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Traffic forecasting at ‘strategic’, ‘tactical’ and ‘operational’ level: A differentiated methodology is necessary

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Traffic forecasting at 'strategic', 'tactical' and 'operational' level:
A differentiated methodology is necessary

Abstract

In this paper we discuss why traffic forecasting is such a difficult endeavour, and point at alternatives to the currently widespread use of traffic models almost independently of the problem situation faced by the planners. It will be argued that it is inherently impossible to make exact predictions about the magnitude of the 'general' traffic growth 20-30 years ahead, since many of the influencing factors depend on inherently unpredictable geopolitical trajectories as well as contested political decision-making. Due to the context-dependency of each particular planning situation, it is also hardly possible to make exact, quantitative predictions about the impact of implementing a specific infrastructure project, compared to 'doing nothing'. We propose to separate the so-called strategic, tactical and operational levels of traffic forecasting into three distinct methodological approaches reflecting the different degrees of openness/closure of the systems at hand: Scenario analyses at the strategic level; theory-informed, mainly qualitative analyses supplemented with simple calculations at the tactical level; while more traditional micro-simulations should be applied only at a detailed operational level.

Traffic models and forecasts [1]

It is an established truth that the possibilities of not hitting the target are ample when preparing forecasts about future traffic volumes on a new road link or a new road system. Many studies have shown lack of correspondence between forecasted and actual traffic (see Nicolaisen, 2012 for an overview), and many hypotheses have been put forth as explanations of such deviations (ibid.).Traffic models are used for several analytical purposes, depending on the planning task at hand, such as forecasting the distribution of traffic flows between different roads in a network; changes in the total amount of traffic within a geographical area, with and without new infrastructure; effects of traffic-regulating measures (e.g. road pricing); and traffic impacts of different land use alternatives. Moreover, some models are used to predict the general, 'background' trajectory of traffic growth at a national or regional scale. Reflecting these different purposes, Camilla Brems et al. (2007) distinguish between what they call strategic, tactical and operational traffic models. The purpose of

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[1] This paper is based on a longer article by the same authors drawing extensively on concepts and terminology from philosophy of science, 'What kinds of traffic forecasts are possible?', published in *Journal of Critical Realism*, Vol. 11 (3), pp. 277-295. As we would like to make our main arguments accessible to an audience of researchers and practitioners in the transport planning community, we have elaborated and shortened the original paper for this purpose.

'Strategic' models is to describe overall, long-term and general effects of the (national or sub-national-scale) transportation system and its relationships with other parts of society. 'Tactical' models cover a long- or medium-term time span (3 – 20 years) and have a level of detail reflecting the aim of assessing significant effects of proposed projects. 'Operational' models aim to forecast changes in traffic flows within limited geographical areas due to relatively minor changes in infrastructure and the operation of public transport schemes. Models at this level need input data in the form of specified assumptions about a number of variables such as traffic growth and the distribution of traffic between different means of transportation. (Brems et al., ibid.)

General mobility development and context-dependent induced traffic

Important macro-level social factors influencing the development of the level of physical mobility include broad characteristics such as the general level of affluence in society, prevailing values, the composition of the population in different areas in terms of household types, employment, income, age, lifestyle groups, etc. These characteristics evolve over time due to a multitude of different kinds of influences and are inherently difficult to predict, particularly in the long term. Moreover, many of the factors influencing the development of the general level of mobility, such as oil prices, petrol taxes and national and local transport policies, depend on inherently unpredictable geopolitical trajectories as well as on contested political decision-making. The system in which the general, 'background' level of mobility in a given society develops must therefore be characterised as a predominantly open one.

Transport infrastructure projects can cause changes in aggregate-level travel behaviour. The establishment of new infrastructure usually induces changes in travel speed, choice of routes, frequencies of trips, choices of destinations as well as transport modes. For example, road capacity increase in congested urban areas in order to make traffic flow easier usually also leads to an increase in traffic volumes by inducing more and longer trips by car. This induced traffic will in its turn counterweigh the initial reductions in travel time.

The changes in aggregate travel behavioural patterns within a geographical area depend on the motives and rationales for travel behaviour among the individuals, which have been shown in qualitative research to consist of a mix of instrumental, symbolic and affective concerns (Steg et al., 2001; Næss, 2006).

Needless to say , the magnitude of induced traffic is influenced not only by the importance attached to different transport rationales today and in the future, but also by the existing traffic situation in the area, the land use, the economic development, etc. These are all context-dependent circumstances. The strength of the correlation between a certain amount of road capacity increase and the additional traffic thus induced will therefore necessarily vary across space and time, due to the different constellations of other causal mechanisms at work in each situation. Accordingly, in empirical studies, the 'elasticity' between road capacity increase and traffic growth has been found to vary considerably. Within a short term (1 – 3 years), a 10 per cent capacity increase in a corridor appears to typically result in 3-5 per cent additional traffic growth, while in a long term (more than 3 – 5 years), the resulting traffic growth is typically 5-10 per cent (Noland & Lem, 2002; Litman, 2011). Similarly, smaller or greater changes in the geographical distribution of the population and jobs within an urban region can cause highly different changes in transport volumes as well as in the shares of different modes of travel.

Traffic forecasts and cost-benefit analyses

Traffic forecasting plays a key role in contemporary transport policy and planning. Not the least, such forecasts are indispensable in cost-benefit analyses, where quantifications of expected time savings, safety effects and changes in pollution and noise levels resulting from proposed projects are needed to make calculations of economic costs and benefits. Usually, such forecasts are produced using mathematical transport models designed to calculate traffic implications of changes in the transportation system. The forecasts are based on observations of present-day traffic, a number of assumptions about variables influencing the traffic situation, and the future development of these variables. Traffic forecasts used as input to cost-benefit analyses usually employ 'tactical' models focusing on infrastructure characteristics and the traffic situation in affected transport corridors, supported with output data from 'strategic' models about more general traits of development.

Below, arguments will be put forth to show that it is very difficult to produce the exact kinds of predictions needed for meaningful cost-benefit analyses (in the form of traffic volumes, distribution and speed). In particular this is entirely unattainable at the 'strategic' level, but also 'tactical-level' predictions of impacts of specific projects are unable to achieve the level of precision presupposed in cost-benefit analysis. The highly restricted potential for accurate traffic predictions at these levels is due to the relative openness of the socio-spatial systems within which transport projects are implemented (Bhaskar, 2008; Danermark et al., 2001).

Using an illustrative example from the Oslo region, we will also show that other approaches than transport modelling can be used in metropolitan-scale planning to assess the likely impacts of different land use alternatives on the amount of transportation and the proportions accounted for by different travel modes.

Which kinds of traffic forecasts are possible?

The questions to which transport models purport to provide the answers are legitimate and important. This does not, however, mean that transport models are necessarily the right tools for answering such questions in any given time or situation.

Assessments at the strategic level

As mentioned above, the purpose of the so-called strategic transport models is to describe the overall effects of the traffic system and its relations on society at large. Demographic and economic development is, more or less, difficult to predict with any reasonable degree of accuracy, especially in a long term. Moreover, land use development is subject to political decision-making that cannot be predicted through transport modelling. The same applies to the impacts of any political decisions made to limit the negative environmental consequences of transportation, for example road pricing or radically increased CO_2 fuel taxes.

The long-term development of the level of car ownership is also notoriously difficult to predict. Car ownership depends, among other things, on whether future urban land use will be characterised by a decentralised location of residences, workplaces and service or by compact and dense urban development. This is, as mentioned, a political choice. The same applies to the future level of public transport services. The general level of traffic growth (or alternatively, stagnation or reduction) will also depend on the general level of road capacity increase and improvement, which is again a political decision. Finally, the traffic development (in particular the modal split) depends on the development of the availability of resources and the attitudes of individuals and households. What trajectories will the purchasing power among different population groups follow, and what about changes in people's attitudes to new mobility schemes such as carpooling and car-sharing?

Trying to predict how the sum of all these global trends and political decisions at national and local level will influence general, long-term traffic growth rates can be nothing other than a more or less qualified guess. The aspects of development dealt with in such forecasting belong to highly open systems where prediction is simply very difficult, if possible at all (see Næss & Strand, 2012 for a broader discussion). In practice, such guesses have usually anticipated a continuation of 'business as usual' for example as regards the construction of more motorways and other major roads. In this sense, the forecasts run the risk of becoming self-fulfilling prophecies, at least if they are used to legitimate construction of expanded road capacity in order to accommodate the predicted traffic roads (Næss, 2011). To counteract this, or as an alternative, it is possible to make different assumptions on each of the factors or the actual variables, and in this way make different pictures of the future.

Because of the inevitable uncertainty about the 'general' (or background) level of traffic growth, it is also impossible to predict with any reasonable degree of accuracy how high the future traffic will be on a new piece of infrastructure. This is part of the reason for the large standard deviations found in the accuracy level of traffic forecasts for new roads or rail lines, based on comparisons of forecasted and actual traffic volumes (mentioned in the introduction) (Flyvbjerg et al. 2005, Parthasarathi & Levinson, 2010; Nicolaisen, 2012).

Assessments at the tactical level

Predicting the *impact* of a proposed project, e.g. the construction of additional lanes on a motorway, is in principle less problematic, although such predictions cannot be very accurate either. Distinct from predictions about future traffic situations, impact predictions are statements of how a given causal mechanism (e.g. the influence of road capacity increase on the volume of traffic) *tends* to operate. Regardless (within certain limits[2]) of the level of the 'background' traffic growth, adding new lanes to a congested urban main road tends to bring about higher future traffic volume than what would be the case in the absence of such a capacity increase.

The elasticities mentioned in a previous section can give some clues to the magnitude of the traffic increase. But as can be seen from the above-mentioned elasticity

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[2] If the general, national traffic volume showed a dramatic negative growth causing it to drop over a few years to, e.g., a third of the present level, additional lanes on the urban motorway would hardly induce any new traffic, since the existing lanes would then already be over-dimensioned, compared to the actual traffic volumes.

estimates, there are quite large margins between the lower and upper boundary of the traffic growth resulting from a given capacity increase. This reflects, in part, the different contexts in which empirical studies have been carried out: the overall geographical contexts are varying, and the years when the studies were carried out differ. Since a number of parameters influencing traffic development have changed over time, we cannot be sure that an effect of infrastructure development found twenty years ago will be the same today, let alone in the future situation to which the forecasts refer.

Notwithstanding the credibility of theoretical and empirical research on the tendency of transport infrastructure development to induce changes in traffic volumes, any prediction about the magnitude of such traffic growth due to a specific proposed project cannot be more than approximate (Næss, 2004; Næss & Strand, 2012). When making this kind of 'soft' prediction, a number of qualitative considerations must be made in order to 'translate' the results of studies conducted elsewhere and at other times to the situation at hand: Is the type of road (or other infrastructure) similar to the projects whose effects were investigated in the research literature about traffic impacts of infrastructure development? Are the predominant transport rationales among the inhabitants affected by the proposed infrastructure development similar to those of the individuals affected by the infrastructure projects investigated in the research on induced travel? Is it likely that the individuals' future balancing between transport rationales will be similar to how it was at the time of the research studies on which the impact assessment is based?

Needless to say, answers to such questions cannot be found by exact calculations. They must be answered through qualitative interpretation. The only defensible predictions at the 'tactical' level are crude, 'rule-of-the-thumb' estimates, adapted to the concrete context. We will then have to discuss which of the elasticity figures would be appropriate to use in the specific situation. Still, an approximate impact assessment is better than no anticipation at all of the likely impacts – the latter would be deleterious to any purposeful action.

Assessments at the operational level

In the opposite part of the openness-closure continuum is the distribution of a given amount of traffic on a limited road network (for example a city centre) and how the traffic flows in the streets will be affected e.g. if a car park is changed from one location within the area to a different one (keeping the number of parking places unaltered), or by shifting the directions of two neighbouring one-way streets. In such a situation, fewer factors influencing travel behaviour will be affected, and a much higher degree of stability between these few factors and the driving pattern could thus be expected.

If a proposed measure cannot reasonably be expected to result in any increase or decrease in the overall traffic volume of the area or the shares of different modes of travel, the impacts will be limited to changes in the distribution of traffic between the different roads of the local network. Such predictions could probably be made with a considerably higher degree of accuracy than predictions at a 'tactical' or 'strategic' level. Yet, even if the proposed infrastructure changes do not themselves cause any change in the overall amount of traffic in the area, such changes may occur due to exogenous changes (i.e. at a tactical or strategic level). The actual number of vehicles in each street can therefore not be predicted with any high degree of certainty even at an ‘operational’ level, although the relative distribution of flows between the different routes of the network may be modelled with a higher degree of precision.

A differentiated forecasting methodology

At the ‘strategic’ level, it is, for ontological and epistemological reasons, hardly defensible to carry out model-based traffic forecasts at all, since such forecasts presuppose the availability of non-existing knowledge about the trajectories of a number of different parameters operating within open systems. Which parameters these are or might be has been discussed in earlier sections of the paper.

It is possible, however, to construct different scenarios reflecting possible future traits of development. According to the Finnish futurologist Heikki Patomäki (2006), scenarios informed by social science should be based on assumptions that can be publicly criticised and debated, starting with an analysis of relevant existing structures and processes and their inherent possibilities, combined with the basic assumption that futures remain open until a particular possibility is actualised.

In futures studies, scenarios are often divided into three categories reflecting different purposes: Predictive scenarios aiming to envisage what is most likely to happen; explorative scenarios illuminating what can happen; and normative scenarios shedding light on how a specific target (or a combination of several targets) can be reached (Børjeson et al., 2006). As argued above, the many uncertain, uncontrollable and contested processes and decisions determining the trajectory of future traffic growth at a national scale speak against the reasonableness of trying to construct a predictive scenario for this growth. Instead, it is preferable to construct a limited number of explorative scenarios for future traffic volumes envisaging, for example, trajectories of different levels (high, medium, low) of positive and negative traffic growth, respectively.

For each of these scenarios, the main scenario-specific assumptions differentiating the scenario in question from the others should be identified and briefly discussed. Assumptions common to all scenarios should also be mentioned and justified. Although the method of backcasting (Dreborg, 1996) is usually applied in connection with normative scenarios, it is also preferable to use some of the ways of reasoning associated with backcasting to illustrate, for example, which geopolitical, economic, cultural, transport policy-related and land use-related conditions that could together possibly produce a traffic volume trajectory in line with the high-growth scenario (and ditto for a negative growth scenario).

According to Patomäki, at ‘any moment in time, many futures are possible, for instance A, B, C and D. Depending on a number of contingent processes, these can give rise to further possibilities, A_1, A_2, A_3, B_1, B_2, B_3, B_4 and so on’. For each proposed project, the main topic of assessment will be the different impacts of project realisation compared to the ‘do nothing’ (or ‘zero’) alternative. But since these impacts may differ, depending on how the general (nation-scale) traffic situation develops, comparisons of ‘do something’ and ‘do nothing’ should be carried out against the background of different 'strategic-level' national traffic growth trajectories.

One reason for comparing project realisation and non-realisation based on several different scenarios for the 'background' traffic growth is the fact that the amount of induced traffic due to new infrastructure provision will most likely be different in a situation characterised by generally high traffic growth than in a situation where the national traffic growth curve is sloping downward. In a situation with generally rapidly declining traffic volumes, adding more lanes to an urban motorway would hardly induce much new traffic. On the other hand, high general traffic growth would result in expanded road capacity being filled up with additional cars faster than in a low-growth scenario.

Neither at the 'tactical' level can predictions of ways that changes to transport infrastructure (e.g. changes in traffic due to the construction of new roads, expansion of existing roads with more lanes, construction of new rail lines, etc.) affect travel behaviour be very accurate. This is because the systems within which the projects are inserted, are more or less open systems. In addition, traditional traffic models have usually been very poor at predicting induced traffic, which has often been totally ignored or estimated to be much smaller than the figures identified in empirical studies. Instead of using sophisticated models to calculate *precisely wrong*, transport planners should aim to be *approximately right*, using theory-informed adaptations of state of the art knowledge about induced traffic to the planning context at hand. Based on this, rough estimates of the amounts of traffic in the 'do something' and the 'do nothing' situations could be produced. As mentioned above, such estimates should be made for scenarios with different trajectories of the 'background' traffic growth.

Adapting the findings of theoretical and empirical studies about the 'elasticities' between infrastructure changes and traffic growth must be based mainly on qualitative interpretation involving contextual human judgment. This does not rule out the use of some basic calculations (without using sophisticated and data-hungry micro-simulation models) of the likely magnitudes of induced and generated traffic. Important impacts of the traffic differences between 'doing something' and 'doing nothing' should also be assessed, e.g. in terms of traveling speeds, accidents, emissions, etc. Simple, 'spreadsheet-like' modelling tools might be developed to ease such calculations.

At the operational level we may suppose that the situation is sufficiently stable and comprehensible that it is possible to use traditional micro-simulations. In such situations it can, as mentioned earlier, be possible to show the consequences of changing the traffic flow in different streets, closing a street to traffic, altering the location of a car park, and of similar examples. Also, marginal differences between the traffic impacts of different road-building alternatives in a given transport corridor can be illuminated.

A practical example inspired by similar thinking

Due to the almost total dominance of model-based forecasting in current transport infrastructure planning practice, it is difficult to find existing examples of the use of our recommended differentiated approach in actual road or rail infrastructure planning. Traditional 4-step transport modelling is often chosen as the default method also for assessments of transport impacts of proposed land use alternatives, but a few examples of alternative approaches do exist within coordinated land use and transport planning. Although not directly corresponding to our 3-level differentiation, a study carried out for the Oslo and Akershus Planning Cooperation on urban developmental alternatives in the Oslo region will be used as an example (Strand et al., 2013). Here, three different approaches were applied at a level termed 'strategic' by those involved but corresponding mainly to what we have referred to above as the 'tactical' level. One of these approaches also included analyses of traffic distribution on the road network, like the 'operational' level discussed above, but at a much higher geographical scale.

The three approaches were: a) simple indicator analysis, b) a simple SPSS based model and c) a transport model (the Norwegian regional transport model). The common base for all three methods was, firstly, general knowledge from urban planning research about influences of land use characteristics on travel, and, secondly, empirical data from travel surveys. The three methods differ in terms of how labour-intensive they are and what kinds of questions they are appropriate for answering. The methods are therefore suitable at different stages of a planning process.

At the introductory stage, the question posed may be like in the Oslo-Akershus Planning Cooperation: What will be the traffic impacts of distributing the expected growth in population and jobs in different ways within the metropolitan area? Theoretical and empirical knowledge from a Nordic context of the generation of transport in different urban structural situations (e.g. Næss, 2012; Engebretsen & Christiansen, 2011) suggests that the growth in the volume of transport could be expected to be smaller, the closer to the dominating centre of the city or the metropolitan area the growth in jobs and population occurs. Similarly, assessments can be made on how the location of growth in jobs and population is likely to affect the modal split. Such approaches are examples of analyses of an indicatory[3] kind, suitable for *ranking* of alternatives, concepts or scenarios. They can also be used as a base for deliberate changes in the geographical distribution of future urban development.

If we want somewhat more specific answers to the question of transport impacts, it may be relevant to take a closer look into the expected origin-destination relations likely to result from different location patterns, and how the available infrastructure in the areas subject to urban development has traditionally influenced travel behaviour. Such analyses can provide information about likely growth rates for different parts of the total transport volume. In the Oslo-Akershus Planning Cooperation study, this was made using a simple spreadsheet calculation[4]. A simpler

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[3] In this specific study, the indicators used were the location of growth in jobs and population relative to the city centre of Oslo, development densities in different parts of the metropolitan area, and different patterns of concentration (decentralized vs. centralized concentration).

[4] In the spreadsheet calculation, the effects of relevant variables were estimated using elasticities found in previous studies in the same geographical context. For the assessment of the impact of

variant of this method was used by the authors a few years ago in a study evaluating which land use development would be preferable in a Norwegian municipality if minimisation of the amount of transport were to be a central goal (Strand et al., 2007).

If we also want to assess future traffic load within different parts of the transport infrastructure, it will be necessary to model this network and specify how the assumed changes in the location of population and jobs in a future situation are likely to generate traffic on different links of the network. Transport models will then have to be consulted. As mentioned earlier, it is important to keep in mind that the traffic load on the road network as a whole as well as on its different parts depends not only on changes in land use and infrastructure, but also on the general 'background' trajectory of traffic growth (or decrease), which cannot be forecasted with any reasonable level of accuracy. Use of different scenarios will therefore be necessary as input to different sets of model calculations. (This was unfortunately not done in the Oslo-Akershus Planning Cooperation study.)

Concluding remarks

The above considerations may leave little justification for using traditional traffic model calculations in making decisions about whether or not to build a proposed kind of infrastructure or if the task is to illuminate impacts of different land use alternatives on the future transport situation (i.e. concept-level decisions). Such modelling may be more appropriate when trying to assess the traffic impacts of different variants of the same conceptual solution (e.g. different line alternatives for a proposed new road in a given transport corridor). The same applies to the distribution of traffic volumes between different links of a road network within a limited area such as a smaller town or an urban district.

From the above, the current tendency among transport model developers of trying to integrate strategic, tactical as well as operational assessment into the same extensive micro-simulation model appears to be not very fruitful. Such models will be data-hungry, slow and highly non-transparent (black box) for everyone except the few persons who have developed it. In practice, there is a risk that model components introduced in order to reduce systematic bias may be 'switched off' in order to reduce computing time or due to lack of data. The slowness and data hunger may also prevent analysts from running more than a few alternative analyses and thus preclude the use of the models as tools for 'what if' analyses in a more open and explorative way[5]. At the same time, the lack of transparency contributes to a

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residential location on the likelihood of being a car driver the following variables were included: Local area density, distance to the city centre of Oslo, number of jobs within 2 km from the dwelling, population within 2 km from the dwelling, travel time ratio car/transit to downtown Oslo, employment in Inner Oslo, proportion of locally employed residents, and proportion living as well as working outside Oslo's toll ring.

[5] We recognize that there are different types of models with different levels of aggregation and transparency for different planning purposes, and that models with a higher level of aggregation than traditional microsimulation models can give more reliable information than mere qualitative

reification of quantitative model output, despite the usually high degree of uncertainty.

Instead, we propose to separate the so-called strategic, tactical and operational levels of traffic forecasting into three distinct methodological approaches reflecting the different degrees of openness/closure of the systems at hand: Scenario analyses at the strategic level; theory-informed mainly qualitative analyses supplemented with simple calculations at the tactical level; with more traditional micro-simulations confined to a detailed operational level.

References

Bhaskar, R. (2008) *A Realist Theory of Science*. London and New York: Routledge.

Brems, C., Fosgerau, M., Hansen, C. O. & Nielsen, O. A. (2007) *Trafikmodeller. Arbejdsnotat til Infrastrukturkommissionen* (Traffic models. Working paper for the Danish National Infrastructure Commission.) Kgs. Lyngby: Denmark's Technical University.

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T. & Finnveden, G. (2006) Scenario types and techniques: towards a user's guide. *Futures*, 38, 723–39.

Danermark B., Ekström, M., Jacobsen, L. & Karlsson, J. C. (2001) *Explaining Society. Critical realism in the social sciences*. London/New York: Routledge.

Dreborg, K. H. (1996) Essence of backcasting. *Futures*, 28, 813-828.

Engebretsen, Ø. & Christensen, P. (2011) Bystruktur og transport. En studie av personreiser i byer og tettsteder. (Urban structure and transport. A study of travel in cities and towns.) TØI rapport 1178/2011.

Flyvbjerg, B., Holm, M. S. & Buhl, S. (2005) How (in)accurate are demand forecasts in public work projects? The case of transportation. *Journal of the American Planning Association*, 71, 131–46.

Litman, T. (2011) *Generated Traffic and Induced Travel: Implications for Transport Planning.* Version of 8 June 2011. Victoria: Victoria Transport Policy Institute.

Nicolaisen, M. (2012) *Forecasts: Fact or Fiction? Uncertainty and Inaccuracy in Transport Project Evaluation*. Ph.D. thesis. Aalborg: Aalborg University.

Noland, R. B. & Lem, L. L. (2002) A review of the evidence for induced travel and changes in transportation and environmental policy in the US and the UK. *Transportation Research Part D* 7, 1-26.

Næss, P. (2004) Prediction, Regressions and Critical Realism. *Journal of Critical Realism*, 3, pp. 133-164.

Næss, P. (2006) *Urban Structure Matters: Residential Location, Car Dependence and Travel Behaviour*. New York/London: Routledge.

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expert judgement, provided that the theories and assumptions on which they are based are appropriately communicated and kept open for scenario-like variation (see, e.g. Wegener, 2011).

Næss, P. (2011) The Third Limfjord Crossing – a case of pessimism bias and knowledge filtering. *Transport Reviews*, 31 (3), pp. 231-249.

Næss, P. (2012) Urban form and travel behavior: experience from a Nordic context. *Journal of Transport and Land Use*, 5 (2), pp. 21-45.

Næss, P. & Strand, A. (2012) What kinds of traffic forecasts are possible? *Journal of Critical Realism*, 11 (3), pp. 277-295.

Parthasarathi, P. & Levinson, D. 2010. Post-construction evaluation of traffic forecast accuracy. *Transport Policy*, 2010, doi:10.1016/j.tranpol.2010.04.010

Patomäki, H. 2006. Realist ontology for futures studies. *Journal of Critical Realism*, 5, 1-31.

Steg, L., Vlek, C. and Slootegraaf, G. (2001) Instrumental-reasoned and symbolic-affective motives for using a motor car, *Transportation Research Part F*, 4: 151–169.

Strand, A., Næss, P. & Tennøy, A. (2007) *Mulighetsstudie nye byutviklingsretninger for Kongsberg. Analyse av transportkonsekvenser.* (Feasibility study of new expansion directions in Kongsberg. Analysis of transport consequences.) TØI Report 936/2007. Oslo: Institute of Transport Economics.

Strand, A., Ø. Engebretsen, C.K.Kwong, L. Isberg and P. Christiansen (2013: Transportkonsekvenser av ulike utbyggingsalternativer i Regional plan for areal og transport i Oslo og Akershus. Sluttrapport. (Transport consequences of different and use alternatives in the Regional Plan for Land Use and Transport in Oslo and Akershus. Summary report. TØI report 1267/2013. Oslo: Institute of Transport Economics.

Wegener, M. (2011): From macro to micro: how much micro is too much? *Transport Reviews* 31 (3), pp. 161–77.