Geographical bias in traffic forecasts? An analysis of accuracy in road-traffic forecasts in cities vs. peripheral regions

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Abstract
Based on a review of available data from a database on large-scale transport infrastructure projects, this paper investigates the hypothesis that traffic forecasts for road links in Europe are geographically biased with underestimated traffic volumes in metropolitan areas and overestimated traffic volumes in remote regions. Our data do not support this hypothesis. Since previous studies have shown a strong tendency to overestimated forecasts of the number of passengers on new rail projects, one might speculate that road planners are more skilful and/or honest than rail planners. However, during the period when the investigated projects were planned (up to the late 1980s), there hardly existed any strong incentives for road planners to make biased forecasts in order to place their projects in a more flattering light. Future research may uncover whether the change from the "predict and provide" paradigm to "predict and prevent" occurring in some European countries in the 1990s has influenced the accuracy of road traffic forecasts in metropolitan areas.

Keywords: Road planning; traffic forecasts; inaccuracy; geographical bias

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Introduction

In a recent study of more than 200 large-scale transport infrastructure projects in Europe and America, Flyvbjerg, Bruzelius & Rothengatter (2003) found considerable deviations between forecast and actual traffic volumes. According to the authors, one cannot fail to notice that the forecasters who work out the projections of large-scale transport infrastructure projects often integrate their own political wishes into the forecasting frameworks. Although sophisticated demand models seem objective and hard to manipulate, it is technically easy to tune the models in ways so that "plausible" or "desirable" results are achieved. Flyvbjerg et al.'s study revealed clear indications of deliberately slanted forecasts among the rail projects, leading to overestimated predictions of the future number of passengers and accordingly of future revenues. For road projects, no similar tendency was found, as underestimation and overestimation of future traffic volumes occurred about equally often.

However, one may hypothesize that traffic forecasts of road projects too are biased, following a systematic where future traffic volumes are overestimated or understated, respectively, depending on what type of prediction error might present the project in the most favorable light. For example, in cities where there is a goal of curbing the growth in car traffic an incentive may exist to produce forecasts underestimating the traffic volumes on new road links[1].

Based on an extended review of available data from the Flyvbjerg database, this paper investigates the hypothesis that deviations between forecasted and actual traffic for large-scale road infrastructure projects follow a pattern where future traffic is underestimated in situations where traffic growth is likely be considered undesirable (notably freeways in metropolitan areas) and overestimated in contexts where a high amount of traffic is likely to be considered desirable (notably rural areas experiencing a decline in trade and industry).

The paper is based on a small study financed by the Norwegian Research Council. The material has been obtained from Bent Flyvbjerg's database and supplemented with information collected from the Internet and road maps of the regions in which the investigated road links are located.

Background

Achieving a more environmentally friendly development of urban transport, with less car traffic and higher proportions of travel by public transit, walking and biking, is often mentioned as an important part of a sustainable development (OECD/ECMT, 1994; European Cities & Towns Towards Sustainability, 1994; the Aalborg+10 Conference, 2004). Whereas most European countries until the early 1990s sought to adapt to the expected traffic growth in metropolitan areas by extending road capacity ("predict and provide"), a number of countries now aim to curb this growth ("predict and prevent") (Hine & Preston, 2003; Bonsall & Milne, 2003). Objectives of reducing car traffic in cities and increasing the shares of public and non-motorized modes have been adopted in national transport policy documents, both in Norway (Ministry of the Environment, 1993; Ministry of Transport, 2002; Ministry of the Environment, 2002) and several other countries (Ministry of Transport, Denmark, 1993; HMSO, 1998). If these goals are to be achieved, it is important to ensure that transport infrastructure investments do not pull in the opposite direction.

Construction of new major roads in urban areas have been criticized for contributing to an unwanted traffic generation (Downs, 1962; Thomson, 1977; Mogridge, 1997; Næss, Mogridge & Sandberg, 2001), but are often defended on the argument that they will reduce congestion without leading to notable growth in car traffic (see, e.g., Ministry of Transport (Denmark), (2000); Nordjyllands Amt et al., 2003). Moreover, large-scale road developments often have considerable consequences for the natural environment, productive soil and recreational assets. In a sustainability perspective, such projects can therefore be problematic not only in urban areas, but in rural regions too, in particular in areas where traffic flows are so modest that the construction of multilane roads can hardly be justified by the traffic situation. In order to obtain a sustainable development within the field of transport, decisions about transport infrastructure investments must be based on realistic need analyses and impact assessments.

Flyvbjerg, Bruzelius & Rothengatter (2003) have carried out a comprehensive study of demand analyses, cost estimations and risk in connection with large-scale transport infrastructure projects. The results of this study have been followed up in an article focusing in particular on the problems associated with demand forecasts (Flyvbjerg, Holm & Buhl, 2005). The studies of Flyvbjerg et al. generally show considerable deviations between forecasted and actual traffic volumes. In particular, deviations are large for rail projects. For more than 9 out of 10 such projects the forecasts overestimated the number of passengers. On average, the number of passengers was less than half of the estimated number. For road projects too the forecasts were often inaccurate, with deviations between forecast and actual traffic volumes of more than 20 % in half of the projects. However, the deviations were not one-sided, as it occurred equally often that the actual traffic turned out to be higher than forecast as lower than predicted.

Flyvbjerg et al. (2003:28-31) have analyzed possible causes of the deviations found between forecasts and actual developments and point to the following circumstances, each of which may lead to inaccurate traffic forecasts:

- Poor forecasting methods
- Poor database
- Discontinuous behavior and the influence of complementary factors
- Unexpected changes of exogenous factors
- Unexpected political activities or missing realization of complementary policies
- Implicit appraisal bias of the consultant
- Appraisal bias of the project promoter

The two latter explanatory factors imply that a more or less conscious distortion of the analyses is made by overestimating the need for the project and understating costs and other disadvantages.

According to Flyvbjerg et al. (ibid.), one cannot fail to notice that forecasters and project promoters often integrate their own biases into the forecasting frameworks. Although sophisticated demand models seem objective and hard to manipulate, it is technically easy to tune the models in ways so that "plausible" or "desirable" results are achieved. Model computations are influenced by the individuals who construct and calibrate the models and carry out the analyses, and the background, knowledge and attitudes of these persons (Tennøy 2003). Flyvbjerg et al. (ibid.) illustrate the influence of the consultants' background and horizon of comprehension by showing an example from the planning of a high-speed rail link between Melbourne and Sydney. Japanese, French and American consultants arrived at widely differing passenger forecasts, reflecting differences between their home countries as regards the shares of public transport in intercity travel.

According to Flyvbjerg et al. (2003:31) the tendency to overoptimistic predictions may be even stronger when forecasts are made by the promoters of the project than estimates produced by consultants. Project promoters often have an obvious interest – economic or prestige-related – in presenting the project in as favorable a light as possible. They may also be under less pressure than consultants to live up to professional standards of quality and objectivity.

A human tendency to wishful thinking might be a possible explanation of the tendency of forecasts to produce a more positive picture than what turns out to be realistic. Thus, “appraisal optimism” (Fouracre et al., 1990) might be a psychological explanation of the observed tendency to exaggeratedly positive projections. However, as pointed at by Flyvbjerg, Holm & Buhl (2002:289) the human psyche is constituted in such a way that we are able to learn from experience. Appraisal optimism might perhaps explain overoptimistic analyses carried out by inexperienced planners. However, forecasts are usually worked out by teams consisting also of experienced experts. It would also be strange if the planning profession as a whole were unable to learn from experience, but continued to commit the same “appraisal optimistic” errors decade after decade (ibid.).

According to Wachs (1989), planners are not always concerned with making as exact and reliable forecasts as possible. Instead, they are often more concerned about having projects financed and built. Realistic forecasts are often not an efficient means to obtain the latter. On the contrary, accurate projections may be counter-productive because the project then runs the risk that other projects bolstered by overoptimistic analyses will be preferred instead.
A closer analysis of the causes of inaccurate traffic forecasts stated by the planners themselves in connection with 234 large-scale transport infrastructure projects (208 road projects and 26 rail projects) suggests that bias in the appraisals of consultants or project promoters is a quite common cause of forecast errors. *Deliberately slanted forecasts* are mentioned as cause of forecast inaccuracy for as much as 25% of the rail projects (Flyvbjerg et al., 2005:139). A further indication of deliberate distortions in order to realize projects that would otherwise not obtain political support is the fact that lower-than-forecasted patronage is often accompanied by seriously understated cost estimates (Flyvbjerg et al., 2003: 38).

Among the investigated transport infrastructure projects, rail links are the only ones for which deliberately slanted forecasts were stated as an explanation for inaccurate traffic forecasts. Among the road projects this is not mentioned as a cause of forecast inaccuracy. Based on these findings, Flyvbjerg et al. (2005) conclude that forecasting work in connection with road projects conforms better to the ideal of fair play than corresponding projections of the demand for rail links. Both the less lop-sided distribution of deviations between projected and actual traffic volumes, and the fact that deliberately slanted forecasts are not mentioned as a reason for prediction errors among the road projects, may speak in favor of this conclusion. In urban areas where there is a political objective to strengthen the market share of public transport, rail projects apparently able to attract a large number of previous auto drivers as passengers may more easily obtain political support and public sector funding.

Systematic bias for road projects as well?

However, one may speculate that traffic forecasts of road projects too might be biased, following a systematic where future traffic volumes are overestimated or understated, respectively, depending on what type of prediction error may present the project in the most favorable light. For example, in cities where there is a goal of curbing the growth in car traffic an incentive may exist to produce forecasts underestimating the traffic volumes on new road links. This might be a part of the explanation of deviations between projected and actual traffic development for the road projects where forecasts have underestimated traffic volumes. On the other hand, for road projects in remote parts of the country, similar distortions as for rail projects are likely to occur, with exaggerated estimates of the future amount of traffic reflecting political wishes of regional development in the wake of new major roads. These different contexts for road projects, with some regions where more road traffic is considered beneficial and other regions where transport policy objectives aim at reducing traffic volumes, may possibly explain why underestimated forecasts are equally common among road projects as overestimated predictions of the future amount of traffic.

In the above-mentioned study of stated causes of forecast inaccuracy (Flyvbjerg et al., 2005), errors in the in-built assumptions of the transport modeling tools regarding trip generation and trip distribution between zones, as well as general weaknesses in the models, were frequently mentioned as causes of false estimates of future traffic volumes on new roads. However, there may arguably be a certain overlap between such apparently innocent projection errors, and errors caused by deliberate manipulation and distortion. The above-mentioned “technical” projection errors may – at least partially – result from transport model insensitivity to the influences of land use and transport infrastructure investments on the modal split between car and other modes of conveyance. As pointed at by, among others, Moen & Strand (2000) and Noland & Lem (2002), the most commonly used transport models have a tendency to underestimate the possibilities of influencing traffic development through transport policy measures and coordinated land use and transport planning. Through this underestimation the analyses produce results legitimating more road construction. Transport researchers have repeatedly criticized these faults of the transport models (see, among others, Newman & Kenworthy, 1989; Kenworthy, 1990; Arge et al., 2000; Tennøy, 2003).

In Norway as well as in most other European countries, forecasts of the amounts of traffic on the road network are usually carried out by engineers based on a variant of a four-step gravity-based transport model. The forecasts are worked out by experts who belong to a particular professional "culture". In modern society, different sectors represent different "cultures" with varying values, attitudes and perceptions of the situation (Strand & Moen, 2000). Within each sector, established rules, standard operating procedures and routines govern the actions of the agents. Through experience, opinions are established about appropriate, correct and incorrect conduct. Adaptation to new challenges arising in the surrounding society may therefore take a long time (Olsen, 1992, quoted from Farsund, 2002). For example, claims for significantly reduced highway construction in urban areas in order to increase the share of public and non-motorized transport are likely to be met by opposition from agencies established with road building as their main task. Among road planners, there has for long time been a prevailing belief that new or expanded major roads in urban areas do not contribute to more traffic. In spite of a number of theoretical arguments and empirical evidence countering this assumption it is widely held among this group of professionals and among many politicians too. Knowledge of high credibility among researchers may end up being marginalized when the assumptions forming the basis of the forecasts are established. In practice, those in power often determine what is to be accepted as truth (Thomsen, 2000; Flyvbjerg, 2002).

Based on the above lines of reasoning the following hypothesis could be formulated:

In metropolitan areas with congestion and obvious traffic-related environmental problems, traffic forecasts for proposed new roads will have a tendency to underestimate the amount of traffic, whereas a tendency to overestimated traffic forecasts will exist among road projects in remote parts of the country with declining regional economies. Among the remaining projects, situated neither in metropolitan areas nor in typically remote districts, forecast inaccuracy will be less pronounced and without bias in any particular direction.

This, then, is the hypothesis we will test below.

The data material

At the outset, Bent Flyvbjerg's database included 183 road projects. However, some of these projects have been made anonymous by the Audit Departments from which the data origin. Due to these restrictions, data about only 84 of the road projects were available for the present study. The material obtained from the database consists of 12 bridges, 3 tunnels and 69 ordinary roads, Among the total sample of 84 road links, 48 are situated in the United Kingdom, 16 in Denmark, 14 in the USA, two in Sweden, and one each in Germany, France and Spain. One road link is a joint Danish/Swedish project.

For all the roads of the sample, the data material includes information of whether the road is a toll road or a free-access road, and the accuracy of the traffic forecast, compared to the actual traffic during the first year of operating the road (for details on measuring inaccuracy, see Flyvbjerg, 2005). The latter variable was measured as the inaccuracy, which we define as the percentage overrun of the number of vehicles, compared to the forecast. (If the actual traffic was lower than forecast, the inaccuracy was thus negative).[2]

After having received the material, the location of each road link was identified using detailed road maps (usually scale 1:200 000, but in some cases slightly smaller or larger scale). The location of all the 84 road links is shown in Næss (2005). The road projects were then classified into the following three categories according to their geographical context:

- Road links in major metropolitan areas
- Road links in remote and/or economically declining areas
- Other road links

The first of the three above-mentioned categories includes road links within metropolitan areas of some 800 000 or more inhabitants. More specifically, the following road links have been classified as situated within major metropolitan areas:
Road links making up parts of the M25 motorway ring in the London region; road links making up parts of the M63/M60 motorway ring in the Manchester region; road links making up parts of the M621 motorway in the Leeds region; the Elbtunnel in the Hamburg region; the Radial 2 motorway in the Madrid region; and toll roads in the following metropolitan areas of the USA: Los Angeles, Houston, Dallas, Chicago, Oklahoma City, Tulsa, Atlanta, Orlando, Tampa and Fort Lauderdale/Miami. In total, 29 of the 84 road links were classified into this category, among which all the 14 roads in the USA, and also the two roads in Germany and Spain.

Defining which areas are remote and/or economically declining is a difficult task, as there are no uncontested criteria for any such definition. We have chosen to lean on the classification used by the European Union when allocating economical support to selected areas from its Structural Funds. Such funding is distributed according to two objectives, Objective 1 and Objective 2. Objective 1 is to support development in less prosperous regions, i.e. areas lagging behind in their development, where the gross domestic product (GDP) is below 75% of the Community average (European Union, 2004). Objective 2 of the Structural Funds aims to revitalize all areas facing structural difficulties, whether industrial, rural, urban or dependent on fisheries (European Union, ibid.). Although many of the areas covered by Objectives 1 and 2 are located in predominantly rural regions, these objectives also cover some major urban areas where unemployment is high. Thus, a few of the areas covered by Objectives 1 and 2 are at the same time included among the above-mentioned metropolitan areas characterized by congested roads. In order to avoid this overlap, only the proportion of the areas eligible for Objective 1 or Objective 2 funding situated outside the metropolitan areas of major cities have been included. The second category of road links thus includes 15 road projects in the following areas: Falster, Lolland, North Jutland and the northwestern part of Viborg County in Denmark; the northern coast of France; and certain areas in Cornwall, Cheshire, Conway, Cumbria, Yorkshire and Colinshire in the United Kingdom.

A main problem with the data

Among our sample of 84 road links, one out of four is a toll road. Arguably, an incentive to exaggerate the future traffic might imaginably be present for toll roads too, as a high amount of traffic would imply high revenues for the owners of the road. Thus, following a logic of “appraisal optimism”, we might expect to find tendencies to overestimate traffic for roads in remote/declining regions as well as for toll roads, regardless of whether or not the latter are located in major metropolitan regions. Moreover, any tendency to underestimate future traffic levels could only be expected to occur among the non-tolled proportion of the road projects in metropolitan areas.

However, two thirds of the toll roads in our material are located in the USA, and all these roads are in metropolitan areas. Indeed, all the American roads included in the sample are toll roads in metropolitan areas. Thus, there is a high degree of statistical confoundation between continent (Europe/America), type of road (toll or non-toll) and geographical location (within or outside a large metropolitan area). As it turns out, the relationship between actual and forecasted traffic volumes among the American roads differs statistically from the rest of the sample. It is, however, difficult or even impossible to determine whether this is due to the tolls, different political/cultural contexts in Europe and America, or the fact that the toll roads are located in larger metropolitan areas than the urban part of the European sample. Due to the serious skewness of the material, we therefore decided to omit the American projects from the analysis, concentrating on the European part of the data, until such a time when more balanced data are available.

However, even this remaining part, consisting of 70 projects, far from fulfills the ideal requirements of statistical analyses. Notably, 12 out of the 14 road links making up the sub-sample of roads in major metropolitan areas are parts of the two motorway rings around London and Manchester. Since this data set is the only one available for the time being, we still proceed with the analysis. Efforts should be made, however, to supplement the material with more projects from more European countries. With a larger data set, more firm conclusions could probably be made.

Results

Among the reduced sample of 70 road links, actual traffic volumes were approximately equal to those forecasted (deviation at most plus/minus 5 percent) on 14 road links (20%), whereas traffic exceeded the forecasts on 27 road links (38.6 %), and turned out to be lower than predicted on 29 road links (41.4%). Overall the material thus shows overestimation of future traffic among a slight majority of projects. As can be seen in Figure 1, the deviations between forecasted and actual traffic volumes follow slightly different patterns among roads located in different geographical contexts. The figure shows how the distribution between considerably underestimated, fairly accurate and considerably overestimated forecasts varies between the following types of roads: roads in major metropolitan areas; roads outside major metropolitan areas in areas eligible to objectives 1 or 2 funding; and roads not included in any of the former two categories.

At first sight, this distribution appears to provide some support to the hypothesis of geographically based bias in the forecast of traffic volumes. Among the road projects in major metropolitan areas, there are more roads with considerably underestimated than considerably overestimated traffic volumes, while the opposite is the case among projects outside major metropolitan areas. The latter tendency is, however, only present for projects not covered by the EU regional policy objectives 1 or 2. Among the non-metropolitan projects in areas eligible to the mentioned EU structural funds, there is a slightly higher proportion of projects with considerably positive than considerably negative forecast inaccuracy. The higher proportion of overestimated traffic forecasts in areas not eligible to Objective 1 or 2 funding than in the areas covered by these structural funds contradicts our hypothesis of geographically based forecast bias.

The numbers of project in each geographical category is low, with 15 roads both in metropolitan areas and in non-metropolitan Objective 1 & 2 areas, and 40 in other non-metropolitan areas. The different proportions of projects with considerable positive and negative inaccuracy among the metropolitan roads are thus reflecting a difference of only three projects (seven considerably underestimated versus four considerably overestimated). Such a small difference might be a result of chance. Moreover, figure 1 is based only on a rough classification of the projects into considerably overestimated, considerably underestimated and approximately accurate traffic forecasts.

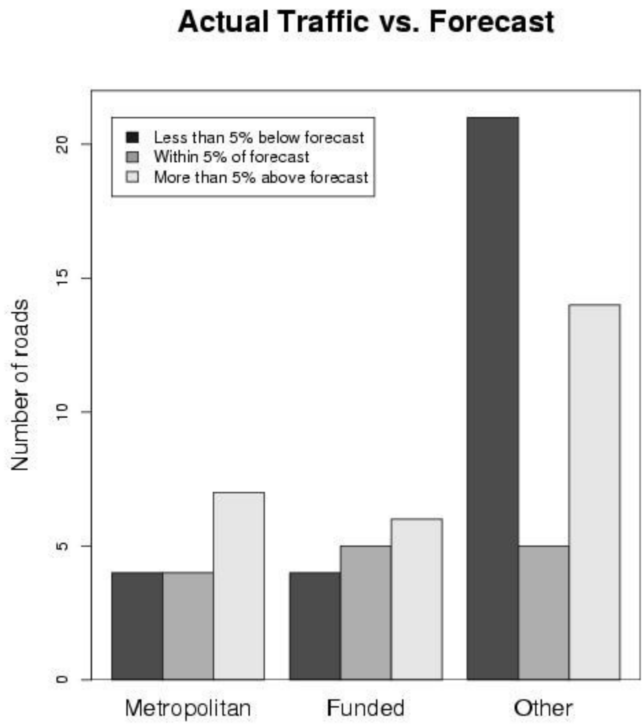

Figure 1: Proportions of roads with actual traffic volumes less than 5% below forecasts, within 5% deviation from forecasts, and more than 5% above forecasts within different road categories: roads in major metropolitan areas (N=15); roads outside major metropolitan areas in areas eligible to EU objectives 1 or 2 funding (N=15); and other roads outside major metropolitan areas (N=40). N = 70 in total.

However, as already mentioned, our data includes more accurate figures showing the inaccuracy, i.e. the percentages overrun of actual traffic compared to forecasts. A negative value of this variable implies that the forecasters have overestimated the traffic, a positive value implies underestimation. So let us turn to the statistical analysis of these more accurate data.

On average for all the 70 projects in the study, actual traffic volumes are about 10 percent higher than the forecasts. Table 1 shows the number of projects and the mean and standard deviation of the inaccuracy for projects within each of the geographical area types (major metropolitan areas, non-metropolitan Objective 1&2 areas, and other non-metropolitan areas).

As we can see in the table, traffic volumes have been on average slightly underestimated in all three geographical location categories. Moreover, when the accurate forecast deviation figures are used, the percentage of underestimation is *lower* in metropolitan areas than outside major metropolitan areas. This is contrary to our hypothesis, according to which underestimated traffic forecasts could be expected to occur particularly in metropolitan areas, whereas the political expectations to road projects in non-metropolitan areas Objective 1& 2 areas could be expected to stimulate forecasters to overestimate future traffic volumes. Evidently, the higher proportion of overestimated than underestimated traffic forecasts in non-metropolitan areas not eligible to Objectives 1 or 2 funding shown in Figure 1 is outweighed by higher average percentages of underestimation among the underestimated forecasts than the percentages of overestimation among the overestimated forecasts.

Table 1: Percentage overrun of actual traffic compared to forecasts for roads in different geographical locations.

Geographical location	N	Mean	Standard deviation
Metropolitan	15	6.3	33.0
Non-metropolitan, Objectives 1 & 2	15	11.7	49.2
Other non-metropolitan	40	10.3	48.7
Total	70	9.7	45.3

However, these findings are not statistically significant, i.e. they can be due to chance. A Bartlett test for homogeneity of variance gives $p = 0.224$. An analysis of variance gives $p = 0.941$, i.e. no significant difference whatsoever.

Discussion

Our data do not provide statistical support to the hypothesis of geographically biased traffic forecasts for road projects. Bearing in mind the grossly biased forecasts among the rail projects included in Flyvbjerg et al's (2003, 2005) material, road planners appear to produce generally more "honest numbers" than their colleague forecasters in the planning agencies dealing with rail projects.

Why do we find such a difference in the reliability of traffic forecasts for different types of transport infrastructure? It is difficult to believe that these differences are due to different skills among the planners. Both in the rail and the road segments, forecasts are normally made by planners with similar education who use similar forecasting methods. It also appears unlikely that forecasters in the road sector are of a superior moral standard, compared to their counterparts in the rail sector.

Instead, the incentives for producing slanted forecasts may have been different in the two segments. During most of the period since the 1950s or 1960s, highway construction has had solid political backing in most European countries. The rapidly rising number of car-owning households provided an increasing population basis for policies facilitating car travel. This popular pressure worked in combination with important branches of the corporate sector and contributed to a situation where few politicians would question the desirability of increasing the standard and capacity of the road network. Thus, highway construction was backed by a powerful coalition of car owners, the road building, car and oil industries, and politicians. These policies were not seriously challenged before the 1990s, when the objective of sustainable development entered the political agenda and concern about the global consequences of emissions from road traffic supplemented the local environmental concerns addressed in the 1970s and 1980s. (See, e.g., Tengström, 1999; Bøgelund et al., 2002; Bonsall & Milne, 2003). However, the vast majority of the projects included in our analysis are from the period before the "predict and provide" paradigm was challenged by politicians other than a few marginal groups. Why should planners make underestimated traffic projections in such a situation, where traffic growth resulting from the projects was not seen as undesirable, but rather as an important item on the benefit side of the account?

For rail planners, the situation was very different. Following the growth in car traffic, the number of train passengers, in particular on local trains in urban areas, had stagnated or declined in most European countries since the 1950s or 1960. Measured in modal shares, the proportion of train passengers had fallen considerably. As a result, train services became less and less economically viable, requiring heavy subsidizing in order to avoid a vicious circle of higher fares leading to even lower number of passengers, etc. As a result, several politicians were reluctant to grant funding for new rail infrastructure, which they feared would lead to pressure for future subsidies in addition to the often high construction costs. Between 1980 and 1990, the length of the motorway network within the European Union increased by 40%, whereas the length of the railway lines decreased by 5% (European Environment Agency, 2001)

Given that planners in both the rail and road sector wanted to see their proposed projects built, an incentive to make distorted traffic forecasts existed for rail projects, but less so for road projects On the contrary, a high forecasted number of future vehicles often served as a main argument for building the proposed road: If the road capacity was not increased in anticipation of traffic growth, congestion would worsen and make traffic jam intolerable. By facilitating traffic growth which would otherwise be suppressed by congestion, the traffic forecasts might thus act as a sort of self-fulfilling prophesies.

In the introduction of this paper, the insensitivity of conventional transport models to the influences of land use and transport infrastructure investments on the modal split between car and other modes of conveyance was mentioned as a possible cause of forecasting error. However, the type of forecasting error resulting from this is not necessarily an underestimation of traffic volumes on urban road links. Transport models ignoring the transport-inducing effects of increased road capacity in situations with congestion on the road network may instead lead to an overestimation of the amount of traffic if the road is *not* constructed. Actually, more detailed case studies indicate that the latter is quite common (Tennøy, 2003; Næss, 2004). For example, in the Environmental Impact Assessment (EIA) of the proposed Third Link across the Limfjord in Aalborg, Denmark, the presupposed traffic growth rate was the same (2 per cent annually) both in the alternatives where a new motorway was constructed as in the zero alternative where no road capacity increase took place. Similarly, in the EIA of a proposed new link of the E18 highway through Kristiansand, Norway, traffic growth within the planning area was presupposed to be almost identical, regardless of whether or not a considerable increase in road capacity was implemented. Both in Aalborg and Kristiansand, "fixed matrixes" (i.e. exogenously given total future amounts of traffic, where the traffic in the analyzed alternatives differ only in their distribution between different parts of the road network) were used in spite of the fact that the same analyses showed a breakdown of traffic flows on large proportions of the road network in a decade or two if the road capacity was not increased. However, if congestion really grew that bad, many peak-period motorists would choose to go by public transport, bike or foot instead of driving (Mogridge, 1997; Næss et al., 2001; Cairns et al., 2002; Noland & Lem, 2003).

The insensitivity of conventional transport models to the influences of road capacity increases on the modal split between car and public transport may also be a part of the explanation of the exaggerated passenger forecasts of rail link projects. If these links were established in transport corridors where extensive expressway construction took place the same time, these new roads would erode the possibility of the rail lines to attract car-owning passengers, with lower-than-estimated numbers of passengers as a result[3].

As mentioned in the introduction, the paradigm of "predict and provide" has been challenged in recent years, and in some countries, including Great Britain and Norway, a "predict and prevent" strategy has been formulated in national policy documents. Although there are indications that the pendulum has already begun to swing back again (Richardson, 2001), an investigation of more recent projects (from the early or mid 1990s and on) in the countries where goals of curbing the growth in urban road traffic have been formulated might possibly show different results from the present study. Investigating whether or not this is the case would be an interesting topic for future research.

In remote regions, the road planners were facing a somewhat different situation. However, here, too, there hardly existed any strong incentive to make biased forecasts. Road building in such areas was commonly held to be a key instrument to promote regional development[4]. This would, however, be a long-term process, and high traffic volumes could obviously not be expected immediately after the opening of new roads in such areas. Politicians therefore often placed little emphasis on the fact that many roads in remote regions had low forecasted numbers of vehicles compared to the construction costs[5].

Toll roads

Our original hypotheses did not include any assumptions about the possible influence on the traffic forecasts from whether or not the road is a toll road. However, as mentioned earlier, for toll roads, overestimated traffic predictions may contribute to give the flattering impression of a project from which high toll revenues can be expected. This may constitute an incentive for forecasters to make biased projections.

Among the sample of European road links, only seven are tolled. Six of these links are bridges, one is an ordinary road, and none are tunnels. Out of the seven toll roads, traffic was overestimated in four cases and underestimated in three cases. Table 2 shows the forecast deviations for the toll roads, compared to the rest of the sample.

Table 2: Percentage overrun of actual traffic compared to forecasts among toll roads and non-tolled roads

Type of road	N	Mean	Standard deviation
Toll	7	- 6.1	57.2
Non-toll	63	11.5	44.0
Total	70	9.7	45.3

There is a slight tendency to overestimated traffic volumes (negative inaccuracy) among the European toll roads, compared to an opposite tendency among the non-tolled roads. However, the internal variation within each group is large (cf. the high standard deviations), and the difference between the means of the two groups is insufficient to indicate significant difference. A two-sided Welch t-test gives $p = 0.456$, indicating that the difference in means between the two groups could be a result of coincidence.

As mentioned earlier, all the fourteen American roads of our original sample are toll roads. Among these roads there is a gross overestimation of traffic, with lower traffic than predicted for 13 out of the 14 roads. On average, the traffic is 42 per cent lower than forecasted. This underestimation is significantly different from zero ($p < 0.001$, two-sided t-test). This clear result could not be shown for the European toll road projects. However, distinct from the American sample, where all toll projects are ordinary roads, six out of the seven European projects with toll are bridges and only one an ordinary road. In the latter tolled road project, actually only 27 percent of the forecasted traffic emerged! It would be very interesting to have data from more tolled road projects in Europe.

The Danish difference

Splitting the European sample we find a striking difference between Denmark and the other countries. Whereas the actual traffic volumes of the non-Danish projects are on average slightly below the forecasted amounts, the number of vehicles on the 16 Danish road links is on average 50% higher than projected (cf. also Flyvbjerg et al., 2005). Among the road projects from other countries than Denmark, roads in the United Kingdom dominate with 48 links, compared to a total of 6 for Sweden, France, Germany, Spain and the joint Danish/Swedish project. Among the UK projects, the mean inaccuracy is only -0.6 percent, whereas the non-Danish projects outside UK have an average inaccuracy of -15 per cent. However, this difference between UK and other non-Danish projects is far from being statistically significant ($p = 0.337$, based on a two-sided Welch t-test). We therefore have combined all the non-Danish European projects in one group and compared them with the Danish projects. The results are shown in Table 3.

Table 3: Percentage overrun of actual traffic compared to forecasts among roads links in Denmark and other European countries

Country	N	Mean	Standard deviation
Denmark	16	49.9	65.6
Other European	54	- 2.1	28.8
Total	70	9.7	45.3

Comparing Denmark with other European countries using a two-sided Welch t-test, we get $p = 0.007$, i.e. high significance. In Denmark, the traffic is on average 50 percent higher than forecasted; for other countries no bias in forecasting is indicated. However, the fluctuations are very high: for Denmark the range is from -43 to 178, for others from -74 to 71. (Notice that -74 means that the actual traffic was only 26 percent of what was forecasted!).

The difference between Denmark and the other European countries is very clear also when controlling for geographical location (metropolitan, non-metropolitan eligible to Objective 1 or two funding, and other non-metropolitan) and whether or not the road is a toll road[6].

A closer look at the data reveals another interesting feature. There seems to have been a change around 1980, as the tendency to underestimated traffic forecasts appears only among the projects commencing from 1980 on. The statistics are for Denmark (Table 4):

Table 4: Percentage overrun of actual traffic compared to forecasts among roads links in Denmark before 1980 and in the 1980s.

Year of commencement	N	Mean	Standard deviation
1962- 1976	7	- 9.3	22.1
1980 - 1988	9	95.9	47.4
Total	16	49.9	65.6

A two-sided Welch t-test gives $p < 0.001$. If the Danish projects from the 1980s are removed, the remaining Danish projects seem to behave like the other European projects. It should be noted that all the Danish projects before 1980 are bridges and tunnels, whereas the Danish projects from the 1980s, except for one bridge, are roads.

The Danish experience with increasing inaccuracy in road traffic forecasts is commented on by Flyvbjerg et al (2005), where an “assumption drag” (cf. Ascher, 1979) in the wake of the price increases of oil and gasoline in connection with the “oil crises” in 1973 and 1979 is pointed at as the most plausible explanation. However, the years after 1980 are also the period when political objectives of curbing urban car traffic have been adopted to a higher extent than earlier. Thus, in this period urban road projects began to run the risk of being placed in an unflattering light if forecasts showed considerable traffic increases due to the extended road capacity.

However, the hypothesis of traffic underestimation in order to mask the conflict between the roads' traffic-inducing effects and environmental objectives has the same problem as the assumption drag explanation: Why does such underestimation occur only in Denmark and not in the other European countries? In the wake of the "energy crisis" in 1973 the policy of the Danish government was to reduce oil dependency. Among other things, fuel taxes were increased considerably, causing a higher price increase on gasoline than in most other countries. This also led to a certain focus in the Danish Ministry of Transport these years on energy conservation (Bøgelund et al., 2002) However, targets of stabilizing (and in a longer term reducing) energy use and CO_2 emissions from transport did not appear in national governmental policy documents until the beginning of the 1990s (Ministry of Transport, 1990 and 1993), i.e. after the commencement of the most recent of the Danish road links of our sample. This too makes it less plausible that the traffic underestimation among Danish road projects commenced in the period 1980 – 1988 might be caused by a fear that realistic projections would threaten the implementation of the projects.

Possibly, "assumption drag" has exerted a stronger influence on forecasts in Denmark than in other European countries. Actually, the "energy crisis" around 1980 appears to have had a stronger impact on the development of traffic in the years from 1979 – 1981/82 in Denmark than in some other EU countries. In Denmark, the amount of road traffic decreased from 1980 to 1981 and did not reach the 1980 level again until 1983 (Ministry of Transport, 2003). The Danish government reinforced the market-based increase in oil prices with a heavy taxation on gasoline in order to make Denmark less dependent on oil import. In certain other EU countries the traffic growth rate in these years was less influenced than in Denmark. Notably, in the United Kingdom, where the majority of roads in our sample are located, road traffic increased by 6 per cent from 1980 to 1983 (Department for Transport (UK), 2005), compared to the zero growth experienced in Denmark in the same period. Yet, it is difficult to see how this difference could in itself cause Danish planners to make forecasts in the 1980s with on average only about half the actual amount of traffic. Among the Danish projects commenced after 1980, only two were started in the beginning of the period and the remaining seven in 1985 or later, i.e. at a time when the amount of road traffic was again increasing. Apparently, Danish forecasters were quick to adjust their assumptions from the steady traffic growth trend of the 1970s to the zero-growth period in the early 1980s, but slow to adjust to the new conditions after 1983 when traffic started growing again. Moreover, Denmark was not the only European country experiencing reduced traffic volumes on the roads around 1980[7]. Thus, other influences have most likely operated together with the "assumption drag" as causes of the underestimated forecasts in Denmark.

Concluding remarks

Our analysis departed from a suspicion that forecast deviations for road projects might follow a pattern where future traffic is underestimated in geographical locations where traffic growth is considered undesirable and overestimated in locations where a high amount of traffic is considered desirable. Our data do not support the hypothesis of geographical bias in traffic forecasts for road links. Since previous studies (Flyvbjerg et al., 2003 and 2005) have shown a strong tendency to overestimated forecasts of the number of passengers on new rail links combined with gross underestimation of construction costs of these links, our finding may appear a bit surprising. Are road planners more honest than rail planners? Or are they just better skilled forecasters?

As argued elsewhere (Flyvbjerg et al., 2002, 2003 and 2005), the cost underestimation and passenger overestimation of rail projects can hardly be explained by "error" alone – strong indices point towards a considerable element of "lie". However, people usually do not lie unless they think lying will bring advantages. Rail transport was in a defensive position during most of the period when the projects considered were planned, and decision-makers increasingly emphasized the economic viability of projects. In such a situation, the possibility of having a rail project realized would be higher if a high number of future passengers could be expected. In the absence of any sanctions against forecasters who made incorrect projections, an incentive for rail planners to overestimate passenger forecasts thus existed. For road planners, however, the situation was different. There was a predominant goodwill in society to road construction, also in urban areas. Although there were concerns about congestion and local environmental problems associated with traffic growth in urban areas, these problems were seen by decision-makers and most planners as manageable. And the way to manage them was by channeling traffic into urban motorways (bypasses, ring roads as well as radial roads). Transport policy objectives of limiting the amount of car traffic in urban areas (as distinct from channeling traffic away from city centers and residential areas) were usually not adopted until the 1990s. At that time, most of the projects of the Flyvbjerg database were already planned. Finally, the allocation of funds for road projects is generally less competitive than the allocation of funds for rail projects.

Our conclusion that road planners hardly had any incentive to produce underestimated forecasts for urban road links refers to the conditions under a “predict and provide” paradigm where traffic growth limitation is not on the decision-makers’ agenda. Our original hypothesis about geographical bias with underestimated traffic forecasts in metropolitan areas was related to a “predict and prevent” paradigm where traffic growth in urban area is considered undesirable. However, as mentioned above, for the vast majority of the investigated projects, the forecasts were made before the pendulum swung toward “predict and prevent” in the United Kingdom and some other European countries in the early/mid 1990s (Richardson, 2001; Whitelegg, 1997). Our conclusion is therefore not necessarily valid for road traffic forecasting in a period where traffic growth limitation is a prioritized political goal. Updating the data material with a higher number of projects planned in the 1990s or later could provide more insight into this. Supplementary data collection and analysis will also be required for a better understanding of the reasons why there was such a huge underestimation of future traffic volumes of Danish road links planned in the 1980s, whereas the forecasts for roads planned in other European countries during the same period showed no such tendency.

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Notes

[1] A similar difference might exist between countries where strong environmental objectives have been adopted and countries without such objectives. This will not be focused in the present paper, but would be an interesting topic of a future study.

[2] For 53 of the road links data about the year of completion was available, whereas such information was missing for the remaining 31 projects. Information about ownership was available for 70 of the projects; among these, 63 roads are publicly owned, four are private, and three are state-owned enterprises. The remaining 14 roads, all located in the USA, are all toll roads, but information about their ownership is not available from the collected data.

[3] We have, however, not had the possibility to investigate whether or not this explanation fits with the actual situation in the corridors of the rail projects of the Flyvbjerg database.

[4] This belief is, however, not very well-founded. See, for example, Flyvbjerg et al. (2003:65-72) and Engebretsen, Lian & Strand (1998).

[5] For example, interviews made with the members of the Norwegian Parliament's Committee on Transport in the beginning of the 1990s showed that it was difficult to identify cases where the benefit-cost ratio had played any decisive role on the politician's standpoint. Other circumstances, notably impacts for local business and trade, the opinions of the local electorate, and the type of project exerted stronger influence on the final decisions of the politicians (Nyborg & Spangen, 1993).

[6] This control was made in the form of a full three-way analysis of variance with backward elimination. In spite of non-homogeneity of variance, the conclusion is so clear that the non-homogeneity of variance cannot destroy it. The factors of the analysis are DK (Denmark or other European countries), toll (yes or no) and geography (metropolitan, non-metropolitan eligible to Objective 1 or two funding, and other non-metropolitan), but only nine out of the 12 combinations are represented in the dataset. Due to this incomplete representation of the combinations, the three-factor interaction cannot be estimated. For the two-factor interactions, we successively remove them, DK vs. toll with $p = 0.568$, DK vs. geography with $p = 0.210$, and toll vs. geography with $p = 0.113$. For the main effects, we remove geography with $p = 0.612$ and then toll with $p = 0.428$. Only DK cannot be removed with $p < 0.001$.

[7] For example, in Sweden, the number of passenger kilometers by cars was reduced from 1979 to 1980 and did not reach the 1979 level again until 1983. The number of tonne kilometers of goods transported by trucks was even more strongly reduced and did not reach the 1979 level again until the mid 1990s (Johansson & Nilsson, 2004). In Germany, the total volume of road traffic (measured in vehicle kilometers) was reduced from 1980 to 1981, but reached the 1980 level again already in 1982 (Tappe, 2001).