Road infrastructure and demand induction

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Abstract
Based on available traffic counts, port statistics and statistics from bridge operators, the paper analyses the development in traffic before and after the opening of selected motorway sections and bridges in Denmark. The paper employs a screenline methodlogy where the total traffic flow across a long screenline is used to measure the development in aggregate demand in selected corridors. The paper analyses demand induction by establishing time series of aggregate demand that is compared with the national traffic index. Significant trend breaks in the association between aggregate demand in the corridors and the national index, following the opening of motorways or bridges, indicates demand induction by infrastructure expansion in a number of instances. Lack of significant trend breaks following opening year is found in peripheral areas where major population centres are missing. This indicates the necessity of some latent demand within suitable travel range for new infrastructure elements to produce significant amounts of induced demand. Estimates of demand induction as a percentage of the realised demand five years after opening are between 10% and 67% for new motorway sections depending on their location – and between 0% and 90% for bridges. The result for the bridges seem to depend strongly upon their location in the national transportation network.

1. Background

The paper is an offspring from the Research project Town, Road and Landscape that aims to assess the effects of the Danish motorway network (specifically the last 20 years) on urban growth and interaction patterns. Interaction distances has been expanded considerably in the last 20 years and formerly separate urban entities are now merging into larger functional regions woven together by still increasing flows of traffic. One of the questions asked in the project is, in what way infrastructure policies has contributed to this development? Beside the question of the changing spatial form of interaction patterns this also touches upon the question of the level of demand induction brought about by new transport infrastructure. Induced demand has been treated in numerous British and American studies especially since the mid nineties (see fore instance SACTRA, 1994; Noland and Lem, 2000). After historical debates on the existence of induced demand conclusions are now generally in favour of the existence of the phenomenon of demand induction. In the project Town, Road and Landscape it has been attempted to assess the consequences of the development of the Danish motorways network over time with available statistical data. The Danish commuter statistics has been used in the project to access the effect of the motorway-network on the development in the commute pattern (Nielsen and Hovgesen,

2004). This paper continues these efforts with the application of a screenline methodology to the assessment of developments in demand and evidence of demand induction following the opening of bridges / tunnels and significant motorway stretches in the period from 1985-2000.

2. Methodology

The developments in demand following the completion of transport infrastructure are difficult to assess as travellers may shift routes, times of travel and even modes of transportation (Downs, 2004). Further the question of a ceteris-paribus increase in demand, implied by the concept of induced demand, is a counterfactual question, to which there are no correct answers.

To assess the developments in demand over time based on existing data on traffic flows from official statistics this paper applies a screenline methodology to a number of cases. The cases are significant stretches of motorway or bridges that opened for traffic between 1985 and 2000. The simple "screenline methodology" has been applied in older studies (Judge, 1983; Hendrikson et.al., 1982). Principally a screenline will capture the overall demand in a corridor irrespective of route changes, wile the assessment of daily or yearly flows across the screenline will capture overall demand irrespective of changes in activity patters. Cervero (2001) has concluded that screenlines tend to overestimate demand induction. An explanation behind this could be that screenlines can never be quite long enough to capture the route changes that may relate to for instance long distance commercial traffic. Practically it is of course difficult to meet all requirements with this methodology. Very long screenlines will tend to blur and dilute any development trends associated with a new infrastructure element at its location.

To assess the effect of the motorway/bridge/tunnel projects on overall traffic volumes, all traffic on major roads that crosses a screen line in the corridor is summarized. The screen lines are primarily drawn between large cities to avoid the bias of the large differences in traffic flows within or near urban areas. As the focus is on a national infrastructure element connecting cities - the screen lines are also given a considerable length to allow for redistributions of traffic flows from alternative routes to different parts of the country. For each screen line the total traffic is followed year by year from 1985 until present (2003). The source of data is the almost continuous traffic counts on all major Danish roads that has been conducted the Danish Road Directorate since the early eighties (Vejdirektoratet, 1985-2003). When necessary this is supplemented with port-statistics (Danmarks statistik, 1985-2004) and in some instances traffic counts conducted by the municipalities and bridge operators (Øresundsbron, 2005).

To approach the counterfactual question of what would have happened had the road not been build – the paper relies on a comparison with the National car travel index (Vejdirektoratet, 2005). This will allow a visual comparison/inspection of trend breaks and their timing – as well as quantitative estimates of the level of demand induction following the completion of the infrastructure cases. Other studies have used more specifically designated "control areas" or "control corridors" (Cervero, 2001). The present study has no such designated "controls" but benefits on the other hand from the possibility of an inspection of the association between the developments in demand in the selected corridors and the national index.

The selected screenlines can be seen on figure 1. The study includes the flow of traffic from 1985 to 2003 over 5 long screen lines - principally orthogonal to the main travel direction – on new stretches of motorway opened in 1990, 1992, 1993, 1994 and 1996. In addition 3 screen lines to account for changes in traffic flows as a result of fixed links between Denmark and Sweden (opened in 2000), between the Danish island of Zealand (with the Capital area) and

Fuen (opened in 1998), - and between Zealand and the islands of Lolland and Falster is established (opened in 1985).

In the case of the bridge between Denmark and Sweden some deviations from the general methodology occur. The bridge is a new road- and rail link between the core areas of two large cities that was previously directly connected by ferries and fast boat services. Furthermore the link is a cross-border connection and therefore difficult to compare with fore instance national indexes. In the case of the bridge between Denmark and Sweden the flow of persons is therefore also included in the analysis. In the absence of perfectly adequate solutions the traffic flows by ferry and by car, across the Danish border to Germany is used as a base line for the assessment of the development in the flow of vehicles and persons across the screenline between Denmark and Sweden.

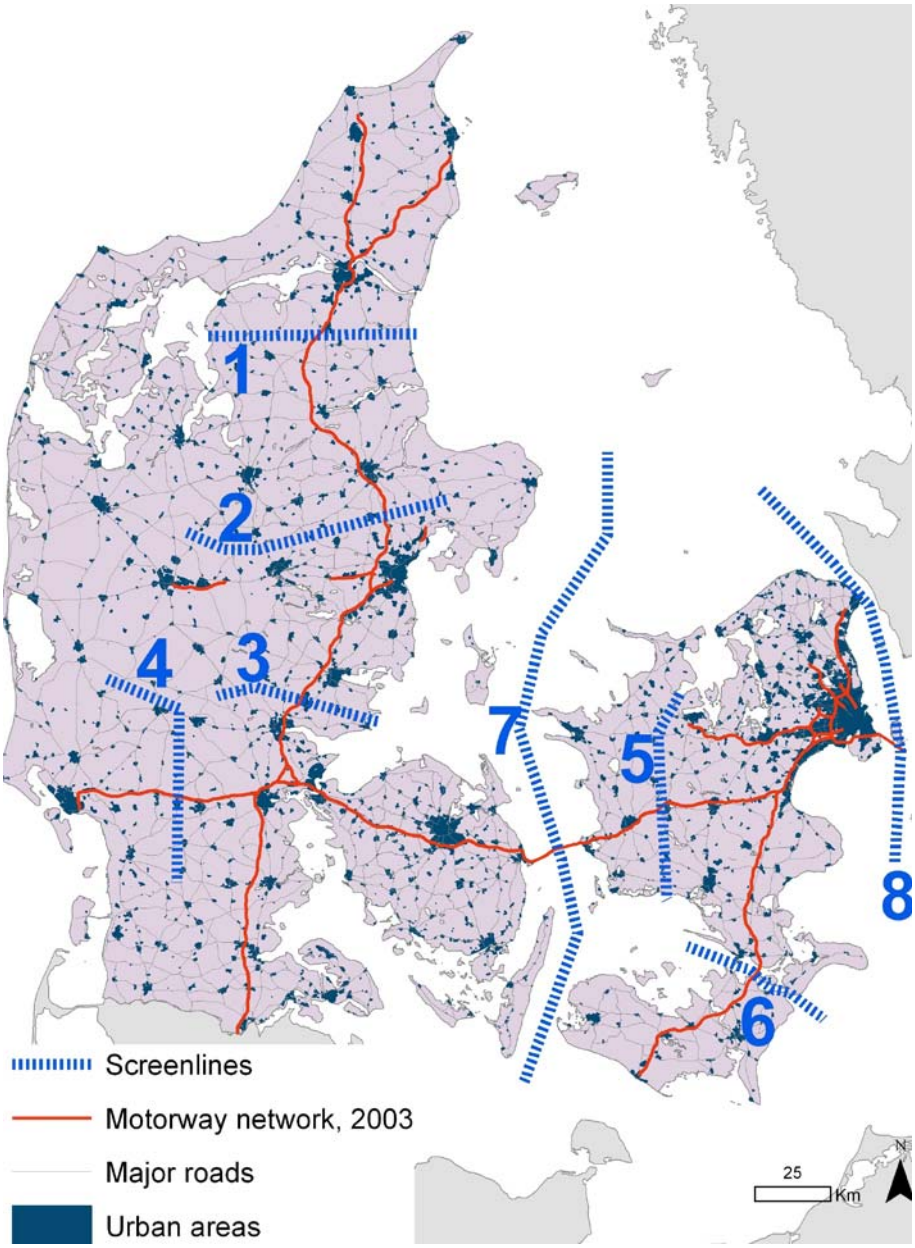

Fig. 1. Location of the 8 screenlines analysed in the paper.

3. Traffic across the screenlines

The developments in traffic flows across the screenlines can be seen in the figures 2-6 for the motorway cases and figures 7-10 for the bridge cases.

For most of the motorway screenlines there seem to have been a relatively constant relationship with the national car traffic index before the time of the opening of the new motorway. This constancy also generally seems to be followed by a trend break after the opening of the new road – indicating the existence of demand induction. The trend break is the most impressive in the case of the Horsens/Vejle screenline on figure 4, followed by the Randers/Aalborg screenline on figure 2 and the Slagelse/Ringsted screenline on figure 6. The trend breaks in the latter two motorway cases are more limited and possibly almost non-existent in the case of the Kolding/Esbjerg screenline in figure 5. In the case of the Kolding/Esbjerg screenline the opening of the motorway section located at the screenline in 1996 does not in itself bring a trend break about. This does not happened before the subsequent opening of motorway sections in 1997 and 1998 has connected the two large cities Kolding and Esbjerg with motorway across the screenline. This indicates the importance of "local" latent demand for the result. However the resulting deviation from trend seems to almost disappear after a few years (figure 5).

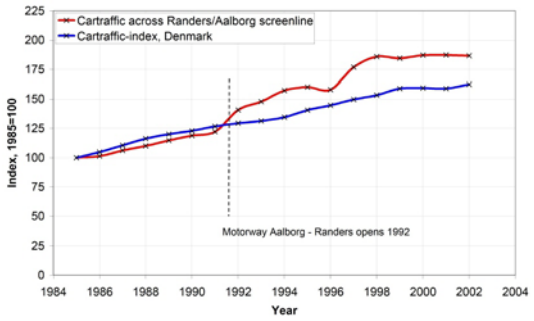

Fig. 2 Cartraffic across the Randers/Aalborg screenline (no. 1 on fig. 1).

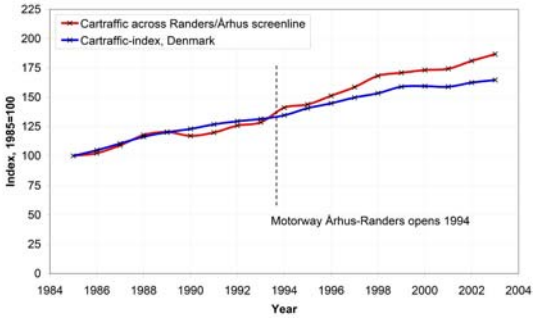

Fig. 3 Cartraffic across the Randers/Århus screenline (no. 2 on fig. 1).

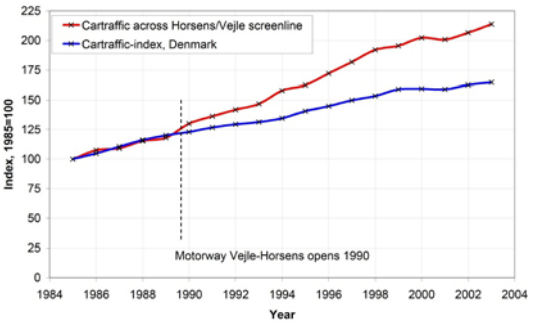

Fig. 4 Cartraffic across the Horsens/Vejle screenline (no. 3 on fig. 1).

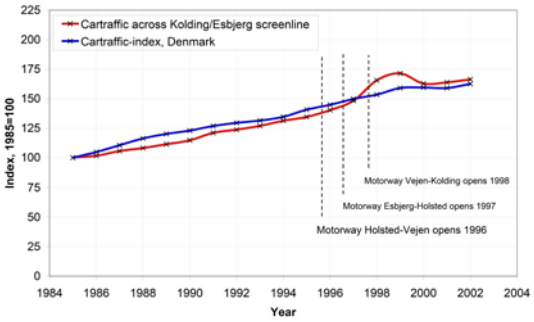

Fig. 5 Cartraffic across the Kolding/Esbjerg screenline (no. 4 on fig. 1).

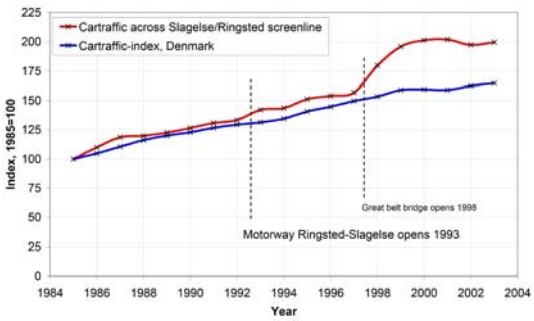

Fig. 6 Cartraffic across the Slagelse/Ringsted screenline (no. 5 on fig. 1).

For the development in traffic flows across the Storstrømmen screenline in figure 7 and the Storebælt screenline in figure 8 there also seem to be a close association with the national index in the years before the opening of the bridge. In the case of Storstrømmen this association more or less proceeds in the years after opening and no clear trend break can be seen. An important explanation may again be the lack of sufficient latent demand. The bridge is located in a largely rural area and the motorway is relatively poorly connected to the population centres of the region. This is contrasted by the development in traffic across Storebælt that followed the opening of the bridge in 1998. In this case there is a strong deviation from the trend which probably reflects the historical importance of this connection as well as its centrality in the Danish urban system. A time series for the development in train passengers across the Storebælt screenline between 1990 and 2003 has been inserted as figure 10 (data from DSB, 2005). The marked trend break seems to affect all (surface) modes of travel.

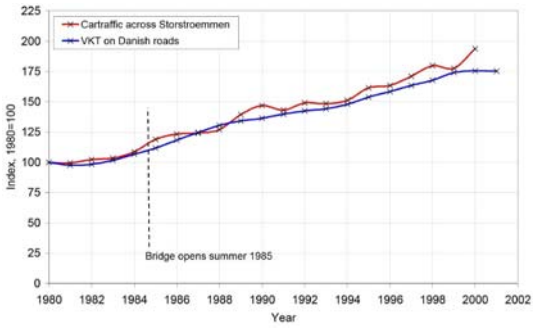

Fig. 7 Cartraffic across the Storstrømmen screenline (no. 6 on fig. 1) compared with Vehicle Km Travelled (VKT) on Danish roads.

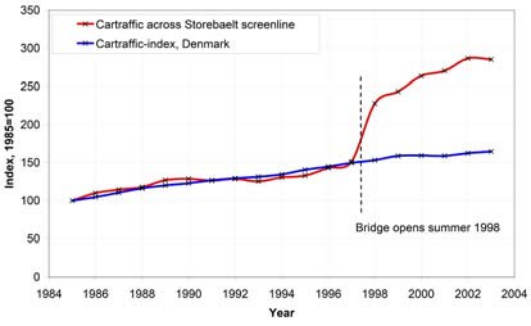

Fig. 8 Cartraffic across the Storebælt screenline (no. 7 on fig. 1)

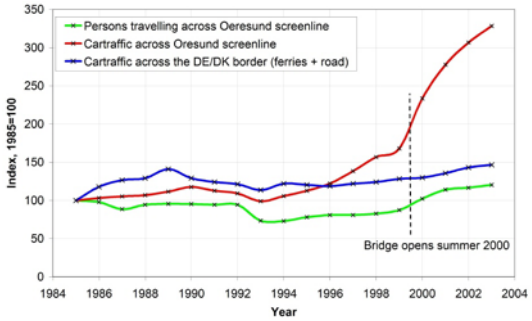

Fig. 9 Cartraffic and persons crossing the Øresund screenline (no. 8 on fig. 1) compared with cartraffic across the Danish/German border.

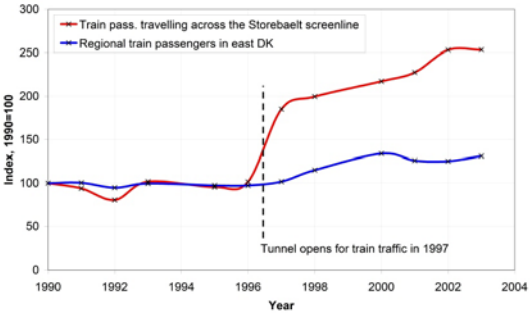

Fig. 10 Train passengers travelling across the Storebælt screenline (no. 7 on fig. 1) compared with the number of passengers in regional train services in east Denmark.

The development across the Øresund screenline and the bridge between Denmark and Sweden is a special case (figure 9). The flow of persons have been included in the analysis as the screenline separates two proximate urban areas – between which boat services has historically been operating. As it makes no sense to compare with the national Danish traffic index – an index for traffic across the Danish-German border is used as an alternative (principally as "control area"). The association between flows of persons and vehicles across the screenline and the control index is less strict and deviations from trend harder to detect. Generally however the flow of persons across the Øresund screenline seems to be broadly similar to the control index. Thus the impact of the opening of the Øresund bridge on the flow of persons between Denmark and Sweden seems to be limited. There is some indication of a positive trend from the years before the opening until after. However the flow of persons have also fluctuated considerably in the

years before the opening and it is to soon to say whether the positive trend from 1999 onwards is lasting.

The development in vehicle traffic across the Øresund screenline contracts the development in the flows of persons. A marked trend break occurs before the opening of the bridge and following the opening year. The vehicle traffic rises 2-3 years before the opening of the bridge in 2000 – but changes pace into an extremely steep rise from 1999 to the opening year 2000 and onwards. The shape of the red curve on figure 9 gives the impression that saturation may occur gradually. Comparing the marked trend break for vehicles with the almost missing trend break for persons travelling across the Øresund screenline – the data indicates that the opening of the Øresund bridge could be associated with a mode change in travel between the two countries – which again would be related to a changing functional relationship between the two urban regions of Greater Copenhagen and Malmø/Skåne as the conditions for interactions across the screenline has been altered following the opening of the bridge.

4. Induced demand

The percentage of the realised demand or flow of traffic across the screenlines that could be described as demand induced by the opening of the new infrastructure element can be estimated if the national traffic index is used as a point of departure for a projection of demand in the "counterfactual" situation where no infrastructure is added. Such an estimate will of course only be indicative of the range of such an effect.

The time series collected for the analysis provides two options for the projection of the demand in the corridor. That is - either simply to assume that the growth in the corridor /across the screenline, in the absence of a new road or bridge, would have been the same as the growth in the national index – or to assume that the growth in the corridor has a fixed proportionality to the national index. In this last instance the relationship between the development in traffic flow through the corridor and the national index will be derived from the part of the time series from before the opening of the new infrastructure. Both approaches were applied in this paper and the result can be seen in table 1. The calculations presented are based on the situation five years after the opening of the road or bridge. This is the longest time horizon that can be applied to the data. In the case of infrastructure effects it is however still a short time horizon and longer term effects may be different.

		Opening year	National growth pct. as forecast	Growth as pct. of national growth
1	Randers/Aalborg screenline	1992	51%	46%
2	Randers/Århus screenline	1994	46%	53%
3	Horsens/Vejle screenline	1990	64%	67%
4	Kolding/Esbjerg screenline	1996	36%	23%
5	Slagelse/Ringsted screenline	1993	11%	10%
6	Storstrømmen screenline	1985	9%	-6%
7	Storebælt screenline	1998	90%	84%

Table 1. Estimates of induced demand in percent of the demand realised five years after the opening. Estimation of the "counterfactual" demand has been attempted on the basis of growth in national traffic index as well as a fixed relationship between screenline demand and the national index derived from a five year period before the opening of the road/bridge.

The estimates of induced demand reflect the deviations from trend in the time series commented upon in the "Traffic across the screenlines" section. Among the motorway cases the three screenlines that had the most marked deviations from trend, the results indicate levels of demand induction between 46% and 67%. The remaining two are between 23 and 36% for Kolding/Esbjerg and around 10% for Slagelse/Ringsted. The latter reflects the combination of high traffic volumes and a limited deviation from the trend from before till after the opening of the new motorway section.
Among the bridges the development in demand for travel across the Storebælt screenline seem to be between 84% and 90% induced by the opening of the Storebælt bridge in 1998. In the case of Storstrømmen demand induction it seems to be close to zero. This probably reflects its status as periphery and the motorway networks poor connection to the larger population centres in the region. The Øresund screenline has been left out of the calculation in table 1 as its basis of comparison differs from the other cases. Using the traffic across the Danish-German border as a baseline for comparison the Øresund bridge do however seem to reach a level of demand induction comparable to the Storebælt bridge: 85% for vehicles and around 60% for persons.

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