The Third Limfjord Crossing– a case of pessimism bias and knowledge filtering

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Abstract

Using the Environmental Impact Assesment (EIA) of the proposed Third Limfjord Crossing in Aalborg, Denmark as an example, this paper discusses how *pessimism bias* against the no-build alternative acted as an instrument to persuade decision-makers into adopting a proposed road scheme. Assuming that traffic growth would be the same whether or not a new motorway was constructed, the planners in the Limfjord case concluded that intolerable congestion would arise in the absence of increased road capacity. The paper discusses how such bias was created through the assumptions of the Limfjord case traffic model, and gives an outline of the planning and decision-making process in which the model was used. The latter includes a formal complaint opposing the motorway project and the responses to this complaint. The paper concludes that a process of knowledge filtering has taken place, where state-of-the-art knowledge about induced and generated travel ended up being dismissed in the political and legal decision-making system.

1. Introduction

Experience from a number of large-scale investment projects has shown that the traffic forecasts for these have often been insufficient and sometimes misleading. Among 183 road projects investigated by Flyvbjerg, Holm & Buhl (2006), one half had a deviation between forecasted and actual traffic of more than ±20%, and one fourth more than ±40%. The situation among the 27 rail projects investigated was even worse. For more than nine of ten such projects, the forecasts overestimated the number of passengers. On average, the number of passengers was less than half of the estimated number (ibid.). Based on these findings, Flyvbjerg et al. (2005) concluded that the forecasting work of the road projects were more accurate than the corresponding projections of the demand for rail links. Among the Danish road projects in Flybjerg's database, a tendency was still found of underestimated traffic forecasts coinciding with a period where national policies aimed at limiting traffic growth (Næss, Flyvbjerg & Buhl, 2006).

Mackie & Preston (1998) have identified 21 different sources of error and bias in transport project appraisal. These were related to objectives, definitions, data, models and evaluation conventions. According to Flyvbjerg (2007), there are three main types of explanations for forecasting errors in the planning of transport infrastructure projects: technical, psychological and political-economic explanations. Technical explanations attribute forecasting errors to shortcomings in the forecasting techniques, inadequate data, the inherent uncertainty in predicting the future, 'honest mistakes', etc. Psychological explanations refer to a widespread human tendency of wishful thinking, causing project promoters and planners to underestimate problems and exaggerate benefits of proposed projects. Such 'optimism bias' will typically result in underestimated construction costs and environmental impacts and exaggerated benefits in terms of congestion relief or new public transport passengers. The political-economic explanations depict project promoters and planners as deliberately and strategically overestimating benefits and underestimating costs in their forecasts in order to increase the likelihood that the projects will obtain approval and funding. (Ibid., pp. 583-584).

Due to the prevalence of cost overruns among both types of projects, Flyvbjerg (2007) considered technical explanations to be unlikely to account for the clear tendency of forecasts to depict road projects as well as rail projects as more favourable than they actually turn out to be. On the basis of interviews with planners and the observation that experience with previous forecasts did not seem to reduce forecasting errors, Flyvbjerg (ibid.) concluded that strategic misrepresentation was a more plausible explanation than optimism bias.

All the analyses of the Flyvbjerg database were based on comparisons of forecasted and actual outcomes of transport infrastructure projects. The psychological and the political-economic explanations referred to forecasts giving a too positive picture of the number of passengers or vehicles on the proposed infrastructure. Flyvbjerg's analyses did, however, not mention forecasts of the alternatives that were *not* implemented (including the 'zero', or no-build, alternative). As will be argued in this paper, erroneous forecasts of the zero alternative may be an important source of bias in road infrastructure planning. The absence of a clear pattern of deviation between predicted and actual traffic volumes for road projects in Flyvbjerg's database thus does not necessarily imply that traffic forecasts for road projects are not systematically biased. Strategic misrepresentation may instead take the form of an unrealistically negative description of how the future situation will be in the absence of the proposed new infrastructure. This type of error has so far not been described much in the literature and is mentioned neither in the various articles by Flyvbjerg and his colleagues nor among the 21 types of error and bias listed by Mackie & Preston (1998).

Using the EIA of the proposed Third Limfjord Crossing in Aalborg, Denmark as an example, this paper discusses how relevant knowledge about induced traffic was filtered away from the planning and decision-making process. By forecasting traffic to grow by the same rate whether or not a new motorway would be built, the 'no-build' alternative could be presented as highly undesirable, thus persuading decision-makers into adopting the proposed road scheme.

The paper draws on theories from different fields. Theories of induced travel are used to demonstrate the inappropriateness of the traffic model on which the forecasts were based, whereas theories of institutions, discourse, decision-making, power, and the use of knowledge are drawn on to shed light on possible explanations for the inappropriate modelling practice seen in the Limfjord case. Moreover, the biased forecasts encountered in the case study are discussed in the light of the body of literature on forecasting inaccuracy in transport infrastructure planning.

2. The proposed Third Limfjord Crossing

Aalborg is situated at both sides of the Limfjord in Northern Jutland and is Denmark's fourth largest city. A four-lane bridge for road traffic and a railway bridge today cross the Limfjord close to the city centre. In addition, the main highway (E45) crosses the Limfjord in a six-lane tunnel 3 kilometres to the east of the city centre. The possibility of constructing a third road connection across the Limfjord has been discussed between local, regional and national authorities for more than three decades. In order to avoid future congestion problems on the road network, an Infrastructure Committee established jointly in 2000 by the Municipality of Aalborg, the County of North Jutland and the Ministry of Traffic recommended the 3rd Limfjord Crossing to be built. An EIA of three different schemes for this crossing was presented in the spring of 2003. After public hearing, the County of North Jutland adopted an amendment to the County Plan in the autumn of 2003, including land reservation for a 450 million Euros motorway link of 20 km with access roads. Three alternative lines of the Third Limfjord Crossing were envisaged: the Egholm Line, the Lindholm Line and the Parallel Tunnel (see Figure 1). Among these the Egholm Line was chosen.

Figure 1: *The three alternative solutions for a Third Limfjord Crossing included in the EIAs in 2003 and 2006.* Source: Danish Road Directorate (2009a).

However, several formal complaints were submitted against the EIA report. Two of these complaints criticized the EIA for lacking assessment of the impacts on habitats and species protected by EU legislation, whereas a third complaint criticized the County for having rejected to include in the EIA an alternative aiming to avoid traffic growth through restrictions on auto usage and substantially improved public transport. The two former complaints were accepted by the Nature Protection Board of Appeal.

The third complaint was accompanied by an academic assessment (written by a professor in urban planning on request (Næss, 2003)) of the validity of the County's arguments for refusing to include the traffic reducing alternative. The paper criticized the underlying premise of the County's claim, namely that traffic growth would be equally high if traffic reducing measures were implemented as it would be with motorway construction and no particular prioritization of buses and bikes. The paper also pointed to the fact that the EIA did not discuss – or even mention – any uncertainties and weaknesses in its own assessments of environmental impacts, although the Ministerial Guidelines state that the inclusion of such a discussion is "highly important" (Ministry of the Environment and Energy, 1996, p. 60). A second paper was later on submitted arguing more in-depth against the claims put forth below by the County in their defence of their estimates (Næss, 2004a).

As part of the handling of the complaint, the Board of Appeal asked for comments from the County of North Jutland. The County withheld its standpoint, referring, among other things, to traffic model calculations conducted in 1998 predicting that a replacement of 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% (in total, not annually!), and would result in an increase in the total vehicle kilometres of car traffic by 0.75% (County of North Jutland, 2004). 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)

In 2006, the Nature Protection Board of Appeal decided to reject the complaint. Concerning the traffic elucidations, the Board stated that "[t]here is no base for rejecting the material as obviously incorrect." (Nature Protection Board of Appeal, 2006, p. 12) However, the Board's acceptance of the complaints regarding impacts on habitats and species protected by EU legislation implied that the land reservation for the Egholm motorway was no longer valid. A new EIA report therefore had to be produced, with more in-depth analyses regarding the influence of the proposed road on protected habitats (Danish Road Directorate et al., 2006). Again, the same traffic model calculations were used.

The future responsibility for the project is still unclear. Implementation will probably require that the national government contributes with the major part of the funding.

3. Some main conclusions of the EIA report

The EIA reports published in 2003 and 2006 are fairly similar, but the latest report includes an extended chapter on terrestrial and marine environment, compared to the 2003 report. Both reports discuss a number of different expected environmental impacts of the proposed motorway alternatives and their related access roads, such as impacts on landscapes and ecosystems, consequences for outdoor recreation interests, groundwater changes due to construction work, etc. We shall not go into these kinds of impacts here. The focus will instead be on the traffic related environmental consequences: energy consumption, air pollution, noise, and traffic accidents.

In the environmental assessments, the three motorway construction alternatives were compared to a 'baseline' alternative, the latter presented as the situation in the year 2015 if no new road is constructed. The planners concluded that the projected traffic growth would cause the average speed on the two existing crossings of the Limfjord in the peak period to drop from present levels of 20 km/h and 55 km/h, respectively, to 15 km/h and 20 km/h in 2015 in the absence of increased road capacity across the fjord. With motorway construction, congestion would instead be reduced. Table 1 shows the results presented in the 2006 EIA report regarding energy use, various air pollution components, and noise.

Table 1: Predicted energy use, air pollution and noise in the baseline alternative and in the three motorway alternatives. Source: 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

As can be seen, the motorway alternatives are predicted to reduce energy use, air pollution, the general exposition to noise (although a few more dwellings will be affected in the Egholm alternative) and the number of traffic accidents involving personal injury, compared to the situation if no motorway is constructed. In the table no explicit figures for greenhouse gas emissions are shown. They are, however, mentioned in the section dealing with profitability. Here, the three motorway alternatives are predicted to yield the following annual savings due to lower greenhouse gas emissions: the Egholm Line DKK 1,075,000; the Lindholm Line DKK 1,439,000; and the Parallel tunnel DKK 611,000.

The traffic volume (measured in vehicle kilometres) differs very little between the alternatives, as can be seen in Table 2. The slight increase in the number of vehicle kilometres by car in the motorway alternatives is due to the future channelling of a larger proportion of the traffic along routes deviating from the straight line between origins and destinations (cf. Figure 1). Apart from this, traffic growth is the same in the motorway alternatives as in the baseline (2 % annually).

Table 2: Predicted traffic volumes for cars, vans and trucks in the baseline alternative and in the three motorway alternatives. Millions of vehicle kilometres annually. Source: Danish Road Directorate, County of North Jutland and Municipality of Aalborg (2006), p. 60.

	Baseline	Motorway, Egholm Line	Motorway, Lindholm Line	New parallel motorway tunnel
Cars	1408	1417	1410	1411
Vans	110.0	109.3	108.8	110.1
Trucks	64.0	63.6	63.6	64.0

4. Assumptions of the traffic model

The predictions about traffic volumes have been carried out by means of the so-called Aalborg Traffic Model, with 2015 as the time horizon. The forecast of traffic volumes in 2015 was 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 et al, 2006, p. 14). The EIA documents do not provide any information about the kinds of causal mechanisms that have or have not been included in the traffic model. The fact that no information is provided about this is in itself a demonstration of the black-boxing character of the model. It is thus not explicitly stated whether or not the model takes the effect of induced traffic into account. However, the fact that the traffic growth is the same in the motorway alternatives as in the baseline alternative clearly indicates that the phenomenon of induced travel has not been incorporated into the traffic model. The omission of induced traffic in the model has also been confirmed in a recent research interview (in the summer of 2010) with one of the planners involved in the transport model forecasts of the Third Limfjord Crossing (Tøfting, 2010).

The non-inclusion of induced travel in the model is sharply at odds with state-of-the-art knowledge about impacts of road improvements on traffic volumes. Theories of transport economics and transport geography as well as a number of empirical investigations in various countries (see, e.g., SACTRA, 1994 and the extensive review papers by Noland & Lem, 2002 and Litman, 2010) indicate that road development facilitating higher travel speeds will result in generated and induced traffic[1] by influencing:

– route choice
– the proportion who prefer to travel in the peak period
– the amount of travel
– the modal split
– land use (in a longer term)
– the quality of the public transport services (in a longer term)

Among these six effects, the four latter contribute to induced traffic, whereas the two former contribute to generated, but not induced traffic. Changes in the amount of travel (longer and/or more frequent motorized trips) and in the modal split (a higher share of car travel) occur in a relatively short time after road capacity has been improved. These immediate changes are reinforced by long-term effects. This long-term induced traffic occurs partly because roads facilitating higher travel speeds by car contribute to more dispersed location of residences, jobs and services, and partly because such built environments are difficult to serve by public transport. In addition, the higher shares of car travel resulting from the short-term changes in modal shares usually reduce the revenues of the public transport companies, who typically compensate for this by reducing their services and/or increasing the fares (Downs, 1962; Thomson, 1977; Mogridge, 1997).

The need to include induced traffic in the forecasting model is emphasized in state-of-the-art literature on traffic modelling. For example, in a recent European handbook on transport modelling (based on a large international research project surveying more than 300 European transport models) it is stated that:

> "The effect of an increase in supply, i.e. an increase in capacity, is relevant to transport analysis as this brings about induced demand. It may also bring about environmental consequences, which are usually significant. … Including these externalities in the analysis should be a part of any transport policy analysis."
> (MOTOS, 2007, Part 1 & 2, p. 60.)

The magnitude of induced traffic of course varies with the geographical and social context. The strongest effects occur in cases where the road network is utilized close to its maximum capacity before the construction of the new road. Judged from several British and American studies reviewed by Noland & Lem (2002) and Litman (2010), a 10% increase in road capacity (measured in the number of kilometres of lanes for car traffic) in a congested transport corridor typically results in an immediate traffic growth of 3-5% and in a longer term (over 5 to 10 years) an increase of 5-10%. The forecasting error from ignoring induced traffic can therefore be substantial.

Although disregarding induced traffic in the quantitative forecasts, the discussion in the Limfjord EIA report points to the fact that the new road will accommodate long-term traffic growth. This traffic growth is, however, depicted as inevitable:

> "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)

The traffic model used in the Limfjord case is by no means unique in a Danish context. In EIA of Danish transport infrastructure projects it is commonplace that the forecasts show very similar traffic volumes in the road construction alternatives and in the baseline alternative. For example, in the EIA of a planned motorway through and/or around the city of Silkeborg, the energy use and $CO2$ emissions in each of three motorway layout alternatives are forecasted to be only 1% higher than in the baseline alternative. There is no mentioning of induced traffic. (Danish Road Directorate, 2006a, pp. 148-149.) On the contrary, traffic in this corridor is forecasted to grow by 2% annually in all alternatives including the baseline alternative (Danish Road Directorate, 2006b, p.81). The motorway alternatives are still forecasted to result in a slight increase in the total number of vehicle kilometres. This is, however, only a result of traffic being diverted to the motorway from existing, smaller roads, where a considerable traffic reduction is supposed to occur. This assumption disregards the fact that the initial reduced congestion level on these roads is likely to attract new motorists, causing traffic to increase again. According to the EIA report, “most travellers do not mind driving a longer distance if they can save time by using a new and fast road connection” (ibid., p. 85). Similar to the Limfjord case, the Silkeborg traffic model thus takes into consideration how a new motorway can change the distribution of traffic flow in a network of roads, but not its contribution to overall traffic growth.

A third example: in a recent EIA for the extension of the motorway between Greve and Køge from 6 to 8 lanes, a total traffic increase of only 0.3% is assumed on the road network influenced by the road capacity increase. Also, virtually no difference is expected whether or not the motorway extension is combined with the construction of a new parallel railroad along the motorway. (Danish Road Directorate, 2009b, p. 146.)

The entirely or nearly identical forecasts for traffic growth in the motorway construction alternatives and the baseline alternatives in the above examples should come as no surprise, given the fact that only very few among the Danish traffic models currently in use take induced traffic into consideration. According to Nielsen & Fosgerau, (2005), induced travel is usually underestimated or totally ignored in the analyses on which decisions about larger Danish road projects are based. In the best cases (notably the Ørestad Traffic Model, OTM), the models consider only immediate increases in traffic[2]. In the worst cases, including the present Danish National traffic model and most Regional models, induced traffic is ignored altogether. (Nielsen & Fosgerau, ibid.). The transport model used for the forecasts in the recent report of the Danish Infrastructure Commission (2008) disregards the effect of congestion as a deterrent against further traffic growth in a given road network. Traffic is therefore assumed to grow at a fixed rate, even in situations where driving speeds have been significantly reduced due to congestion resulting from prior traffic growth (Danish Infrastructure Commission, 2008, p. 127).

Neglecting of induced traffic is, as can be seen above, commonplace in Danish traffic model forecasting so far. It is not within the scope of this paper to provide an overview of the extent to which traffic models in countries other than Denmark take induced travel into account. However, disregard of induced traffic is certainly not an isolated Danish phenomenon. According to the above-mentioned European handbook containing guidelines for constructing national and regional transport models, ‘many traffic models overlook induced traffic despite empirical evidence of the importance of this’ (MOTOS, 2007, Part 3, p. 24). Before the late 1990s, induced travel was generally ignored in the traffic models used in Norwegian transportation planning (Minken, ibid.). According to Marte (2003), induced travel has usually been ignored or considerably underestimated in transport modelling and planning in Germany. Similarly, Button and Henscher (2001, p. 125) state that most urban road studies in many countries are based on traffic models that use fixed trip matrixes, in which both total travel and its distribution are independent of the state of the network. Although the situation may have changed since 2001, traffic models neglecting induced traffic seem to be widespread in project evaluation. The frequent use of fixed matrixes is also criticized in the European MOTOS handbook (MOTOS, 2007, Part 1 & 2, p. 100.) According to Litman (2010, pp. 10-11), most current traffic models can predict route and mode shifts, and some can predict changes in scheduling and destination, but few adjust trip frequency, and most ignore the effects transportation decisions have on land use. The above criticism adds to similar arguments put forth through more than two decades by scholars such as Mogridge (1990, 1997); Newman & Kenworthy (1989); Kenworthy (1990); Arge et al. (2000) and Tennøy (2003).

In some more recent models, induced traffic has been incorporated. For example, in the United States, several traffic models that include induced and generated traffic – at least to some extent – have been developed (Litman, 2010, p. 11). According to Nielsen (2010, personal communication), the most recently developed Swedish traffic models include induced traffic and could generally be considered as examples of European-level 'best practice'. In Norway, two transport models for the Oslo region (FREDRIK and RETRO) recognize that congestion reduces the attractiveness of car travel. These models hence assume lower traffic growth if congested roads are not expanded than if the road capacity is increased (Minken, 2005). In Denmark, research and development work is currently going on in order to create a new National Traffic Model in which full account of induced traffic will be taken (Nielsen, 2010, personal communication).

5. Exaggerated benefits, underestimated negative environmental impacts

A well-known quote from the play "Peer Gynt" by the famous Norwegian dramatist Henrik Ibsen reads as follows: "When the starting point is at its weirdest, the result is often most original." This appears to apply particularly well to the EIA of the proposed new motorway across the Limfjord: Building a new motorway will reduce energy use, diminish greenhouse gas emissions, improve air quality, reduce exposure to noise, and save lives and limbs from traffic accidents. If this is to be believed, it would almost be environmentally irresponsible not to build the new motorway.

As can be seen when comparing Tables 1 and 2, the increase in road capacity represented by the new motorway across the Limfjord and associated access roads is assumed to improve overall travel speeds, reduce emissions per vehicle kilometre and (mostly due to the lower number of crossings when driving on a motorway) and improve traffic safety. However, because the assessment ignores induced and generated traffic, these benefits are likely to be considerably exaggerated. Induced travel implies that the new road capacity will gradually start to fill up again, which will eventually cause traffic speeds to drop. The neglecting of this has caused the traffic modelling expert Otto Anker Nielsen to state that "time-saving benefits tend to be clearly– and systematically – overestimated in the documents forming the basis for decisions about larger Danish road" (Nielsen & Fosgerau, 2005). Moreover, lower-than-forecasted improvement of congestion relief implies that energy use per vehicle kilometre will be less improved than indicated by the model simulations. In addition, the number of vehicle kilometres will also be higher due to induced travel. Most likely, therefore, total energy use and greenhouse gas emissions will be considerably increased instead of being reduced.

Induced travel also implies that more people will be exposed to the risks of traffic accidents. And since trips do not start and end on the slip roads of the motorway, but from origins to destinations all over the city and the region, the increasing traffic caused by the new motorway will expose a larger number of people to risk of accidents along local roads. The same applies to local air pollution. These effects may well outweigh the lower safety risk and emissions per vehicle kilometre – other things equal – of motorways, compared to other roads.

Moreover, the Limfjord impact assessment of energy use and carbon dioxide emissions seems[3] to take into account the gains from avoiding speed levels within the energy-inefficient range below 40 km/h but not the fact that an increase in traveling speeds beyond 80-90 km/h entails a considerable increase in energy use per vehicle kilometre (IEA, 2005; Wang et al., 2008).

The above-mentioned shortcomings of the model simulations all tend to depict the proposed road in a more positive light than what would have been the case if the missing causal mechanisms had been included in the calculations. We shall return to the implications and possible explanations of this in a later section of the paper.

6. Pessimism bias against the 'no-build' alternative

Paraphrasing the term of 'optimism bias' used by Flyvbjerg et al. (2005, 2006) about forecasts giving a too positive picture of an investigated alternative, I will use the term 'pessimism bias' about forecasts depicting an investigated alternative in a too negative manner. I here understand the term 'bias' in a political/sociological sense, as bias against a particular policy (i.e. not to expand road capacity) and in favour of widely held ideals among a group of professionals (more specifically, the predict-and-provide ideal among the road planning community). Pessimism bias thus refers to a practice of drawing an unrealistically negative picture of the results of not following a proposed policy[4]. By forecasting that intolerable congestion would arise in the absence of increased road capacity, the traffic model forecasts in the Limfjord case produced pessimism bias against the no-build alternative. The traffic model thus depicted the construction of a new motorway as something necessary in order to avoid a future situation commonly held to be undesirable. Technically, the pessimism bias emerged through the model's assumption of identical traffic growth regardless of whether or not a new motorway would be constructed.

Arguably, pessimism bias is a quite common phenomenon in debates about proposed policy measures. At a geopolitical scale, the 'necessity' of going to war against Iraq in order to prevent Saddam Hussein from attacking Western countries with weapons of mass destruction might serve as an example. A more recent example from the Danish political debate of depicting a gloomy future situation unless certain policies are followed is the ways in which forecasted growth in the number of pensioners is used to legitimize a dismantling of the Danish welfare state (disregarding the fact that the forecasted growth in the number of pensioners is outweighed by a stronger forecasted growth in the general level of affluence).

One might perhaps expect that omitting induced travel would result in underestimated forecasts of the future traffic on the proposed new roads. However, in the Danish cases the error resulting from neglecting induced travel is arguably an overestimation of traffic growth in the no-build alternative rather than an underestimation of traffic growth in the build alternatives. In the above-mentioned Danish EIAs (except the one for Motorring 4, where short-term induced travel was taken into account), a common traffic growth rate of 2% annually for the build- and no-build alternatives has been assumed. This growth rate is similar to the observed traffic growth during recent decades along main Danish transport routes and is also similar to the national forecasts for future traffic growth, e.g. in the report by the National Infrastructure Commission (2008) for the period until 2030.

There are of course a number of unavoidable uncertainties associated with traffic growth forecasts. Changes in oil prices may for example alter the conditions for traffic increase. The national traffic growth forecasts do, however, not seem to be obviously off the mark, given a continuation of business-as-usual policies. The hitherto observed traffic growth is partially a result of road investments having facilitated this growth. Without these investments, people would not to the same extent as today have chosen distant destinations, and a higher proportion than today would have chosen other modes than the car. In other words, in the absence of road improvements, traffic growth would not have followed the same trajectory as the observed development.

Arguably, the main error resulting from neglecting induced travel is therefore – at least in the Danish context – an exaggeration of traffic growth in situations where no road capacity increase takes place. As shown in the Limfjord case and also highlighted in the report from the National Infrastructure Commission (2008), 2% annual traffic growth without road capacity increase will in most urban regions result in increasing congestion and a strong decrease in average traffic speeds. However, if traffic flows deteriorate to the extent forecasted in the no-build situation, the congested roads will not attract the same number of additional vehicles as in a situation where congestion is relieved through road capacity increases. This deterrent effect of congestion is, however, not taken into consideration in the traffic models where induced traffic is neglected. Interestingly, the omission of the deterrent effect of congestion is mentioned as a source of error in the report by the National Infrastructure Commission (2008, p. 137), but this did not prevent the chairman of the committee from using a calculated 5-hour daily commuting time among some residents of Copenhagen Metropolitan Area in the absence of road capacity increases as an argument for the necessity of massive investments in new road building (Aagaard-Svendsen, 2007).

If the above arguments about the frequent occurrence of pessimism bias against the 'no-build' alternative are valid not only in a Danish context but also internationally, evaluation of forecast inaccuracy based on comparison of forecasted and actual traffic on implemented road schemes may be insufficient in order to discover forecasting bias. In the studies carried out by Flyvbjerg and his colleagues (Flyvbjerg et al., 2005 and 2006;

Flyvbjerg, 2007), forecasts for rail projects were found to be systematically biased with a gross overestimation of the number of passengers for most of the projects. Flyvbjerg attributes this bias to strategic misrepresentation rather than to technical deficiency or wishful thinking. Distinct from the investigated rail projects, forecasting errors for road projects were found to be much more evenly distributed around the mean, yet with a small average tendency (9%) of underestimated traffic volumes. Judged from comparisons of forecasted and actual traffic volumes for implemented infrastructure projects, it might thus seem as though road planners generally make more 'honest' forecasts than their counterparts making forecasts for rail projects. It is, however, difficult to imagine that road planners are ethically superior to their rail planning colleagues. If strategic misrepresentation is a phenomenon occurring in forecasting of road traffic as well as for rail traffic, the reason why it is not discovered in comparisons of forecasted and actual traffic volumes might be that the forecasting errors apply to the 'no-build' alternatives rather than to the implemented schemes.

It would, of course, be necessary to collect data about forecasted traffic volumes in the 'build' and 'no-build' alternatives as well as actual traffic on the implemented schemes for a large number of road projects in order to substantiate how frequently pessimism bias occurs[5]. However, given the fact that many models ignore induced traffic and hence will produce similar corridor-level traffic forecasts for the 'build' as for the 'no-build' alternatives, and the fact that these forecasts are often based on historic trends of traffic increase where some of the observed increase has been induced by prior road capacity increases, it seems plausible to assume that traffic models ignoring induced traffic will tend to produce overestimated forecasts for the 'no-build' alternatives rather than underestimated forecasts for the 'build' alternatives.

7. Unreliable traffic forecasts: technical, psychological, institutional and political explanations

As mentioned in section 2, forecasting errors in transportation planning have been attributed to technical, psychological and political-economic reasons (Flyvbjerg, Holm & Buhl, 2006; Flyvbjerg, 2007). In addition to these categories of explanations, the discussion below will also include the influence of institutional-organizational conditions.

Clearly, there are technical explanations of the implausible assessments of traffic-related environmental impacts in the Limfjord case. The traffic models simply do not take into consideration the causal mechanisms by which road capacity increases under congested conditions tend to result in increased traffic. This is consistent with the causes of forecasting inaccuracies stated by project managers and evaluators interviewed by Flyvbjerg, Holm & Buhl (2006). Among 208 investigated road projects, errors in the estimation of trip generation, trip distribution or in the forecasting model generally were mentioned as causes of inaccuracy by, respectively, 27%, 23% and 22% of the respondents. In addition, land use development was mentioned as a cause of error by 26%. The latter source of error corresponds well with the inability of most traffic models to account for long-term effects of induced travel, cf. section 4.

However, the technical error of disregarding induced travel may perhaps not be purely technical. Arguably, there may be a certain overlap between such apparently innocent projection errors, and errors caused by the organizational context of forecasting. The insensitivity of traditional traffic models to induced travel has been criticized by transport researchers for decades (see, among others, Newman and Kenworthy, 1989; Kenworthy, 1990; Arge et al., 2000; Tennøy, 2003). As mentioned earlier, it is possible to develop models that include induced and generated traffic (Litman, 2010). When traffic modellers still continue to construct models disregarding induced travel, and transportation planners and policy-makers continue to use the results of such model calculations as arguments in favour of project implementation, part of the reason could be that the model results tend to fit well with the interests of project promoters. Let us therefore turn to some alternative explanations of forecasting errors.

Optimism bias due to a human psychological tendency of wishful thinking has been suggested as a source of forecasting errors by some authors, including the Bank of Sweden Nobel Memorial Prize awarded psychologist Daniel Kahneman (1994). However, this does not seem a plausible explanation of the lack of inclusion of induced travel in the traffic models used in the Third Limfjord Connection EIA. As mentioned above, the forecasts for traffic growth in the motorway alternatives are probably not very much off the mark. Rather, the forecasts for the no-build alternative could be characterized as pessimism bias. Such bias does not fit with the psychological explanation of forecasting bias based on wishful thinking. Moreover, the pessimism applies to alternatives that the project promoters did not want to have realized and which they hardly expected would be implemented.

Let us therefore instead focus on political-economic and organizational-institutional explanations. Defective forecasts sometimes result from lack of knowledge and too narrow horizons among the professionals performing the analysis. Lack of cross-sector integration in public administration may be a related cause of too narrow analyses. The sectors represent different "cultures" in terms of dominating values, attitudes and opinions about which needs are the most important. The actions of the employees are often strongly influenced by established rules, standard operating procedures and routines (Olsen, 1992). Within a segment of public administration a culture typically develops according to which certain solutions are considered to represent ‘progress’ while alternative solutions may be perceived as ‘inferior’ or ‘primitive’. Providing the best possible conditions for car travel may thus persist as a professional ideal within many highway administrations in spite of political goals of limiting urban motoring. Pressure from other sectors of society urging an agency to downsize traditional tasks may easily be perceived by the employees as a threat against their jobs.

In some cases, forecasters have been exposed to strong pressure from elected officials (Flyvbjerg, 2007). For example, when a new railroad line was planned to Oslo’s airport at Gardermoen in the 1990s, the forecasters were told to disregard the existing bus services and slower but cheaper regional trains in the forecasting models used to predict the number of passengers of the new line (Johansen, 2005, personal communication). As a result, the forecasts overestimated the actual number of passengers by 67% (NOU

1999:28). Among politicians in Northern Jutland, there has been – and still is – a strong belief in motorway construction (Region of North Jutland, 2007). We have, however, not had access to any information showing whether or not politicians have put any explicit pressure on the forecasting process in the Limfjord Connection case. Probably, any political influence on the forecasts has been more sophisticated and indirect: if the transport planners know that the politicians strongly favour the construction of the new motorway, they may be less concerned about shortcomings in the traffic model if remedying these shortcomings would only weaken the arguments in favour of the politically much wanted new road scheme.

Summarizing, there are obviously technical explanations of the implausible traffic forecasts and assessments of traffic-related environmental impacts of a Third Limfjord Crossing, as the traffic models simply ignore induced travel. But the reasons for sticking to such an inadequate model are probably political-institutional. In spite of repeated criticism from researchers[6], the traffic consultancy company responsible for the model simulations as well as the traffic planners have been unwilling to admit that the forecasted equal levels of traffic growth in the alternatives with and without motorway construction are implausible and misleading. It is, however, difficult to distinguish which of the two sources of bias – political pressure or institutional inertia – has exerted the strongest influence. Rather, it seems like the professionals as well as the majority of politicians have all operated within a 'predict-and-provide' paradigm where infrastructure development making it easier to drive by car have been seen as entirely positive.

8. A case of knowledge filtering

Nowadays, it is not common to find academic studies denying the traffic-generating impact of road capacity increases in congested transport corridors. However, among policymakers and politicians, there seems to be a quite widespread belief in the possibility of significantly reducing congestion through road construction. For example, in 2005, the previous Danish Minister of Transport and Energy stated that an expansion of the road network is the recipe for overcoming congestion:

> "Long queues of cars will no longer exist in 20 to 30 years. Within this time, I believe that the motorway network will have been expanded in accordance with the needs."[7]

As observed by Chang (2007), in several cases of environmental controversies the actors sceptical to the dominant scientific view represent political-economic dominance, while their opponents represent scientific dominance. The burden of proof is often asymmetrically distributed. Those who seek to change the status quo and challenge powerful interests have the greatest need for resources to 'rationality' (Flyvbjerg, 1998).

However, in spite of the evidence now available about induced and generated traffic, the academic criticism against the use of inadequate traffic models in the Limfjord case was not able to win through in the practical planning and decision-making process. The Limfjord planning and decision-making process is thus a case of *knowledge filtering*, defined as suppression of knowledge which would otherwise have been relevant in the given context. The social order within segments of society involved in a particular activity (here: road construction) will be bolstered if the policies pursued within this field are widely perceived as beneficial and based on solid knowledge. It will therefore be in the interest of actors economically or ideologically tied to certain policies to ensure that the impacts of these policies are widely held to be in line with social objectives (Barnes, 1988, quoted from Haugaard, 2003). Knowledge claims raising doubt about the compatibility of dominating practice within these areas with social goals, e.g. about environmental sustainability, may thus not be welcomed by these actors.

According to Haugaard (2003), knowledge claims can be seen as acts of 'structuration', where only these claims validated through 'confirm-structuration' by relevant other people obtain the status of valid knowledge. However, the process of 'confirm-structuration' may follow different procedures in different parts of society, and the outcome of these processes may also be different. Scientific validity criteria will probably exert a stronger influence on the formation of assumptions and beliefs among researchers studying a phenomenon than among politicians and stakeholders influencing or affected by the phenomenon in question. Thus, knowledge considered highly credible among researchers within a field may still be met with scepticism among policy-makers and stakeholders (Flyvbjerg, 2002). Psychological processes of 'cognitive dissonance' (Festinger, 1956) may be part of the explanation why 'inconvenient truths' are disregarded or outright rejected.

In the Limfjord case, the Nature Protection Board of Appeal stated that there was no base for rejecting the results of the traffic model calculations and the associated estimates of energy use and emissions as obviously incorrect. Thus, in spite of the academic arguments presented during the process and in the complaint, the highest authority in the Danish society on planning issues judged that this knowledge did not provide a base for rejecting the claim that constructing a motorway across the Limfjord will reduce the overall energy use, emissions, noise and traffic accidents. This seems to be a textbook example of how scientific rationality on the one hand and the power of vested interests and entrenched politics on the other hand struggle to determine what comes to count as credible knowledge in policy-making and political decisions. Or, as stated by Flyvbjerg (1991:433):

> "... power does not seek knowledge because knowledge is power. Power defines, instead, what counts as knowledge, and ultimately what counts as reality. .... Power is more concerned with the defining of reality than with understanding how reality is, otherwise, constructed. This ... is the most important single characteristic of the rationality of power, i.e. of the strategies and tactics employed by power in relation to rationality."

9. Concluding remarks

The purpose of an EIA is to assess impacts 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 of its neglecting of the relationship between increased road capacity and increased car traffic, the Third Limfjord Crossing EIA arrived at the misleading conclusion that the proposed new motorway connection will result in a reduction of all the above-mentioned environmental parameters.

By drawing an unrealistic and exaggeratedly negative picture of the situation that will emerge if the road capacity is not increased, the analyses of the Third Limfjord Crossing gave the impression that the proposed new infrastructure was necessary in order to avoid a situation most people would consider highly undesirable. Pessimism bias against the no-build alternative thus acted as an instrument to persuade decision-makers into adopting the proposed road scheme. Such forecasting error may be an important source of bias in road infrastructure planning. The fact that the analyses of forecast inaccuracy carried out by Flyvbjerg and his colleagues (Flyvbjerg, Holm & Buhl, 2005 and 2006; Næss, Flyvbjerg & Buhl, 2006) did not include forecasts of non-implemented alternatives may explain why these analyses did not show any clear and strong overall tendencies of systematic forecasting bias for road projects.

Nearly 20 years have elapsed since the Australian researcher Jeff Kenworthy published his critical article "Don't shoot me - I am only the transport planner!" (Kenworthy, 1990). In spite of the long-standing criticism levelled by transportation researchers, many modellers and traffic engineers continue to make forecasts in the same old way. By ignoring induced travel, the impact of the quality of the public transport services, and the effects of reallocating road space from car lanes to bus lanes, the model calculations in the Limfjord case serve as an argumentation in support of the claim that measures to limit traffic growth do not work.

The professional activity of transport modelling is one characterized by a low degree of transparency. This applies to the degree to which data and methods are transparent and under the scrutiny of peers, as well as the extent to which it is transparent and liable for critique from outside, e.g. from professionals within other fields, the media and politicians (Osland & Strand, 2008). Seen in this perspective, traffic models could be considered as 'black boxes' with a content that it is not considered necessary to take into consideration. According to Hajer (1995:272), 'black boxing' (i.e. closing technical analyses and their presuppositions inside a 'black box') is

> "maybe one of the most basic discursive mechanisms. Making things appear as fixed, natural and absolute conditions is the most effective means to avoid potential oppositional forces."

Through reification of particular rationalities, scientific decision support models used within infrastructure planning can play an important role in power struggles over how to conceive of a problem and its solutions. Such models are often regarded as truth-production technologies and can thereby make the modellers appear as 'independent' experts (Henman, 2002).

It is hardly just to put all the blame for the use of misleading traffic models on the individual modellers and planners who construct and use the models. Their work must be seen in the wider contexts of professional culture and political climate. If a planner runs the risk of being fired if she insists on carrying out the analyses based on different assumptions than those stated by the administrative or political leadership, the latter are the real culprits, not the subordinate technical clerk. To the extent that producing forecasts which deliberately present transportation investment projects in a better light than what is realistic can be termed lying (Flyvbjerg, Holm and Buhl, 2002), what we are facing is arguably 'institutional lies' (Martin, 2004; Edelman, 1971) rather than individuals violating the norm of speaking truthfully. Having said this, each professional has an ethical responsibility not to give misleading presentation of the relationships and conditions dealt with in her or his analyses. Forecasters should, for example, speak out to their superiors if they are asked by the latter to base their forecasts on inappropriate assumptions, and argue that obvious distortions (such as neglecting induced travel) should be remedied. The 'black box' nature of traffic models can make it difficult to discover manipulation. It is therefore crucial that those who operate and interpret such models live up to high ethical standards of professional conduct.

Even if all theoretically plausible and relevant factors of influence are included, transport model computations pretend to provide much more accurate predictions than what is epistemologically defensible (see Næss, 2006 for a more thorough discussion). Seen in the light of the inevitable and considerable uncertainty associated with the results of transport modelling analyses (and the substantial costs such modelling work represents in many planning processes), the possibility of replacing such model computations with simpler assessments of the magnitudes of relevant factors that may contribute to increase or reduce traffic, and their approximate net effect, should be seriously considered. Anyhow, transport modelling should only be used in environmental impact analyses of large-scale infrastructure projects if the built-in assumptions of the model have been quality controlled by independent experts from a subject field covering a wider range than that of the model makers.

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Notes

[1] Induced travel refers to increased total vehicle miles travel (VMT) compared with what would otherwise occur (Hills, 1996). Generated traffic refers to additional vehicle traffic on a particular road, especially in the peak period. The generated traffic includes the part of the induced traffic that takes place on the new road, as well as traffic that has been moved spatially and temporally from other roads and/or other hours of the day (Litman, 2010).

[2] In a recent EIA based on the OTM model, a proposed extension of one of the ring roads around Copenhagen (Motorring 4) from 4 to 6 lanes has been forecasted to result in an additional traffic growth of 4-5% (Danish Road Directorate, 2009c, p. 120.) Although taking short-term induced traffic into consideration, this forecast too ignores long-term induced traffic resulting from the increase in road capacity.

[3] The EIA displays no explicit information on the way energy use and emissions have been calculated, but it can be inferred from the forecasted lower levels of energy use and CO_2 emissions in the motorway alternatives than in the baseline that the higher fuel consumption at high speeds has been ignored or significantly underestimated.

[4] My use of the term 'bias' differs from the way it is used by Kahneman (1994) and Flyvbjerg et al. (2005, 2006), whose use of the term refers to optimism based on a psychological inclination toward wishful thinking.

[5] Such an investigation has recently been started in cooperation between Aalborg University, Denmark's Technical University and the University of Oxford.

[6] Already in 1998, I was invited to comment on the model calculations in a public meeting organized by the Danish Association of Engineers, where I put forth criticism similar to the arguments presented in this paper. The criticism was also repeated in a session at the conference "Traffic Days at Aalborg University" in 1999, where the traffic modelers responsible for the Limfjord EIA traffic forecasts were present.

[7] "Vejer til visioner". Minister of Transport and Energy Flemming Hansen interviewed by Mads Folmer-Jensen. *Rambøll Imorgen*, June 2005, pp. 17-18.