial order and the computerized forecast's assumed stagnation within the inner city, a decline took place within the inner city of Copenhagen, and this was a contributing cause for why the forecast did not prove to be accurate. In addition to technical issues, it can also be argued that this incorrect estimate was due to the organizational frame prevailing within the Department of the City Engineer. Even though the data did not show decline, this does not mean that a decline could not have been assumed in the model. However, due to incommensurability of this assumption with the organizational frame, this was less likely to have been accepted. It can, of course, be argued that this wrong estimate was due to optimism bias rather than organizational issues, as will be discussed below. Nevertheless, it seems reasonable to conclude that organizational frames had an influence on the assumed land-use alternatives. In fact, it was shown how the continued prevalence of the mono-centric order (50-25% employment increase) was inscribed into the basic assumptions of a number of forecasts prepared by the Department of the City Engineer in the late 1950s and early 1960s.

Psychological factors in the form of optimism bias were also somehow shown to cause predictive inaccuracy. It can be argued that the error in judgment made for the development in workplaces and residences within the inner city could just as well be due to optimism bias instead of organizational frames, which would mean that only the optimistic assumption about stagnation was applied. In this incidence, it is very difficult to differentiate between organizational and psychological explanations. Yet, even though it cannot be firmly established that wrong estimates of parameters and assumptions were due to optimism bias, it was shown that the continued slip of deadlines due to optimism regarding the timeframe of completing the forecast

was surely a relevant cause of inaccuracy. The forecasting group was clearly overly optimistic about the timeframe for finalization of the computerized forecast. Even though this did not directly influence the model assumptions, it did mean that the forecast was completed in a rush. Hence, it did indirectly result in the forecast being based on a simplified and untested approach to modelling of the modal split.

Hence, all of the theoretical perspectives did somehow contribute to the understanding of why the forecast did not prove to be accurate. On the basis of a comparison between forecasted and observed traffic, it would have been impossible to infer these causes. Moreover, even though the existing perspectives are all pointing at relevant causes, none of them are adequate on their own. In the concluding chapter, the implications of these findings in regard to the state-of-the-art literature will be explained (see section 13.3).

12.5.3 Disestablishment of the forecasting group

This final subsection elaborates on how the work on developing this model came to shape Danish transport modelling practice.

Even though the forecasting programme was continued after the results on the Lake-ring had been produced, it was cancelled in the early 1970s. There were several reasons given for this; one such reason is concerned with organizational changes which took place within the Department of the City Engineer. Wassard had been subjected to a strong criticism due to the marginalized position which master planning undertook within the organizational structure of the Department. According to Wassard himself, this criticism was nothing more than a smear campaign lead by a left-wing ideologist (Wassard 1986). Nevertheless, as a reaction to the criticism, the Department of the City Engineer was restructured in 1968. The Urban Planning Office, where the forecasting programme was located, was transformed into a Department of the Comprehensive Plan, with Kai Lemberg as head. However, he did not share Vedel's passion for traffic forecasting, and the forecasting work was prioritized less than it had been before the organizational restructuring (Interview Stærmosé 2012). Another reason the forecasting programme was discontinued was seemingly generated by the detours made in respect to overcoming the Copenhagen forecasting programme's problem of data availability. The financial burden of enrolling FFWS in the forecasting programme generated a transformation in the organizational context of transport modelling within the Greater Copenhagen Area, as the responsibility of producing a comprehensive regional forecast was passed to the Regional Planning Council. The detours made in order to overcome the problem of limited data availability also generated a transformation in the transport modelling technology. Instead of using the transport modelling software developed by the Department of the City Engineer, FFWS used a software program originally developed by the American Bureau of Public Roads and modified by FFWS itself, which had developed it further by adding a new trip production model.²¹¹ Because the Regional Planning Council's new model was perceived as more advanced than that of Copenhagen, it took the position as the producer of certified knowledge claims about traffic within the Greater Copenhagen Area from around the early 1970s (see section

²¹¹ *Notat om fremstilling af et forbedret programsystem for behandling af trafikanalyser og beregning af fremtidig trafik*, S.D. K.A.O, 25.03.1968 (Plandirektoratets arkiv, S.D. trafikprognose, 1960?-1969?, EDB-programmer og hjemmeinterview, Box 1,

12.4.1). This led to there being less reason to continue the Copenhagen forecasting work. Yet, although the Copenhagen forecasting programme was discontinued, the pioneering work nevertheless came to shape Danish transport modelling practice, both in direct and indirect manners. This will be elaborated on next.

While the use of the Copenhagen model was stopped within the Greater Copenhagen Area, parts of the model was still put directly to use within other contexts. The Road Directorate took over the Copenhagen modelling programs (Interview Stærmosé 2012) and they were also made available to Danish public authorities through the Data Centre.²¹² The gravity model and a utility program to calculate distances between zones were also incorporated into a modelling system drawn up by the Laboratory for Road Data Processing, which was applied in the comprehensive transportation studies initiated by the Road Directorate in the provincial towns of Århus, Odense and Kolding in 1967,²¹³ and in Aalborg from 1972-1973 (Nyvig 1973) (see chapter 9.1). However, it seems as though the assignment model was not put to use in other contexts. In fact, in the following decades, it was not common practice to include capacity restraint in Danish transport models. It was not until 1979 that the Regional Planning Council's model was upgraded with capacity restraints (Hovedstadsrådets Planlægningsafdeling et al. 1979). In Aalborg, the transport model was not upgraded with this feature until the early 1990s (see section 9.4).

While parts of the Copenhagen modelling system were put directly to use within contexts outside the Greater Copenhagen Area, this was not the case within the Greater Copenhagen Area. Here, use of the Copenhagen model was stopped at the benefit of the Regional Planning Council's model. Yet, the technological frame which was built during the process of designing the model still came to shape the design of the Regional Planning Council's model. FFWS' modelling system was, in several respects, more comprehensive than that of Copenhagen, e.g. it was designed to calculate all kinds of person and car trips rather than being limited to home-work travel in the peak-hour. In other regards, however, it was more simplified than the Copenhagen model (trip distribution and assignment). This is not to imply that Copenhagen's gravity or assignment model could be merged with FFWS' trip production and modal split model; although the two models were developed within technological frames which were commensurable with systematic and rational-comprehensive interpretation horizons, the two technological frames were not commensurable with each other in all respects. The two models were based on different forecasting approaches and the different sub-models could not be combined. The parameters of the required inputs to the respective models' sub-models were simply different from the parameters of the outputs produced by the other model. The discrepancies between the two frames created room for negotiation about how to develop the new model. In other words, the discrepancies generated a process of domestication in which some of the discrepancies were accepted to the benefit of the FFWS frame, others to the benefit of the Copenhagen frame. For instance, though the Department of the City Engineer had

²¹² *Vejdatabehandlingsudvalget. Referat af fællesmøde for vejdatabehandlingsudvalget (30. møde) og tilsynsudvalget for laboratoriet for vejdatabehandling (15. møde) i Københavns amtsgård fredag den 30. august 1968 kl. 14,00. september 1968* (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 2)

²¹³ *Laboratoriet for vejdatabehandling. Rapport vedr. laboratoriets hidtidige og fremtidige arbejde. 1.14.1969* (Trafikministeriet, Vejdatabehandlingsudvalget af 07.07.1960: Materiale (1960-1973), Box 3)

developed an assignment model which included capacity restraint, the choice was still made to use the more simplified approach of FFWS, namely an all-or-nothing assignment. However, in the contract signed with FFWS, a condition was added, stating that the assignment model should be designed in a manner which enabled inclusions of capacity restraint at a later point.²¹⁴ This upgrade was not conducted until 12 years after the contract was signed, but the group had already considered including the Copenhagen work on capacity curves during the program's revision in 1971.²¹⁵ We will return to this revision below. Still, the FFWS model could only compute on the basis of straight-lined capacity curves, meaning that the Copenhagen work could not be used without modifications. Ultimately, use of an all-or-nothing assignment was not the only simplification to be accepted in the course of applying FFWS; in the Copenhagen model, it was desired to include biking, but this was not possible due to structural constraints. As part of the Greater Copenhagen Regional Transportation Study, data on biking was collected, implying that it now was possible to overcome the structural constraints. In fact, according to the contract:

“All types of person journeys in the Study Area by all of the main modes of transport are to be studied, including the characteristics of trips made by public transport as well as those of road traffic.”²¹⁶

Even though biking declined considerably during the 1960s, it was still one of the main modes. Therefore, it can be argued that it ought to have been included. Yet, because biking was not made explicit in the exhibit to the contract, the Regional Planning Council accepted that FFWS did not include it.²¹⁷

While the two above discrepancies between the technological frames were accepted in favour of the FFWS approach, the Copenhagen frame also shaped the design of the FFWS model. For instance, the division of zones in the Copenhagen model was also used as the basis of the Regional Planning Council's model. The division of zones was not copied, however, but rather overtaken in a modified form. The zones in the inner city of Copenhagen were made less finely-meshed, while the outer zones of the forecasting area were made more so.²¹⁸ In that sense, the division of zones was domesticated in accordance with its new regional organizational context. However, domestication of the FFWS model did not only happen during its initial design stage. In 1971, after the first forecasting results had been produced, the Regional Planning Council's model was reopened. Also in this case was the opportunity for change to take place, generated on the basis of non-acceptance of the model results. As mentioned above, the original forecast results, issued in 1970, showed a tremendous increase in car traffic. Despite the forecast never

²¹⁴ *Exhibit 1 to the Agreement of August 23, 1967. p. 8* (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1967, Økonomi m.m., Box 1,)

²¹⁵ *Planlægningsafdelingens Supplerende Prognose for 1975*, EPA j.nr. F-5-1., JM/HS, 01.11.1971 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)

²¹⁶ *Exhibit 1 to the Agreement of August 23, 1967. p. 1* (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1967, Økonomi m.m., Box 1,)

²¹⁷ *Indstilling fra Projektgruppen til Teknisk Ledelse om afslutningen af Egnsplansrådets trafikanalyse (udkast)*, Egnsplansrådet, Planlægningsafdelingen, OD/ANJ, 29.01.1969 (Plandirektoratets arkiv, Trafikanalyse 1967, 1967-1968, Teknisk arbejdsgruppe underudvalg og div, Box 1)

²¹⁸ *Sammenligning af gammel og nye zonenumre*, GPD, 16.9.1968. (Plandirektoratets arkiv, Egnsplanner, 1960-1961, 1960-1961, Box 1,)

having fulfilled, the results were nevertheless accepted in the planning report where the forecast was first issued (Egnsplanrådet 1970). However, the Copenhagen County Road Engineers did not accept the results of the 1975 forecast. Compared to the actual development, they found the forecast higher than likely and therefore requested a more realistic basis for the short-termed road planning.²¹⁹ Due to this non-acceptance, it was decided to reopen the Regional Planning Council's model and revise the assumptions. Within this window of opportunity which was created, the FFWS model was subjected to a second round of domestication. For instance, instead of using the original car ownership forecast drawn up by FFWS, it was decided to use a forecast prepared by the consultancy firm Viaplan, which had assisted the Road Directorate in making the evaluation of the Goods-ring (see section 12.4.1). Even though this forecast was considerably lower than FFWS' original forecast, Ottesen still desired to use a more conservative forecast for the central municipalities. He suggested using a trend projection on the basis of the actual development leading up to 1970, but with a predicted car ownership rate of 213/1000 inhabitants instead of Viaplan's 247/1000. In accordance with the Copenhagen approach, Ottesen hence suggested using a geographically varied car ownership rate as opposed to the uniform approach of FFWS. Even though this proposal was met with non-acceptance by a representative from the Road Directorate, Ottensen was backed by a representative from the County of Copenhagen and the proposal gained acceptance.²²⁰ The technological structure of FFWS's model, however, constrained this act of domestication. It was simply impossible to introduce the correction directly into the model. However, this structural constraint was worked around by lowering the average household income (a fictive parameter influencing car ownership and trip production in the model) in the zones covering the central municipalities.²²¹ Hence, in spite of the Regional Planning Office's model coming to obtain a hegemonic position, implying that use of the Copenhagen model was stopped, the pioneering work nevertheless came to influence the basis of transport model-based knowledge production within the Greater Copenhagen Area.

12.6 Sum up

In this final section of the second embedded case, an answer will be drawn to the sub-question which was particularly addressed in this and the preceding chapter, which is that of how the model results were put to use and whether they gained acceptance. However, before elaborating on the answer to this question, some reflections will be presented on the mechanisms presented in this chapter which were found to shape the transport model-based knowledge production.

In this chapter, it was shown how the transport model-based knowledge production was shaped by time constraints and structural constraints in terms of lack of knowledge and data availability. This was particularly true in respect to the modal-split model. Although it was originally intended

²¹⁹ *Resumé af møderne i PU siden 6. september 1971, Vejdirektoratet, 26.11.1971; Foreløbigt notat om ny trafikprognose for Hovedstadsregionen 1975, GPD, 7.08.1972 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)*

²²⁰ *Referat af PU møde mandag den 15. maj 1972, Klaus Bach Andersen, 25.05.1972 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)*

²²¹ *Foreløbigt notat om ny trafikprognose for hovedstadsregionen 1975, GPD, KAO/EA, 7.8.1972 (Plandirektoratets arkiv, Trafikanalyser og prognoser, 1975, Trafikprognose, PU-gruppe -, Box 1)*

to include biking, structural constraints meant that this mode could not be inscribed. Structural constraints also resulted in the modal-split model not being validated by a test on the base situation. Time pressure during the final stages of preparation also led to only a single Lake-ring alternative being evaluated during the Committee stage, with only an all-or-nothing assignment having been conducted. Hence, structural constraints meant that the original meaning could not be fully inscribed into the content of the model, instead causing the circumstances to demand that simplifications be made.

In regard to the sub-question particularly addressed here, it was shown in this embedded case, in accordance with the case of the Third Limfjord Crossing (see section 6.5), that the model was used as both a political and a truth-production technology (see section 4.2.2). The model-based knowledge production was used to reify that Copenhagen could legitimately expand the capital tied to its structural position within the mono-centric spatial order. These roles were different from the manifest roles which the model was originally envisioned to undertake, namely as a forecasting technology and a consciousness-raising technology permitting evaluations of several alternatives, as well as iterative improvements of these alternatives.

However, in spite of the similarities, the roles which transport models undertook in this embedded case cannot be reduced to the ones undertaken in the Limfjord case. The transport model-based knowledge production was not only used to legitimize action which was in conflict with the legitimate capacity for action of certain structural positions within the prevailing order, or, as in the Limfjord case, which was in conflict with the prevailing transport political objectives. In fact, the transport model-based knowledge production was also used to problematize such actions of discrepancy. The regional planning agencies used transport model-based knowledge production to problematize the understood nature of the prevailing mono-centric spatial order, as well as the legitimacy of Copenhagen's plans for expanding the capital of its structural position. Use of transport model-based knowledge production in this manner is not unique to this case. A respondent who works as a project manager within a public transport company elaborated on the role undertaken by a traffic model in preparing a new transit plan. He stated:

We actually shifted our strategy based on these model calculations. [...] This is an example of how adjusting the model can mean that new problems become evident. [...] This is one of the things that I think has been positive about using the model; new issues pop up, which means that you can use the model in a more iterative manner. (Interview 2011; Own translation)

Thus, transport models cannot only undertake a disciplinary role which aids in narrowing the scope of political debates, but can also contribute to questioning practices that were previously taken for granted, and thereby contribute to opening up the arena for change. Yet, in this embedded case, the Regional Planning Secretariat used the transport model-based knowledge production not only to reify and legitimize the spatial order to which it was adherent, but also to problematize other issues. Nevertheless, this does not imply that the role of transport models in this embedded case can be reduced to a political technology which is used to problematize spatial or social orders incommensurable with the one which prevails within the model's social operational milieu, or, conversely, to serve to reify the legitimacy of this order. In fact, it was shown that critical transport model-based knowledge claims were produced in the end, and

these ultimately problematized the political interests which were dominant within its social operational milieu.

It was shown throughout the embedded case that the transport model-based knowledge production was increasingly shaped by politics, and in this and the previous chapter, it was also shown how the technicalities of transport model-based knowledge production also shaped political debates. In fact, in the Copenhagen City Council, the political dispute on the Lake-ring came to revolve around the transport model-based knowledge production as a central contention point. It was also shown that acceptance of the transport model-based knowledge production was dependent on whether the model results supported or contradicted the audience's interest and interpretation horizon. The majority, which supported implementation of the Lake-ring, accepted the knowledge production and used the forecast result to reify and legitimize the decision on its implementation. The minority, however, did not accept the certified knowledge production which opposed their convictions. Therefore, they attempted to de-reify the transport model-based knowledge production by pointing out its technical insufficiencies, and on that basis, they requested more comprehensive evaluation results. Although the majority still approved implementation of Lake-ring, the minority's non-acceptance of the model results did, in accordance with the findings of Sager & Ravlund (2005), Porter (1992) (see section 4.2.6 and section 7.2 of this thesis) translate into a subsequent round of transport model-based knowledge production. Even though the critical knowledge claims produced in the second round were withheld, the fact that this knowledge production contradicted the dominating political interests of its social operational environment shows that political dominance does not necessarily determine the outcome of transport model-based knowledge production. Moreover, even though the model results gained acceptance at the local level, they were met with non-acceptance at the level of national politics. Hence, while relations of power inscribed into the content of transport models can, to some degree, shape the outcome of planning and decision-making processes, they do not determine them. Transport model-based knowledge production can be utilized in various manners during planning and decision-making processes, and the particular effect on the outcome is contingent upon the interaction with multiplicities external to the models in which the knowledge production is taken up. Ultimately, while the technicalities of transport modelling and the surrounding politics are likely to shape and be contained in one another, they cannot be reduced to one another.

13 Conclusion

In this final chapter, based on a synthesis of the findings from the two embedded cases, an answer to the main research question is first drawn. Next, the thesis' contribution to the research objectives concerned with induced traffic will be discussed, followed by the thesis' contributions to the state-of-the-art literature on the causes of inaccuracy and bias. We will close with a consideration of issues to be addressed in future works.

13.1 Mechanisms shaping transport model-based knowledge production

Based on a synthesis of the two embedded cases' findings, an answer will be drawn below to the main research question, namely:

How is transport model-based knowledge production shaped and by which mechanisms?

The deliberation of the research question will be structured in accordance with the different types of mechanisms presented in the Chapter 4. However, as the mechanisms shaping transport model-based knowledge production are dynamic and interrelated in scope, some of the discussion will go between the different types of mechanisms.

13.1.1 Acceptance

Haugaard relates the concept of acceptance to reproduction of social order, as well as reproduction of the social capital tied up to structural positions within social order. In Chapter 6, it was shown that omission of induced traffic was accepted among key stakeholders despite this simplification equalling bias. As a result of this acceptance, an evaluation practice was reproduced, which is at odds with the prevailing transport political objectives. In addition to social order, it was shown that acceptance can also be tied up to reproduction of spatial order and the spatial capital of structural positions within this order. In fact, the concept of spatial order was shown to be important for understanding how transport model-based knowledge production is shaped. The battle of the future spatial order of the Greater Copenhagen Area and the distribution of development within this order constituted a crucial contextual factor in which the transport model-based knowledge production was situated, thereby shaping the knowledge production. Indeed, it can be argued that the need to make others accept the continued prevalence of Copenhagen's structural position as the all-dominant centre within the spatial order of the Finger Plan constituted one of the rationales for developing the computerized transport model. However, in order to do so, other forms of power were also brought into play. These will be elaborated on in the following sub-sections.

Haugaard also holds that social order is reproduced through acceptance of social structures in the form of systems of meaning production. Accordingly, the social construction of technology holds that the meaning different social groups assign to an artefact is crucial for understanding the development trajectory of a technology. In this thesis, meaning production was also shown to be a relevant mechanism for understanding how transport model-based knowledge production is shaped. In the first embedded case, it was shown that the meaning that induced traffic signified to the respondents was decisive for how they rationalized their acceptance of

omitting it (see chapter 6). In the second case, it was shown that the objectives used to develop the computerized transport model were vital for understanding how and why the transport model's technical content was designed as it was. In this case, it was also shown how the perceived future prevalence of the mono-centric spatial order was reproduced through its inscription into the model's assumptions (see chapter 9).

Even though meaning and its acceptance is important in order to understand why the model developed as it did, technical constraints were also shown to serve as mechanisms shaping the transport model-based knowledge production. In fact, technical constraints, limited data availability in particular, served as mechanisms which constrained inscription of meaning, resulting in the original meaning not always being successfully inscribed into the technological content of transport models. In Chapter 6, it was also shown that there was not a direct connection between the neglect of induced traffic in the Aalborg model and the interpretation horizon of the planners and consultants who worked with this model. In the second embedded case, it was shown that a number of detours were made in order to circumvent the problem of data. In accordance with Latour's theorization (see section 4.2.2), this generated a number of changes in the model objectives and resulted in a more simplified approach than originally had been envisioned. However, the transformation in meaning and model properties did not result in the model being rendered unacceptable. In both of the embedded cases, planners were shown to accept technical constraints and the resulting simplified transport modelling approaches, despite the system biases they contained (see chapters 6 & 9).

13.1.2 Non-acceptance

According to Haugaard, non-acceptance of innovative acts of structuration which challenge the establishment is often tied to a desire to maintain the status quo, but it can also be related to attempts of marginalized groups to create fundamental systemic change. Accordingly, it was shown in the first embedded case that non-acceptance of transport model-based knowledge production among the audience was the result of to a desire to maintain the prevailing social order within the Danish Highway Authority in the form of a decentralized organizational structure (see section 7.2). However, along with attempts to expand the capital of structural positions, it was shown in the second embedded case how non-acceptance was connected to Copenhagen's attempt to defend the capital's structural position against a new and challenging spatial order (see section 9.2.3). Furthermore, in this case, it was shown how non-acceptance of transport model-based knowledge production was linked to attempts to destructure the prevailing mono-centric spatial order (see chapters 11 & 12).

In this thesis, non-acceptance was not only found to be connected to attempts to defend or challenge the prevailing order, it was also shown to constitute a relevant mechanism to shape the transport model-based knowledge production. This was particularly the case for non-acceptance among project opponents. Because the knowledge production had to be met with acceptance in order for proposed infrastructure projects to be implemented, non-acceptance of the initial knowledge production implied that increasingly rigid and scientifically grounded model-based knowledge claims had to be produced in order to increase the likelihood of acceptance (see section 7.2; chapter 12). Therefore, these findings underpin Wyatt's (2003) argument that those who are non-users of a technology, must also be accounted for, in order to

understand technological change (see section 4.2.3). It was also shown that, similar to non-acceptance, non-use can be based on a desire to de-structure a particular technology or the social capital of those whose acts of structuration are connected to that technology. However, despite acts of non-acceptance among the audience was found to serve as a mechanism which facilitated model modification in several incidents. Non-acceptance did not always involve that the transport model-based knowledge production was reopened for change (see sections 6.4 & 11.4). Moreover, even when non-acceptance contributed to opening up the basis of model-based knowledge production, changes did not always actually occur (see chapters 8 & 12.1). Hence, although non-acceptance served as a mechanism which generated transformations in the transport model-based knowledge production, thereby facilitating model advancement, its effects were not universal, but rather context-specific.

Haugaard argues further that system bias implies that some issues are organized into politics while others are organized out. Accordingly, it was shown how the transport model-based knowledge production was shaped by system biases embedded in the technological structure of transport models. In the second embedded case, it was shown how a system bias was embedded in the partial forecast for the capacity demands in the harbour crossing. This system bias led to critical issues being excluded from the planning and decision-making agenda, making the mono-centric spatial order more appealing. It was also shown that in spite of that this system bias being partly explained by technical constraints, the non-deliberation of the implications of these technical constraints could not be explained by ignorance (see chapter 11). The system bias hence seemed to have been created on both a technical and political basis. In the first case, system biases were also shown to shape the transport model-based knowledge production. It can be argued that the non-inclusion of induced traffic in and of itself constituted a system bias embedded in the Aalborg model. In this case, however, a system bias was also shown to surround the knowledge production, meaning that it was positioned as a domain beyond the possibility of political scrutiny (see chapter 6).

13.1.3 Interpretation horizons

According to Haugaard, systems of thought sustain the conditions of possibility of the social order by facilitating acceptance of certain types of structuration practices while impeding the acceptance of others.

In this thesis, the hypothesis concerning the conceptual link between induced traffic and the predict-and-provide interpretation horizon, levelled in previous work, could not be generally confirmed. However, this does not imply that systems of thought were not found to constitute a relevant mechanism shaping the transport model-based knowledge production. Neither does it imply that a conceptual link between induced traffic and the predict-and-provide interpretation horizon does not exist. This will be elaborated on further in section 13.2.3. In the second embedded case, systems of thought, in the form of rational-comprehensive and systematic approaches to planning, were shown to shape the model-based knowledge production in several ways. First, they generated a scaling up of planning perspective, resulting in corridor-based transport evaluation methods becoming increasingly perceived as unacceptable. The change in the scale of planning associated with these systems of thought also generated changes in methods of data collection, computing technology and forecasting methodologies. In fact, the

prevalence of these systems of thought made acceptance of computerized transport modelling appealing because it was perceived to make town and traffic planning truly rational. In other words, these systems of thought facilitated the emergence of computerized sequential transport modelling within Danish transport project-evaluation practice.

Haugaard, however, argues that actors are not trapped in a single interpretation horizon. Accordingly, it was shown in the second embedded case that, in addition to the instrumental-rational minded systems of thought, the transport model-based knowledge production was simultaneously shaped by political rationalities. It was shown how the spatial policy controversy regarding the future spatial order of the Greater Copenhagen Area also served to facilitate the decision to develop the computerized transport model. Moreover, while some of the system biases embedded in the model could be explained by technical constraints, the non-deliberation of the critical issues was seemingly excluded based on political rationalities. Hence, the transport model-based knowledge production was shaped simultaneously by rationalities pertaining to technical and political systems of thought. In fact, these two types of rationalities were shown to be present throughout the whole process of developing the model. Furthermore, they were not only present, but they also interacted and came to be embedded within one another. As the stake in the spatial policy controversy was raised throughout the process of developing the model, the transport model-based knowledge production increasingly came to be imbued with politics. Eventually, it became impossible to completely separate technical insufficiencies from political rationalities; the direction of influence between politics and technology was not a one-way relationship. It was also shown how the political debate on the Lake-ring in the Copenhagen City Council came to revolve around the technicalities of the transport model-based knowledge production. However, while the model-based knowledge production was imbued with partisan politics, it was not reducible to such. In fact, it was shown how the model produced knowledge claims which contested the political interests dominating within its social operational environment. Hence, the relationship between technical and political aspects of transport model-based knowledge production is complex and context dependent. Even though the two types of interpretation horizons are likely to be entwined with one another and can even be embedded in one another, they cannot be reducible to one another.

Although systems of thought constitute relevant mechanisms shaping the transport model-based knowledge production, it was also shown that in order to comprehend how transport model-based knowledge production is shaped, it is necessary to account for how technological aspects can be part of an interpretation horizon, as well as to consider the cognitive issues related to systems of thought. In other words, it is important to contemplate the concept of technological frames and how the building of such a frame can be guided by existing socio-technological practices (see section 4.2.5). Accordingly, it was shown how the development of the computerized transport model was shaped by the socio-technological practice of transport project evaluation which prevailed prior to the model's emergence. Although the socio-technological frame used in American comprehensive transport planning was accepted as the best practice and served as a prototype for the development of the computerized transport model, this did not mean that American methods of transport project evaluation were accepted unconditionally and simply copied into Danish planning practice. Rather, it was shown that the transport project evaluation practice which prevailed prior to the emergence of computerized transport modelling took part in shaping how American practice was translated into Danish

practice. In doing so, Danish transport project evaluation practice also transformed. In other words, domestication served as a mechanism shaping the transport model-based knowledge production. Moreover, while use of the Copenhagen model was stopped within the Greater Copenhagen Area, the technological framework which was developed during the process of designing the computerized transport model served as a base for domesticating the new authoritative regional model. This developed within a technological framework which was incommensurable with the Copenhagen framework. This process of domestication did not only go on in the design stage, but also in secondary stages of operation, in which an opportunity for change was created due to non-acceptance of the first forecast results.

13.1.4 Opening up the practice of transport modelling

Distinct from Lukes, Haugaard theorizes his fourth type of power creation as a conversion of practical consciousness into discursive consciousness. Haugaard, however, defends Lukes' concept of false consciousness in situations where deliberate misinformation occurs (see section 4.1.4). Accordingly, it was shown that the transport model-based knowledge production was, in some incidences, shaped by strategic misrepresentation. In these incidences, it can be argued that that the transport model-based knowledge production equalled false consciousness. This will be elaborated on further in section 13.3.3.

In this thesis, it was argued that even though Haugaard's theorization of the fourth type of power creation is relevant, its scope is too narrow. In order to make this type of power creation more comprehensive, it can be theorized as a capacity to create moments of opportunity for re-politicization of institutionalized practices. In accordance with this reconceptualization, several mechanisms in the second embedded case were found to create opportunities for the transport model to be opened up and changes to take place. It was shown how a reframing in the spatial scale of planning, generated by the emergence of the rational-comprehensive and systematic planning as prevailing systems of thought, resulted in the practice of corridor-based evaluations beginning to be problematized, thereby contributing to opening up transport project evaluation practice for change (see chapter 9). In this case, change was actually shown to be brought about as it facilitated the emergence of computerized sequential transport modelling. It was also shown how re-politicization and reframing of the policy controversy on the future spatial order of the Greater Copenhagen Area, due to Copenhagen's plans for developing Amager, served as a mechanism which contributed to reopening the assumptions of the forecast (see chapter 10). Also, in this incidence, the opportunity for change meant that change actually was brought about as additional alternatives were included to reflect the new contentious points of the spatial policy controversy (see section 10.6). Moreover, it was also briefly explained how a reframing or transformation in computing machinery served as a mechanism which contributed to opening up the transport model-based knowledge production for change (see section 12.5.). This was due to the introduction of a new computing system incommensurable with the former. Hence, in accordance with the argument of Kline and Pinch (1997) (see section 4.2.4), it was shown how reframing can serve as a mechanism for opening the transport model-based knowledge production up for changes to be made. However, it was also shown that it was not only reframing within the social domain which contributed to allowing for changes to the transport model-based knowledge production; change can also be attributed to reframing within the spatial and technical domains. In fact, it was shown how a reframing within one of these

domains generated transformations in the other domains. This fact illustrates how transport model-based knowledge production is shaped through socio-technological-spatial relations.

13.1.5 Truth

Haugaard's fifth form of power creation concerns reification. According to Haugaard, actors use truth in order to make others accept that the social capital tied to the structural position which they hold should be expanded beyond what is legitimately conferred upon that position (see section 4.1.5). Accordingly, in the second embedded case, it was shown how Copenhagen was in need of truth in order to make others accept the legitimacy of its plans for expanding on Amager, despite these plans being inconsistent with the authority conferred upon Copenhagen's structural position by the prevailing regional plan. This need for truth was fulfilled through the transport model-based knowledge production, which was used to reify the claim that development on the island was "free of cost." However, the need for truth also served as a mechanism which shaped the transport model-based knowledge production in and of itself. It facilitated the inclusion of additional alternatives into the forecasting programme, some of which resembled the Amager development plans which Copenhagen needed to reify (see section 9.2).

In this thesis, a claim was levelled that agents, in addition to using truth as part of a pro-active strategy, can also use truth as part of a defensive strategy to bolster the social capital of their structural positions against the attempts of others to confine it (see section 4.1.5). This claim was also empirically underpinned. The advancement of a new poly-centric spatial order, incommensurable with the mono-centric order of the Finger Plan, constituted an attack on the capital of Copenhagen's structural position. Therefore, Copenhagen was in need of truth in order to defend its position as the all-dominant centre. This need for truth constituted an important contextual factor which facilitated the decision to develop the computerized transport model. The defensive need for truth also had a great influence on the drawing up of the land-use alternatives, which the model was originally supposed to evaluate.

The need for truth was also shown to function as a mechanism which shaped knowledge production in a different manner. As elaborated on above (see section 13.1.2), non-acceptance served as a mechanism facilitating model advancement. This mechanism occurs because the more likely knowledge claims are to be met with non-acceptance, the more they need truth in order to be accepted. This applies both to defensive and offensive truth-seeking strategies. In the first embedded case, it was shown how non-acceptance of the intercity expressway system proposed by the three private engineering firms generated an amplified need for truth, which facilitated a transformation in how their innovative act of structuration was originally framed. Non-acceptance of the project's current demands and monetary benefits meant that the act of structuration was, in the second round, reframed towards the project's future demand and socioeconomic benefits. In other words, in this thesis, dynamic mechanisms of power, constituted through interactions between acts of structuration and attempts to de-structure these acts, were empirically shown to shape the transport model-based knowledge production by generating an amplified demand for truth, which facilitated model advancement. This seems to underpin a statement by Porter:

“Quantitative rigor is most valued when there is political need of its odor of objectivity, as a defense against suspicions of ideological bias or, worse, corruption.” Porter (1992, p. 30)

13.1.6 Narrowing down the scope for action

Haugaard’s sixth form of power creation concerned conversion of discursive consciousness into practical consciousness, and was theorized as discipline. This type of power creation was not, however, found to shape the transport model-based knowledge production to the same degree as the above mechanisms. Nevertheless, this does not mean that it can be concluded on the basis of this thesis that discipline constitutes an irrelevant mechanism. In the second embedded case, where the empirical depth was the greatest, the period investigated was marked by societal, spatial and technological change. Hence it is not the most ideal period for investigating discipline as a mechanism. However, the empirical depth was rather shallow for the investigation of the period in which the four step sequential framework was institutionalized within Danish planning practice, and it therefore did not allow for deep explorations of how disciplinary mechanisms facilitated institutionalization of the framework of four-step transport models. Nevertheless, in section 13.2.3, some alternative hypotheses will be levelled about why the practice of neglecting induced traffic has been sustained. In fact, all of these hypotheses are concerned with understanding why the phenomenon of induced traffic was increasingly part of planners’ practical consciousness up to the 2000s, after having been part of their discursive consciousness in the 1960s and before. Moreover, if Haugaard’s sixth form of power creation is theorized more broadly as contractive procedural mechanisms narrowing down the range of possible options, then this type of mechanism was, in fact, shown to shape the transport model-based knowledge production. As it was shown in the second embedded case, the possibilities for what to include in the model and how to include it were open to various choices in the start-up phase of the forecasting programme. However, as it was impossible to include everything in the model, it was necessary to filter out some of the possibilities, and this served as a mechanism which shaped the transport model-based knowledge production. For instance, it was shown how the range of land-use alternatives was narrowed down throughout the process of developing the model. It was, however, also shown that such types of closure mechanisms were not permanent or irreversible. As discussed in section 13.1.4, mechanisms which contributed to reopening the possibility of choice were also shown to shape the transport model-based knowledge production, which implied that additional land-use alternatives were included.

The transport model-based knowledge production was also shaped indirectly by mechanisms of closure. It was shown how the questioning of the taken-for-granted nature of the Finger Plan’s spatial order resulted in spatial planning of the Greater Copenhagen Area being opened up for change to take place. It was also shown that computerized transport modelling was called upon in order to evaluate the different alternatives of the dispute and thereby contribute to creating closure by reifying one of the alternatives. In fact, this need for closure serves as a contextual factor facilitating the decision to develop the computerized transport model (see chapter 9).

13.1.7 Coercion

Haugaard's last type of power creation was coercion. In this thesis, coercion in the form of physical power was not detected as a relevant mechanism. However, coercion in the form of illegitimate social power was found to be relevant. Even though any direct political pressure on the planners and consultants who conducted the model-based knowledge production was not exposed in the case of the Limfjord crossing, this type of power was evident in the second embedded case. A respondent expressed that he had been subjected to coercion and asked to spy on the leader of the forecasting programme. However, he did not accept this act of coercion. Hence, even though coercion was found to be exercised in this case within the context of transport model-based knowledge production, it was not found to shape it directly. Based on the findings of the thesis, coercion is seemingly the least relevant among the explored mechanisms. This does not imply that it can be firmly concluded that coercion is an irrelevant mechanism, but rather implies that based on the thesis' empirical material, this mechanism has not been detected to any appreciable extent. However, the majority of this thesis is based on documentary sources, a type not well-suited for exploring coercion. For instance, it is likely that if acts of coercion were exercised, they would not have been written down in the minutes. In order to explore this mechanism properly, a research design based on interviews would be needed.

13.1.8 Sum up

The transport model-based knowledge production is hence shaped in various ways and by a multiplicity of mechanisms. The shaping mechanisms were found to pertain to the respective domains of the social, the technical and the spatial. In fact, mechanisms pertaining to these respective domains were found to shape the transport model-based knowledge production in dynamic and interacting manners, working through both time and space. It was also shown that the effect of these shaping mechanisms on the transport model-based knowledge production was not deterministic in scope, but context dependent. Despite non-acceptance facilitating opportunities for change to come about such an opportunity was not created in every incidence. Moreover, as coercion was detected as a shaping mechanism to only a limited extent, this implies that the transport model-based knowledge production was mainly shaped by mechanisms stemming from the (re)production of the social-spatial-technological order.

13.2 Contributions to the understanding of why induced traffic often is neglected

Based on a synthesis of the findings of the two embedded cases, this section elaborates on the thesis' contribution to the research objectives concerned with induced traffic. More specifically, these objectives are as follows: contributing new knowledge about why it is often accepted not to include the effect of induced traffic in standard transport models applied within contemporary planning practice; obtaining new knowledge about why the practice of neglecting induced traffic emerged; gaining a deeper understanding about how and why the practice has been sustained; and problematizing the contemporary practice of neglecting induced traffic. These four objectives will be elaborated on in turn.

13.2.1 Why not accounting for induced traffic is often accepted

This sub-section elaborates on the thesis' contribution to obtaining a deeper understanding of why it is often accepted not to include the effects of induced traffic in standard transport models applied within contemporary Danish planning practice. Even though one respondent regarded the effect of induced traffic to be negligible (see section 6.4), the findings of this thesis generally did not confirm the hypothesis levelled by Cerwenka and Hauger (1998), as well as Noland and Lem (2002), that induced traffic is neglected in evaluations of road projects because traffic engineers, who work within a predict-and-provide paradigm, view travel demand as inelastic in regard to money and time costs. On the contrary, induced traffic was generally found to be accepted as a real phenomenon among a wide range of respondents, including those who seemingly worked within a predict-and-provide interpretation horizon. Neglect of induced traffic from the content of standard traffic models therefore does not seem to mirror planners' interpretation horizon. Instead, acceptance is rationalized with reference to a taken-for-granted practice, where omission is part of the prevailing order and "how things are done around here." Even though the bias against the no-build alternative, generated by neglect of induced traffic, was raised to discursive consciousness and problematized, this simplification was still accepted. Indeed, this acceptance was rationalized with reference to a system bias, meaning that the technical content of the model was made an area of non-politics, and therefore beyond the scope of critical scrutiny. The meaning of induced traffic was also shown to be contested. While project opponents often problematize neglect because socioeconomic benefits are perceived to be overvalued, one of the respondents interpreted the consequences of neglecting it oppositely, claiming it was an underestimation of socioeconomic benefits. Therefore, neglect of induced traffic could be accepted because it has been perceived to constitute a conservative practice even though environmental impacts were underestimated as a result. Most of the respondents, however, rationalized their acceptance by referring to technical constraints. These constraints were accepted on the basis of the following rationales: biases of omitting induced traffic will be eliminated when comparing build alternatives, and the effect is already indirectly included in forecasts based on trend projections. Still, the unintended effect of accepting to neglect induced traffic is that a bias against the no-build alternative is generated. In subsection 13.3.4, it will be explained how acceptance of not including induced traffic can serve to reproduce the predict-and-provide horizon as an unintended consequence.

13.2.2 Why the practice of neglecting induced traffic emerged

By rolling back the concept of induced traffic throughout the history of Danish transport project evaluation practice, this thesis has also contributed to producing new empirical knowledge about why the practice of neglecting induced traffic emerged in a Danish context. These contributions will be elaborated on below.

The knowledge produced from the historical inquiry into the concept of induced traffic did not lend support to the hypothesis advanced in previous work regarding the link between the predict-and-provide interpretation horizon and the neglect of induced traffic. On the contrary, induced traffic was shown to have been observed empirically, formulated theoretically and even included in transport project evaluation practice from more than a century and a half ago. In fact, this was also the case in the 1930s, the 1960s and the early 1970s, even in evaluations

conducted within a predict-and-provide interpretation horizon. Furthermore, induced traffic was included in the results of a partial forecast generated on the basis of Denmark's first computerized sequential transport model. However, distinct from contemporary practice, induced traffic was, in a historical perspective, found mainly to signify a phenomenon that enlarged the benefits of infrastructure capacity enlargements. This was shown to apply both to an intercity context (see the first embedded case) and an urban context (see the second embedded case). Hence, even though induced traffic was also found to signify such meaning to one of the contemporary respondents, it can be concluded that induced traffic was, in a historical context, given meaning within a different interpretation horizon than the one dominant at the time. It was not until the late 1960s, when the transport political discourse started to transform, that induced traffic was found to be problematized as an undesirable phenomenon, and this was on a normative ground rather than a socioeconomic one. This finding did, however, only apply to a political minority. At the level of planning induced traffic in the early 1970s, it was still found mainly to signify a benefit in regard to transport project evaluation practice. Technical constraints were also shown to be part of the reason why induced traffic began to become omitted. There was simply a lack of knowledge about how to include such effects in the model in a valid manner (see section 7.3). In the second case study, it was, from the beginning of the forecasting programme, planned to include induced traffic in the forecast by lowering the distance exponent in the gravity model for the forecast year, reflecting the improved travel conditions. However, based on a comparison of travel data from 1945 and 1956, the distance exponent was shown not to decrease as much as expected. On that basis, it was accepted not to include induced traffic in the preliminary forecast, in spite of the acknowledgement that this simplification was biased (see section 10.7.1). Moreover, because induced traffic was already partly accounted for in forecasts, based on trend projections of past growth rates in car ownership, inclusion of induced traffic as an individual effect in such a forecast implied a risk of double counting (see section 7.3). However, the unintended result of this practice was that a new bias was generated when comparing the build-alternatives with the non-build alternative. In the below sub-section, a hypothesis advanced by Næss et al (2013) will be put forth, which links acceptance of this practice to the predict and provide paradigm.

The finding that the phenomenon of induced traffic, in a historic context, primarily signified a positive phenomenon, squares with the findings of Goodwin (1998) and Labb (2012). According to them, the phenomenon started to be omitted from American transport project evaluation practice in the 1960s (Labb 2012) and from British practices in the 1970s (Goodwin 1998). Yet, although induced traffic also began to be neglected within Danish planning practice around the 1970s, the hypotheses levelled by Goodwin (1998, 151) concerning why induced traffic began to be neglected within British planning practice, cannot provide a sufficient understanding of why induced traffic began to be widely ignored within Danish practice. His first hypothesis states that the practice emerged because the effect was not included when the formal cost-benefit appraisal system for road projects was initially developed, though this was the intention. After this practice had been sustained for some time, it ended up being accepted as a default practice. In contradiction to this, guidelines for how to value several benefits and costs associated with induced traffic were found in the Danish cost-benefit manual from 1974. Nevertheless, Goodwin's hypothesis on how induced traffic became a standard practice might constitute part of the explanation for why the practice of neglecting induced traffic has been sustained. This will

be elaborated on in the below sub-section. Goodwin's second hypothesis argues that the practice of neglecting induced traffic emerged as a reaction to non-acceptance. Because induced traffic signified a benefit, project opponents problematized inclusion of the phenomenon, which they perceived to weigh illegitimately in favour of project approval. As a reaction to their non-acceptance, recalculations were conducted without induced traffic and this practice gained support from the Treasury because it signified a conservative practice. This hypothesis has a larger explanatory value than his first. In a Danish context, it was accordingly shown that neglect or deliberately low estimations of induced traffic signified a conservative practice. Within this interpretation horizon, neglect of induced traffic was hence perceived to be legitimate. However, despite concerns of overestimating induced traffic also being expressed in a Danish context, it was found, contrary to Goodwin's hypothesis, that neither the existence of the phenomenon itself, nor the legitimacy of including it in evaluations of transport projects, were met within non-acceptance from project opponents. It was only the magnitude of the effect which was found to be contested by project opponents (see section 7.1); though in the late 1960s, they also considered whether the phenomenon favoured or disfavoured road construction. In the single incidence where non-acceptance of the transport model-based knowledge production was rationalized with reference to induced traffic, non-acceptance was tied to exclusion of the phenomenon. Hence, even though induced traffic was found to signify a positive effect, non-acceptance of the phenomenon among project opponents can seemingly not explain the neglect within Danish planning practice.

Based on the thesis' historical enquiry into the phenomenon of induced traffic in regard to Danish transport project evaluation practice, it can be concluded that the most important factors for understanding the emergence of the practice of commonly not including induced traffic are as follows:

- Induced traffic was given meaning within an interpretation horizon where it mainly signified a positive contribution to evaluation of transport projects. Neglect thereby constituted a conservative practice, making it a legitimate practice by extension
- Lack of knowledge about how to model induced traffic
- Inclusion of induced traffic as an independent variable in trend projections was perceived to imply a risk of double counting and overestimation of traffic
- Empirical evidence derived from comparing travel data over time did not show as great an effect of induced traffic as expected

13.2.3 Why the practice of neglecting induced traffic has been sustained

This sub-section elaborates on the thesis' contribution to gaining a deeper understanding of why the practice of neglecting induced traffic has continued.

In the period from 1970-2000, environmental and health concerns obtained increasingly prominent positions within the prevailing transport political discourses. This also facilitated a transformation in transport project evaluation practice. Particularly in the 1990s, as part of the EIA legislation and the increased political attention on obtaining sustainable transportation systems, new demands were created for quantification of a wide range of transport-related environmental and health impacts. In order to conform to these demands, transport model

outputs were increasingly used to model such impacts. However, even though a new multi-modal national transport model was developed in order to comply with the new political transport political objectives, technical and resource constraints led to properties, reflecting these objectives, not being successfully inscribed into the technical content of the model, and due to its inaccuracy, it was hardly put to use. This meant that the practice of using simplified regional and urban transport models was sustained. Hence, despite an opportunity for change being created, the fundamental structure of standard Danish transport models did not transform in a manner which facilitated the inclusion of induced traffic. However, inclusion of induced traffic was not a requirement for the quantifications of environmental and health impacts to gain acceptance. In fact, it seems that neglect of induced traffic was accepted both among the Danish road and environmental authorities. Hence, acceptance does, to a large extent, seem have been conditioned on whether environmental and health impacts were quantified, rather than on whether the effects were estimated on a valid basis.

However, sustained neglect of induced traffic cannot be explained by the fact that the phenomenon disappeared from planners' discursive consciousness. Even though it was shown in the Limfjord case that induced traffic was not an effect which was discursively considered to be included in the Aalborg model between the 1970s and 1990s, a few Danish transport models accounting for the effect were, in fact, developed in the 1970s, 1980s and 1990s. Yet, based on the findings of this thesis, it seems reasonable to conclude that the prominence of induced traffic decreased based on planners' interpretation horizons. Moreover, in accordance with Goodwin's first hypothesis, it seemingly became part of planners' practical consciousness instead. As it was shown in a contemporary perspective, acceptance was, in fact, rationalized with reference to a normalized practice (see chapter 6). But how can sustention of such a practice be explained when Goodwin's hypothesis of neglect of the official cost-benefit framework seemingly does not hold explanatory power in the Danish context? Unfortunately, based on the broad methodological technique used to investigate this issue and the lack of the backstage perspective, it is not possible to give a firm answer to the question. However, in the following, some possible hypotheses will be discussed.

One hypothesis is that technical constraints served to legitimize sustention of the practice of neglecting induced traffic, until it eventually became taken for granted. Despite advancements in transport modelling having made it technically possible to include induced traffic in sequential four-step transport models by integrating feedback loops from assignment (step four) back to the previous steps, the gap between the newest technology available and the technology that is used in practice has traditionally been wide. Through the 1990s, it was standard practice for transport mode-based knowledge production to be based on the assignment procedure of an all-or-nothing assignment (see chapter 8). Such assignment procedures do not account for capacity restraint and hence cannot calculate how new induced traffic can inflict time losses on the existing road users. Inclusion of induced traffic within such a framework is therefore likely to imply an overestimation of aggregated time benefits and neglect, which becomes conservative within a socioeconomic interpretation horizon. Hence, technical constraints could serve to legitimize and sustain the practice of neglecting induced traffic, allowing this to eventually become accepted as a more-or-less normalized practice.

Another hypothesis is the predict-and-provide interpretation horizon and the transformation of induced traffic's meaning from a phenomenon contributing positively to evaluations of transport projects to one mainly associated with negative effects. If this transformation was associated with temporal inertia, then low estimations or neglect of induced traffic could still be framed as a conservative and legitimate practice despite the change in transport political objectives. It can be argued that such a temporal inertia in the transformation of the meaning of induced traffic is particularly likely to have occurred within a predict-and-provide interpretation horizon. This is because release of latent travel demand brings one closer to the ideal of frictionless transport systems. Within such an interpretation horizon, induced traffic can therefore be defended as a beneficial effect. Accordingly, it was shown in an urban context of the mid-1960s that repression of travel demand was perceived to be normatively undesirable within the predict-and-provide interpretation horizon, and in order to rectify this wrong, traffic had to be set free through the means of road construction (see chapter 11). The transformation in meaning of induced traffic from mainly signifying a benefit to mainly indicating a cost is therefore likely to have been associated with a larger degree of inertia within the predict-and-provide horizon than within environmentalism. In support of this hypothesis, it was shown that despite the emerging shift in policy discourse, the concerns expressed in the Danish socioeconomic manual from 1974 in regard to induced traffic actually overestimated its benefits (see chapter 8). Such inertia suggests that it could be possible to sustain the practice of neglecting induced traffic, making it more likely that this practice ended up being taken for granted. In fact, in a contemporary context, it was shown that to one respondent, the phenomenon did mainly signify a positive socioeconomic contribution.

The third hypothesis is developed by Næss et al (2013) and also draws on the predict-and-provide interpretation horizon. It sets out to explain why the bias against the no-build alternative, generated due to neglect of induced traffic, has been widely accepted even though environmental issues obtained more prominent positions on the transport political agenda. It suggests that this bias has been accepted because the fundamental objectives which transport models were used to elucidate did not transform from where and how much capacity should be built to whether to build additional capacity at all, but largely remained within the framing of the former objective. This implies that the no-build alternatives, rather than actual alternatives, have only served as bases for comparison. Such a framing of the objective of transport model-based knowledge production can be linked to the predict-and-provide interpretation horizon and its overriding rationale of accommodating predicted travel demand. In support of this hypothesis, it was shown in chapter 7 that acceptance of omitting induced traffic as an independent variable was rationalized on the basis of induced traffic already being somehow included in forecasts, based on projections of past growth trends. Inclusion will hence be biased due to double-counting. However, the unintended effect of this acceptance is that a new bias is generated when comparing build alternatives with no-build alternatives. It was also shown that the objective of the transport model-based knowledge production throughout large parts of the third Limfjord crossing's history was narrowly framed around capacity enlargements as solutions to the forecasted capacity problems (see chapters 6 & 8). In this case, it was also shown that the no-build alternative was not perceived as an actual alternative, only as a base for comparing the build-alternatives (see chapter 8). Moreover, in a contemporary context, it was shown that neglect of induced traffic was accepted because the objective of the transport model-based

knowledge production was to single out the most optimal layout, and therefore, omission was accepted because the biases generated by neglect of induced traffic would be reduced when comparing the build alternatives (see chapter 6). In accordance with the above hypothesis, such framings of the objective of the transport model-based knowledge production can serve to sustain the practice of neglecting induced traffic as acceptable, since it is likely that it eventually became a normalized practice and gradually became part of planners' practical consciousness.

In this thesis, however, it was also shown that the link between the predict-and-provide horizon and bias against the no-build alternative is not universal. In fact, in the incidence where the predict-and-provide horizon was most pronounced, namely in "Amager and the Master Plan" from the mid-1960s, induced traffic was not only included in the forecast for the build-alternative, but the inverse effect, namely the capacity restraining effect on traffic growth, was also elaborated on qualitatively in regard to the no-build alternative (see chapter 11). Nevertheless, this finding does not necessarily contradict the hypothesis. In fact, if the hypothesis is combined with the two above hypotheses levelled above, namely that induced traffic continued to signify a positive phenomenon within the predict-and-provide paradigm and that inclusion was associated with technical constraints, then it is likely that neglect of induced traffic also continued to signify a bias in favour of the no-build alternative, and neglect could thereby be defended as a conservative practice which served to legitimize acceptance of the technical constraints and the narrow focus on the build-alternatives.

This thesis did not, in either a contemporary nor in a historical context, confirm, in general, the hypothesis stating that transport planners who work within a predict and provide horizon conceptualize travel demand as inelastic in regard to generalized travel costs. Nevertheless, it cannot be concluded that there does not exist any conceptual links between acceptance of neglecting induced traffic and the predict-and-provide interpretation horizon. On the other hand, it cannot be firmly concluded that such alternative links exist. The hypothesis regarding technical constraints combined with the two alternative hypotheses about links between predict-and-provide and neglect of induced traffic make it likely that the practice of neglecting induced traffic was sustained as legitimate until it eventually became taken for granted. However, a conversion of induced traffic from planners' discursive consciousness to their practical consciousness only seems likely if neglect was not problematized by project opponents on a regularly basis. If omission, in fact, was widely met with non-acceptance between the 1970s and 1990s, it would have to be continuously defended and thereby also rationalized. In such a case, the phenomenon would most likely be sustained on the level of discursive consciousness. However, even though the minority in the Copenhagen City Council problematized that induced traffic was not included in the forecast for the Lake-ring, this was not shown to be the case in general. Despite project opponents problematizing the transport model-based knowledge production throughout the history of the Limfjord case, it was only after the 2000s that this knowledge production was problematized due to neglect of induced traffic. However, the thesis' empirical depth on this issue is insufficient to conclude whether project opponents generally accepted neglect of induced traffic during the period. There is therefore a need for further research into the issue about why the practice of neglecting induced traffic has been sustained. This will be elaborated on in section 13.4.1.

13.2.4 Problematizing contemporary neglect of induced

This subsection elaborates on the thesis' contributions to problematizing the contemporary practice of neglecting induced traffic.

Even if the two hypotheses advanced above, i.e., that sustained acceptance of neglecting induced traffic is connected to the predict-and-provide horizon, turn out to be invalid, and there do not exist a connection between predicted and provide and neglect of induced traffic, where the latter is generated by former, acceptance of not including induced traffic can still, as an unintended consequence, generate the reverse effect, serve to sustain such a predict-and-provide practice. Due to the bias generated against the no-build alternative, transport model-based knowledge production which does not account for induced traffic will show that capacity enlargement is an effective policy means to reduce road congestion while simultaneously fulfilling the current transport political objectives on reducing vehicle kilometres travelled and related environmental impacts. The predict-and-provide solution will therefore seem to be a win-win situation, even though it will lead to a path which is moving away from environmental policy objectives. If politicians are not made aware of the misguidance of such policy advice, but accept it, a false consciousness will be created among them. Hence, acceptance of the certified scientific knowledge production as the basis for the future course of action for reaching the policy targets implies that the predict-and-provide horizon is reproduced tacitly. This is in spite of it having been more or less officially abandoned in Denmark.

In this thesis, it was shown that to some, neglect of induced traffic constituted a normalized practice. However, through the historical scrutiny of the phenomenon of induced traffic, the understood nature of this practice was problematized, and it was raised to discursive consciousness that, for more than a century and a half, the phenomenon has been accepted within both planners' interpretation horizons as well as their transport project evaluation practices. The capacity-restraining effects of traffic growth were even quantified in the partial results of the first Danish computerized sequential transport model. Through the historical approach employed in this thesis, it was shown that omission of induced traffic should not be presumed to be a taken-for-granted practice and that there is nothing natural about the contemporary practice of widely neglecting the phenomenon in Danish transport project evaluations.

Despite the general acceptance of neglecting induced traffic in contemporary practice, this phenomenon will likely change in the near future. Both the new national transport model and the activity-based model for the Greater Copenhagen Area, which are currently under development and are meant to substitute for the prevailing urban and regional transport models, are supposed to account for induced traffic when fully developed. These models will serve to rectify the bias against the no-build alternative. Such an advance is vital for making valid evaluations of the current transport political objectives and for producing decision support which does not indirectly contribute to reproducing the predict-and-provide paradigm. However, in the second embedded case, it was shown that shifts in modelling paradigm can be constrained by the institutionalized procedures of data collection, which are designed to support the prevailing methods of transport project evaluation and not the new paradigm. As the contemporary institutionalized procedures of data collection do not fully support the two new

modelling approaches, particularly the activity-based version, there is a risk that data constraints will prevent them from becoming institutionalized, and that simplified transport models, which neglect several aspects of induced traffic, will continue to be applied in practice. Moreover, in spite of the scientific advance which these two new models seemingly represent, it is unlikely that they will not be associated with any form of predictive inaccuracy or bias at all. It is therefore vital that these models are not black-boxed and are treated as truth-production technologies. If the system bias detected in the Limfjord case led to transport model-based knowledge production being positioned as a domain of non-scrutiny and incontestable truth, and this is not somehow rectified, Danish transport project evaluation practice will continue to constitute a problematic practice. Because transport model outputs serve as inputs to evaluations of various transport-related impacts, they constitute a vital nodal point in the production of knowledge about these impacts. It is therefore of democratic importance that the validity of their technical content can be contested and submitted to public scrutiny. This possibility is particularly important in the implementation of a national transport model, as there is a chance that the same model will be used to evaluate almost every larger Danish transport project. There will therefore be less possibility for contesting its knowledge production by comparing it to model-based knowledge claims produced under alternative assumptions. There is a risk that it will monopolize the knowledge production and be treated as a truth-production technology. Increasing the openness about what traffic models contain will not only increase the democratic process, but as this thesis has shown, by problematizing and attempting to render the technical content of transport models non-acceptable, it can serve as a mechanism for stimulating innovations and advancements within transport project evaluation practice.

13.3 Contribution to literature on the cause of inaccuracy and bias

This section elaborates on the thesis' methodological, theoretical and empirical contributions to the state-of-the-art literature on causes of inaccuracy and bias in travel forecasting. The respective contributions will be discussed in turn. However, as the different contributions are interrelated, there will be several overlaps in the respective discussions of them. Lastly, on the basis of the thesis contributions, it will be concluded that in order to advance state-of-the-art knowledge on the causes of inaccuracy and bias, there is a need to extend the paradigm which currently prevails in the available literature.

13.3.1 Methodological contribution

In this thesis, it was argued that statistical ex-post evaluations of traffic forecasts, which are the dominant methodological approaches to determining the causes of inaccuracy and bias in travel forecasting within the state-of-the-art literature, are insufficient for exploring how and by which mechanisms transport model-based knowledge production is shaped. Hence, they are also insufficient for exploring the cause of inaccuracy and bias. Because several different mechanisms can cause the same effects, it cannot be inferred which mechanisms are causing the observed patterns of inaccuracy and bias on the basis of ex-post evaluations of model predictions as the only empirical object of inquiry. This thesis therefore took an alternative methodological approach and the contributions of this approach will be elaborated on in this sub-section.

The first methodological contribution of this thesis was to call for an extension of the empirical object of inquiry, moving beyond statistical ex-post evaluation of transport model-based predictions as the dominant approach and instead encompassing processes of transport model-based knowledge production within the context of planning and decision-making processes. It is within these domains that mechanisms shaping the transport model-based knowledge production unfold, and therefore it is also here that the main empirical inquiry should be focused.

The second methodological contribution was to take a qualitative methodological approach, distinct from the quantitative approaches which are dominant within the field. This methodological approach was shown to be fruitful. Many of the mechanisms found to shape transport model-based knowledge production, e.g., the various forms of power, cannot be measured or weighed, and hence cannot be quantified, and instead require qualitative deliberations into the rationalities, struggles and constraints which surround the transport model-based knowledge production.

The third methodological contribution was to combine empirical information collected from the frontstage, backstage and the audience of transport model-based knowledge production. The methodological advantage of including the backstage was that it became possible to collect information on rationalities, struggles and constraints shaping the technical content of transport models. It also made it possible to expose acts of strategic misrepresentation. In other words, it allowed for a much more in-depth scrutiny of the mechanisms which shaped the transport model-based knowledge production than would have been possible if data collection had been restricted to the frontstage. The methodological advantage of also collecting data on the audience was that information about the bone of contention in which the transport model-based knowledge production is situated could be much better comprehended. Data on the audience also made it possible to explore how practices of acceptance and non-acceptance within this domain contributed to shaping the transport model-based knowledge production.

The fourth methodological contribution was to include a temporal and historical dimension into the research design. Inclusion of these dimensions was shown to be productive, as it made it possible to investigate mechanisms which are dynamic and transformative in scope. As it was shown in both of the embedded cases, such mechanisms are important to account for in order to comprehend how transport model-based knowledge production is shaped. The temporal and historical dimensions were, however, included differently in the two embedded cases. In the first case, the inquiry was based on a very long timeline. Such a broad technique allowed for explorations of how the meaning of induced traffic transformed throughout history. By zooming in on a particular period, this mechanism would have been impossible to infer. The disadvantage of this approach was, however, that processes of transport model-based knowledge production were not explored in-depth, meaning that less room was left for inclusion of the backstage perspective. Nevertheless, this approach was productive. Both the knowledge which was produced about why the practice of neglecting induced traffic emerged and the hypotheses about why the practice has been sustained are substantially different from my original propositions. My starting point was that induced traffic was omitted due to strategic misrepresentation and that the relation between travel demand and generalized travel cost was perceived to be inelastic within the predict-and-provide horizon. Hence, what emerged from

taking a broad historical approach to the study of induced traffic was not only that the arbitrariness of the contemporary practice of neglecting induced traffic was raised to discursive consciousness and problematized, but so was the arbitrariness of my original propositions. Distinct from the approach taken in the first embedded case, the temporal and historical dimensions in the second embedded case were incorporated by examining a particular historical period and then temporally following the processes of transport model-based knowledge production in great detail. The benefit of including the temporal dimension in this manner was the possibility of exploring, in great detail, how various mechanisms which were dynamic in scope shaped the transport model-based knowledge production. The benefit of taking the historical approach to the study of mechanisms shaping transport model-based knowledge production was that in addition to exploring such mechanisms, the retrospective approach made it possible to elaborate on why the forecast did not materialize as expected. This is, of course, also a necessity for empirically exploring the ontological theoretical perspective on the cause of inaccuracy and bias. The historical approach, however, also had its downside, as there is less opportunity to collect empirical data based on interviews as one does when studying contemporary processes of transport model-based knowledge production.

13.3.2 Theoretical contribution

In this thesis, it was also argued that most of the theoretical perspectives advanced in previous work are insufficient for comprehending mechanisms which shape the model-based knowledge production. There are several reasons for this. First, previous theorizations are mainly based on mono-causal frameworks. Therefore, they are too narrow in scope to comprehend the diversity, multiplicity and complexity of mechanisms unfolding within planning and decision-making processes. Secondly, previous works' use of the concept of power as intentional manipulation and lies is too narrow in scope. Power is not a mono-dimensional concept which can be contained within a single entity, but rather a plural concept consisting of complex and diverse mechanisms which buttress and counteract each other through dynamic interactions. Thirdly, a weakness repeated in all previous theoretical work, except that of Næss (2011), is that the theoretical perspectives are all rooted in either social or technical dimensions. None of them considered the mutual interaction between social and technical issues. Hence, in order to better comprehend theoretical mechanisms shaping the transport model-based knowledge production, this thesis has argued that it is necessary to go beyond the theorization of previous work and advance on some of the respective theoretical perspectives' shortcomings.

In order to comply with these demands, this thesis therefore applied a multi-conceptual framework which embraces power multiplicities and accounts for mutual-interactions between social and technical mechanisms. As the basis for the reconceptualization of power, a multi-conceptual and dynamic framework of social power creation, developed by Mark Haugaard, was applied. Distinct from strategic misrepresentation, which is a repressive form of power, this framework takes its departure in a consensual understanding of power and revolves around social order and practices of acceptance and non-acceptance as key concepts. The main benefit of applying this framework was that it allowed for a dynamic understanding of how transport model-based knowledge production is shaped by various mechanisms of power. Such an understanding could not have been obtained by approaching the research question from a singular perspective. Although Haugaard's framework was extensive and constituted a

productive starting point for the reconceptualization taken on in this thesis, it was still too narrow in scope for complying with the demands created by conceptualizing socio-technological relation. This demand constituted a productive challenge to Haugaard's framework. According to Haugaard's theorization, power derived from social order is created by social structures in the form of systems of meaning production which order behaviour and thereby ensure predictability. It was, however, argued by others that conceptualizing structures solely as being social creates too narrow a scope to comprehend the mechanisms which order the social. Due to the structuring effect of technology (and material urban structures such as land use and infrastructure), it too can aid in ensuring social predictability and constituting social order. By conceptualizing technology in accordance with social institutions, it was possible to explore how the social shaped the technical and vice versa. In other words, it became possible to conceptualize how social and technical mechanisms can be embedded in one another without being reducible to one another. By integrating the socio-technological dimension into Haugaard's framework, the constitution of social order could better be comprehended. Hence, as a spinoff from the demand created by the reconceptualization needed to comprehend mechanisms shaping transport model-based knowledge production, a contribution to Haugaard's theorization of power was also made. However, as it will be elaborated on in the section below, using this logic means that the conceptualization of socio-technological relations employed in this thesis was also too incomprehensive in scope, both for comprehending mechanisms shaping transport model-based knowledge production and for understanding the constitution of order.

13.3.3 Empirical contribution

This subsection elaborates on the thesis' empirical contributions to the state-of-the-art literature on the cause of inaccuracy and bias.

The first of the thesis' empirical contributions was to fill in parts of the empirical knowledge gap on how processes of transport model-based knowledge production unfold. As argued methodologically, filling in this empirical gap is vital for obtaining a deeper understanding of the causes of inaccuracy and bias. In this thesis, the gap was bridged through a detailed empirical exploration of the process of developing the first Danish computerized transport model, with a focus on both the technical content and the social context of the model. By doing so, it was shown that the mechanisms which shaped the transport model-based knowledge production were far more diverse, complex and varied than any theorization thus far has managed to comprehend. Even though the theoretical framework applied in this thesis was extensive and useful for comprehending many mechanisms which were empirically found to shape transport model-based knowledge production, the framework was too incomprehensive to account for all relevant mechanisms. Despite the framework's complexity, it was too simple in the sense that the spatial dimension was not well integrated into it, even though it was shown empirically that mechanisms pertaining to this domain were, in fact, shaping the transport model-based knowledge production. Empirically, it was shown that in order to comprehend mechanisms shaping transport model-based knowledge production, a multi-conceptual framework which embraces socio-technological-spatial relations will have to be developed further in future research.

Another empirical contribution was to underpin one of the thesis' methodological arguments, namely that statistical ex-post evaluation of forecast results as the only object of inquiry is inadequate for inferring the cause of inaccuracy and bias. As clearly demonstrated in the second case, an examination based on such an approach would have made it impossible to infer all of the mechanisms which were empirically found to shape the model-based knowledge production. In fact, in the contemporary part of the Limfjord case (see chapter 6.), it was shown that even a case study mainly based on document studies and supplemented with interviews was insufficient in empirical depth for inferring which of the theoretical perspectives was the dominant cause of the bias in the model. In fact, though the workings of the different mechanisms could better be established at the empirical depth taken on in the second embedded case, this level was not deep enough to firmly conclude which mechanism was the dominant cause of inaccuracy and bias. Yet, the case clearly showed that there was not just a single mechanism of significance; in fact, in many cases, their real significance was created through interactions among mechanisms. Hence, it was shown empirically that in order to comprehend the cause of inaccuracy and bias, richness in empirical details is required, and this cannot by any means be obtained through mere quantitative ex-post evaluation.

However, even though it has been demonstrated that those existing theoretical perspectives which have been inferred from ex-post evaluation studies have been inferred on an insufficient basis, this does not imply that these theoretical perspectives in themselves are insufficient. Another empirical contribution of the thesis to the state-of-the-art literature was to scrutinize previous theorization at an empirical depth not found in previous work. In the following, we will return to the ontological, technological, psychological, political-economic and organizational theoretical perspectives and discuss in turn their respective relevance to the thesis' empirical findings.

The ontological perspective was shown to be relevant for understanding inaccuracy and bias in both of the embedded cases. Of particular note are the oil supply crises in the 1970s, caused inaccuracy and bias but were impossible to predict in models. This is also the case with the decline in the birth rate, due to the introduction of free abortion, birth-control pills and women's entrance of the labour market. These factors were some of the contributing causes for why the forecast for the overall population in the second embedded case turned out to be overestimated. Hence, the ontological perspective's main contribution was empirically confirmed, namely that even if social and technical biases could be eliminated in the future, one should still not expect traffic forecasting to become an exact science. Yet, the findings also showed that technical and social biases should not be neglected.

In both of the cases, technical insufficiencies were found to be a relevant cause of inaccuracy and bias. In fact, in the first embedded case, most of the respondents rationalized their acceptance of omitting induced traffic due to technical constraints. In the second case, it was shown how technical constraints generated a number of transformations in the modelling approach, leading to simplifications being made. Yet, even though the technical perspective was certainly shown to be relevant, it was also shown that the technical perspective alone is inadequate for grasping why such technical constraints are accepted as well as how and why they are worked around if they are not. In order to do so, it is necessary to incorporate social perspectives as well.

In this regard, optimism bias was found to be a somehow relevant cause of inaccuracy and bias. In the first case, it was shown that because the politicians wanted to signal that they were managing a community of progress, they were overoptimistic about how much their city would grow in the future in terms of population. In the second case, it was more difficult to infer whether psychological or some other issues were the cause of bias in regard to the overestimation of population and workplaces within the inner city. However, in this case, optimism bias was nevertheless shown to shape the transport model-based knowledge production, as the forecasting team certainly was overly optimistic in regard to the timeframe for accomplishing the forecasting programme. The simplifications triggered by this did, in fact, cause inaccuracy. Hence, though the psychological perspective was perhaps the existing theoretical perspective least underpinned by the thesis' empirical findings, it was still shown to be relevant.

In regard to the political-economic perspective, it was argued in chapter 3 that its use of the concept of power as manipulation is too narrow in scope to comprehend how various forms of power can shape transport model-based knowledge production and cause inaccuracy and bias. This argument was also empirically underpinned throughout the analyses, where several forms of power relations were shown to be relevant. However, among the types of relevant power, strategic misrepresentation was common. Though it could not be concluded on the basis of the empirical material that strategic misrepresentation occurred in the first embedded case, this was actually documented in the second case. Here, it was firmly established that the transport model-based knowledge production was strategically misrepresented through the withholding of inconvenient knowledge claims. However, despite this seeming to have been the case, it cannot be firmly established that strategic misrepresentation actually took place through deliberate manipulation of the model-based knowledge production. On the other hand, even though the empirical findings confirm the relevance of strategic misrepresentation, they do not provide a good argument for why strategic misrepresentation is the main cause of inaccuracy and bias (see section 3.4). In order to test the political-economic perspective, it can, of course, be contested whether the second embedded case constituted a critical case. Therefore, the conditions of possibilities for generalizing on the basis of the case can also be doubted. Yet, if we assume that it does constitute a critical case, it can be argued that when strategic misrepresentation occurred within a milieu in which the discourses on comprehensive-rational and systematic planning were strong among planners and where the benefit of developing a computerized transport model was rationalized on the basis of its making rational town and traffic planning possible (see section 9.3.3), then strategic misrepresentation is also likely to occur within a wide range of other settings. However, if the condition of possibility for generalizing on this basis is accepted, then the case also provides an argument for why it seems unlikely that strategic misrepresentation constitutes the dominant cause of inaccuracy and bias. Power was shown not to be omnipotent, and therefore, it could not keep the shady business fully concealed. In accordance with the study of Kain (1990), it was shown that withheld reports were, in fact, betrayed and leaked to the press. Hence, if strategic misrepresentation constitutes the dominating cause of bias and inaccuracy in traffic forecasting, one should expect more of such stories to be brought to light. Furthermore, the empirical findings did not support Flyvbjerg's hypothesis about the survival of the un-fittest (see section 3.4). In fact, despite the forecast for the harbour crossing capacity appearing to be strategically misrepresented (see

Chapter 11) and the project gaining acceptance among the majority in the Copenhagen City Council, it was neither accepted among planning peers nor among the majority within the National Parliament, who authorized the decision on the project's approval. Hence, distinct from Flyvbjerg's argument, strategic misrepresentation did not lead to project approval and survival of the un-fittest. However, even if the importance of strategic misrepresentation may have been overstated in previous work²²², the empirical findings of this thesis clearly show the political-economic perspective points in an important direction when calling attention to the politicized context in which the transport model-based knowledge production is situated. In fact, the hint on this direction has been a great source of inspiration for the approach taken in this thesis.

The organizational perspective was also shown to make a relevant contribution to the understanding of the cause of inaccuracy and bias. Despite the findings generally not confirming the organizational theory concerning the conceptual link between neglect of induced traffic and the predict-and-provide interpretation horizon, which has been contended in previous work, the finding that induced traffic, in a historical context, was given meaning within a different interpretation horizon also fits within the organizational perspective. This is also the case for the alternative hypotheses which have been advanced about conceptual links between predict-and-provide and neglect of induced traffic (see section 13.2.3), as well as the finding that the model-based knowledge production was shaped by the prevalence of rational-comprehensive system-based interpretation horizons (see embedded case 2). However, despite the empirical findings showing that the organizational perspective, with its focus on meaning and interpretation horizons, provides a relevant conceptual starting point for investigating mechanisms shaping transport model-based knowledge production, they also showed that it is inadequate to presume that meanings are fully and freely inscribed into the technical content of transport models. In accordance with the argument of Latour (see 4.2.2), such technical obstacles did, in fact, lead toward detours and transformations in the initial meaning and objectives. Therefore, one cannot come to a firm conclusion about the values, meaning and understandings of the interpretation horizons prevailing within the social-operational environment of a transport model solely by investigating the model's technological content.

On the basis of this case study, it is not possible to evaluate the hypothesis on selection bias. Yet, the findings of this thesis show that even if selection bias is the major cause of the observed biases in ex-post evaluation studies, this does not imply that the other contextual perspectives are irrelevant.

Despite this thesis having shown that comparisons between forecasted and observed traffic as the only object of inquiry is insufficient for comprehending mechanisms shaping the transport model-based knowledge production, the above discussion shows that the existing theoretical perspectives, several of which have been inferred from this approach, actually point toward relevant mechanisms. On the other hand, the fact that previous theoretical perspectives all make somehow relevant contributions also implies that individually, all of them are insufficient. Therefore, as a basis for comprehending the causes of inaccuracy and bias, the dominant tendency within state-of-the-art literature to advance mono-causal theoretical explanations is incomplete. Indeed, this thesis has shown that different mechanisms can be embedded in one

²²² At least, the stated importance of strategic misrepresentation has not been firmly documented yet.

another and even be so entangled that they are difficult to unwrap from one another. This finding underpins the argument by Næss (2011), namely that mechanisms pertaining to the different theoretical perspectives are not mutually exclusive, but rather co-working. However, one needs to go further than Næss (2011) and not only focus on how various social dimensions can be co-working and shape transport models' technological content, but also consider how the technical can facilitate and constrain social relations.

13.3.4 Need to extend of the prevailing paradigm

Quantitative ex-post evaluation studies constitute the dominant approaches within state-of-the-art literature on inaccuracy and bias. The knowledge produced on the basis of such methods, concerning whether and to what extent traffic forecasts are inaccurate and biased, has made important contributions to the literature. They have shown that one should not mistake traffic model predictions with prophecies of truth. This contribution is highly relevant for planning and decision making as it raises discursive consciousness about predictive uncertainty and thereby also increases the likelihood of precautionary measures being taken. It is therefore important that this type of knowledge is not only produced, but to an increased extent, thrown back into planning and decision-making processes.²²³ Yet, in order to explore the cause of inaccuracy and bias, quantitative ex-post evaluation studies and their evaluation of model outputs as object of empirical inquiry are insufficient for comprehending the causes of the exposed inaccuracies and biases. Likewise, in spite of the previous theoretical perspectives each having made valuable contributions, their respective explanatory efficacy is incomplete for comprehending the cause of inaccuracy and bias.

Hence, both the theoretical and the methodological approaches dominant within state-of-the-art literature are insufficient for comprehending the causes of inaccuracy and bias in traffic forecasting, and throughout the thesis, these claims have been empirically underpinned. Therefore, in order to advance state-of-the-art knowledge on the causes of inaccuracy and bias, an extension of the prevailing paradigm is needed. In order to advance new knowledge on the causes of inaccuracy and bias, it is vital that the three following issues are given much more attention in future research agendas than they have received as of late. First of all, processes of transport model-based knowledge production within the context of planning and decision making should, to a much higher extent, be explored as objects of inquiry. Secondly, the causes of inaccuracy and bias should be approached from a multi-conceptual framework. Thirdly, qualitative methods should be applied to a much broader extent.

In this thesis, an alternative approach which complies with these demands has been developed. Even though this approach has been shown to be productive and appears promising to develop further, there is still a needed for development of other alternative approaches. Indeed, because the empirical data are almost always too complex to be fully comprehended within even the most comprehensive theoretical and methodological frames, it can be argued that development and application of diverse frameworks is likely to yield the largest insights into the causes of inaccuracy and bias.

²²³ In this regard, the UNITE project will make an important contribution to Danish transport project evaluation practice.

The claimed necessity for extending the current paradigm does not imply that there is no need for statistical ex-post evaluation studies in future work. Indeed, if the object of inquiry within such studies is expanded to also encompass evaluation of model inputs and parameters, this can be expected to yield new productive insights into the causes of inaccuracy and bias. Moreover, despite the difficulties caused by time lags, the approaches likely to yield the most insight are those which are multi-conceptual in scope and combine statistical ex-post evaluation of forecast input, parameters and results, with qualitative explorations into processes of transport model-based knowledge production.

13.4 Future work

As stated in section 13.2.3, in order to obtain a deeper insight into why the practice of neglecting induced traffic has been sustained, there is a need for further research. In order to scrutinize the alternative hypotheses concerning technical constraints as well as alternative links between the predict-and-provide horizon and neglect of induced traffic, it is necessary to explore Danish transport project evaluation practice during the period between the 1970s and 2000s at a considerably deeper empirical depth than has been done in the explorations of this thesis. As part of such an in-depth investigation, it is particularly relevant to explore further which meaning induced traffic signified to different social groups during the period. The social groups particularly relevant to include are: transport planners who worked within a predict-and-provide and a predict-and-prevent interpretation horizon, respectively, planners working within environmental agencies and politicians and social groups pertaining to the general public who are both for and against road construction, respectively. An important objective is not only to map whether induced traffic was part of the respective social groups' discursive or practical consciousness, but also to explore which meaning induced traffic signified and whether this meaning transformed over time due to changes in transport political discourse. In other words, it is important to explore both how acceptance and non-acceptance of not including induced traffic was rationalized among different social groups.

13.4.1 A socio-technological-spatial theoretical framework

Although the theoretical approach taken in this thesis was shown to be productive for exploring a wide range of mechanisms which shaped the transport model-based knowledge production, it was still too narrow in scope. Empirically, it was shown that the transport model-based knowledge production was formed through socio-technological-spatial relations. Therefore, development of a theoretical framework which encompasses these relations seems to be a promising way forward. However, integration of the spatial dimension into Haugaard's framework will mean that it becomes even more complex, which is likely to constitute a barrier. Even though the framework of this thesis was too incomprehensive, it was also too complex. The attempt to bring the socio-technical dimension into Haugaard's framework resulted in the framework becoming very extensive, perhaps even too extensive. While the productivity of Haugaard's framework stems from the fact that it theorizes several interacting mechanisms of power, the multi-conceptual character of the framework is also a challenge for the task of integrating more dimensions into it. Hence, in order to add further complexity to Haugaard's framework by also integrating the spatial dimension into it, there is a need to simplify it. One way to do this is to re-theorize the different types of power creation on a more overall level,

making them work as procedural mechanisms. This means that tacit knowledge and discipline, for instance, would have to be reframed as mechanisms which take part in opening processes up for change to come about, and as mechanisms which take part in narrowing down alternative possibilities for action, respectively. Simplifying the theorization of power in this manner will make it easier to integrate the spatial dimension into the framework. However, the implication of such a reconceptualization of power as overall procedural mechanisms is that the framework will be most suitable for making a screening of power mechanisms, helping to sharpen the analytical focus on particular empirical phenomena. After such a screening, the task will be to explore the empirical phenomena in-depth. Hereafter, it is possible to turn towards the theoretical framework again, and based on the empirical scrutiny, elaborate on which type of theories are relevant to draw upon in order to fill in a more detailed theorization on how the mechanisms unfold.

Despite the challenge of integrating socio-technological-spatial relations into Haugaard's framework, the potentials of overcoming the barriers are large. In fact, it will not only make an important contribution to the conceptualization of mechanisms shaping the transport model-based knowledge production, but because the nature of socio-technological-spatial relations also constitutes mechanisms which take part in ordering of the social, and thereby in ensuring social predictability, it will also constitute a contribution to the understanding of power creation. Moreover, in the prefatory chapter, it was argued that travel behaviour was also shaped by socio-technological-spatial relations. Hence, socio-technological-spatial relations appears to be a promising framework for approaching knowledge production, mobility and power, and therefore the development of a socio-technological-spatial framework seems particularly relevant for approaching planning in general.

13.4.2 Testing the theoretical and methodological framework on contemporary cases

The benefit of integrating the historical dimension into the framework of this thesis was that it made it possible to roll back an overestimated traffic forecast through the planning and decision-making processes by which it was produced and applied. This approach was important in order to illustrate the claim that statistical ex-post evaluations are an insufficient basis for inferring the cause of inaccuracy and bias in traffic forecasting and that an extension of the dominant paradigm is therefore needed. However, as argued in section 13.3.1, integration of the historical perspective into the framework also has its downside. The opportunity to collect empirical data based on interviewing is less than when studying contemporary processes of transport model-based knowledge production. Therefore, in order to obtain an even deeper empirical basis for exploring the mechanisms shaping the transport model-based knowledge production, it seems promising to apply improved theoretical and methodological versions of this thesis' framework on a contemporary case. A contemporary approach, however, implies that it is impossible to infer whether the mechanisms found to shape the model-based knowledge production generated an accurate, over or underestimated forecast. In section 13.3.4, it was argued that the largest insights into the mechanisms shaping the transport model-based knowledge production are likely to be yielded through qualitative explorations into processes of transport model-based knowledge production when approached from a multi-conceptual framework and combined with statistical ex-post evaluation. Integration of the temporal dimension is therefore still important in a contemporary context. However, the temporal dimension can, with

advantages, be integrated oppositely to how it was done in this thesis, namely as a future prospect rather than a retrospective one. In fact, explorations of a contemporary case will benefit greatly from being part of a research programme which runs several years ahead and also includes a detailed ex-post evaluation programme of the forecast's inputs, parameters and results.

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This thesis explores the research question: How is transport model-based knowledge production shaped and by which mechanisms?

The background of the study is that previous work, based on ex post evaluation of traffic forecasts, has shown that results have often been inaccurate and sometimes systematically biased. The cause of the observed discrepancies is, however, contested within state-of-the-art literature. The thesis aims to contribute, empirically, methodologically and theoretically, to this literature. Existing theoretical perspectives are mostly inferred from statically generated comparisons between forecasted and observed traffic. In this thesis, the empirical object of inquiry is instead shifted towards the exploration of transport model knowledge production within the context of planning and the decision-making processes and it is based on empirical data, collected from the front-stage the back-stage and the audience of transport model based knowledge production. Moreover, unlike previous work, this thesis applies a multi-perspective framework of power, integrating socio-technical dimensions.

The research question is addressed based on two embedded cases, both of which include temporal and historical dimensions as important

elements. In the first case, induced traffic is analysed in respect to transport project evaluation practice. In a contemporary context it is shown that, despite the fact that neglect of induced traffic is likely to cause biases, such neglect was nevertheless generally accepted. History is then used to problematize this practice, and it is shown that there is nothing natural about omitting induced traffic. Based on the critical historical approach alternative hypotheses are also inferred which among others link neglect of induced traffic to the predict and provide horizon in a new manner. In the second embedded case, the results of an overestimated traffic forecast is rolled back in time, through the planning and decision-making processes in which it was produced and applied. Based on in-depth analyses of these processes, the mechanisms which shaped the knowledge production are inferred. The case shows that multiple, dynamic and interacting mechanisms shaped the knowledge production and to comprehend them and their workings, based on the accuracy of forecast alone, would have been impossible. The thesis concludes that in order to advance state-of-the-art knowledge on causes of predictive inaccuracy and bias, an extension of the prevailing paradigm is therefore needed.

