PhD Study Plan (after 2 months):

Doctoral Programme:	Engineering, Science & Medicine
Project title:	Systematic biases in transport models
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Date of enrolment:	01 October 2009
Expected date of completion:	31 August 2012

Signature

Date	PhD student	Morten Skou Nicolaisen

Study plan approved

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Systematic biases in transport models

1. Summary

Inability to accurately forecast how much the traffic volume will be affected by a given project has been a longstanding problem of the transport planning profession. Inaccurate forecasts can lead to overestimation of project benefits, and since projects have grown to a size where lower than expected benefits impact the economies of a wide range of stakeholders (including entire nations), it is imperative that transport modelling becomes significantly better at forecasting developments in traffic. At the same time planners, politicians and other decision makers need to be well aware of any uncertainties and systematic biases in these models. This project aims at investigating whether such inaccuracies are results of random technical deficiencies, or if the models are encumbered with more systematic biases causing traffic volumes to be continuously over- or underestimated depending on the project type.

This project will compare forecasted and actual traffic volumes for numerous transport projects, in order to determine the cause and degree of forecasting inaccuracy in them. In addition to this the responsible planners will be questioned about project details, and a few projects will be selected for in-depth case studies. The aim is to provide a set of recommendations for how to reduce the systematic biases that still seem to exist in much of contemporary transport modelling, whether the cause of these may be technical, psychological or political. Studies like the present one are rare in both planning research and practise as it is not customary to evaluate the accuracy of initial forecasts after project implementation, despite the widespread acknowledgement of the problem. It is therefore expected that the results of this project will be a valuable addition both for researchers and practitioners within the field.

2. Scientific content

2a. Background

Traffic forecasts resulting from transport models have often proved to be highly inaccurate, insufficient or misleading. Post-auditing of major transport projects is not common practise and a similar lack of interest seems to be evident in the field of transport research in regard to evaluating transport forecasting techniques. Given the magnitude of resources devoted to transport infrastructure projects in recent years, these inaccuracies can (and do) lead to quite drastic misjudgements of the financial viability and environmental impact of such projects, as these are highly dependent on accurate forecasts (Pickrell, 1989; Richmond, 1998).

Cost overruns of more than 100% of the initial estimates are not at all uncommon either (Flyvbjerg et al., 2002), and especially so for larger projects. As costs are usually estimated too low and the transport demand is off the mark, the obvious result is projects with budgets that are knee-deep in red numbers.

Reducing the inaccuracy of demand forecasts is thus a key element in improving evaluations of the financial viability of future infrastructure projects, as the positive effects from improving transport efficiency (time savings, congestion reduction, etc.) account for the majority of the benefits in cost-benefit analyses (Mackett, 1998; Nielsen & Fosgerau, 2005; van Wee, 2007).

If we look back a few decades we will notice that the pattern has not changed a great deal. Cost overruns and inaccurate demand forecasts traces back through most of the last century (Flyvbjerg et al., 2003), while techniques for feasibility analysis and demand forecasting have gone through a major development during this period. It seems odd that technological advances and research in transport development have not managed to improve the viability nor the reliability of transport models; modellers simply do not seem to have learned much from past experiences.

2b. Research

While the topic of uncertainty in transport models has not yet had a large amount of research directed at it, there has been some previous studies of forecasted vs. actual traffic in transport investments. Flyvbjerg et al. (2003) finds that the average forecast for passengers in rail projects is more than 100% above actual values, while more than half of investigated road projects are off by 20% compared to actual traffic development. The study involves a large number of cases, which is quite a rarity due to problems associated with the lack of available data (and likely also access to it). The findings support conclusions from earlier studies (Pickrell, 1989; Richmond, 1998; Walmsley & Pickett, 1992), although these were based on much smaller sample sizes.

One result from these studies is that analyses are often overly optimistic and will generally overestimate future traffic where this is desirable (e.g. urban rail projects) while underestimating future traffic where such growth is considered undesirable (e.g. congestion alleviating) (Flyvbjerg et al., 2003; Bain, 2009; Næss et al., 2006). In the former example ticket sale is an important source of income to ensure the financial viability of the project, and in the latter the time saving benefits from capacity expansion is a major factor in the cost-benefit analysis (Nielsen & Fosgerau, 2005). It is thus beneficial for the *perceived* financial viability of projects to either over- or underestimate traffic forecasts, depending on the type of project, but it is very detrimental to the *actual* financial viability. In the case of rail construction or a tolled road project there is often an overly optimistic expectation to the size of the user base. Conversely, in the case of road construction to reduce congestion burdens in urban areas there is often a significant amount of induced or generated traffic. This is largely ignored in forecasts, but often results in new capacity being 'eaten up' by traffic growth after project implementation, leaving roads just as congested as before(ibid.).

<u>Types of inaccuracy</u>

From the few available studies one thing seems clear, which is the inaccuracy of forecasted vs. actual traffic development. However, explanations for why this inaccuracy is present are not equally clear. The above mentioned problem of excluding recognized uncertainty such as induced traffic on new infrastructure projects can be seen as a technical one, in which the solution would be to enhance transport models to better account for the supply-demand interrelationship that dictates the amount and direction of such traffic (Litman, 2009; Noland & Lem, 2002). Results of these studies generally show that induced travel does indeed exist, and that it usually ramps up over time so that long-term effects are more than doubled in size compared to short-term effects. In addition to induced travel the models usually ignores or poorly includes effects such as changes in trip destination and travel mode.

However, besides the technical challenges of including such effects in transport modelling, there have also been studies that mention psychological and political factors as causes of uncertainty in transport models. Optimism bias has been claimed by Lovallo & Kahneman (2003) to explain the large inaccuracies in demand forecasts and similar planning analyses. This represents a perspective that builds on a more general psychological theory of unrealistic optimism in regard to predicting future events (Armor & Taylor, 2002; Weinstein, 1980). Kirkebøen (2009) also points to optimism bias (overconfidence) and mentions confirmation bias as another typical explanation. The 'confirmation trap' results in a natural drive towards confirming rather than disconfirming, meaning that for most people falsifying a hypothesis is not the natural way of approaching a given problem. They are much more likely to seek confirmation for results that would favour their own perspective, and while seeking information that could invalidate the arguments for this perspective is often the most effective way to test out its weaknesses this is not a natural reaction.

Flyvbjerg et al. (2002), Flyvbjerg et al. (2008) and Jones & Euske (1991) find that perhaps strategic misrepresentation rather than optimism bias explains the inaccuracies in transport modelling and budgeting. As already mentioned there are various conditions that dictate the financial viability of infrastructure projects, which might differ between individual projects. Depending on the type of project there is thus an incentive for project promoters to either over- or underestimate the demand forecast in order to make the project appear more financially viable than alternatives, as there are usually multiple projects competing for a limited amount of funds. At the same time there is a lack of incentive for planners to produce more 'honest' numbers as there is little risk involved from doing the opposite (Flyvbjerg et al., 2003). Wachs (1989) also describe how planners are often prompted to advocate projects in the guise of scientific rationality by adjusting data and assumptions until they fit whatever project profile that best serves their own (or their clients') ideological conviction or financial interests.

An aim for this project is thus to identify sources of systematic biases in transport projects in order to explain their causes and adjust for them in models if possible. However, as technical aspects of modelling seem to be only part of the explanation for why inaccuracies persist in forecasting, it might not be possible to overcome the problem through model adjustments alone. This brings up another relevant topic for discussion, which is the fundamental theoretical foundation of forecasting.

The potential accuracy of forecasting

At first glance traffic forecasts might appear to be closely related with the natural sciences, due to the avid use of complex mathematics to produce model results. While it is true that some knowledge of math is required to construct and operate these models this is no guarantee of them being accurate representations of actual traffic development or producing valid results. The causal mechanisms that form the logic structure of the model, as well as the inputs with which it must be fed, are not derived in the same manner that one constructs a theory of gravity by observing falling objects. These are largely dependent on human action and choice, and as such require an understanding of these phenomena which is provided by social sciences.

The natural vs. social science dispute is nothing new, but it is especially important to keep in mind when involved with traffic forecasting. The results produced by transport models are often seen as objective figures to form a basis for decision making, but they are nothing more than an expression for how the planners behind the model believe development will proceed in the future. There are no laws of nature concerning traffic flows or fuel prices, and the assumptions on which the model is constructed therefore have to be based largely on educated guesses from planners.

Does this mean that model results are useless? Hopefully no, but it is important to keep in mind that forecasts are nothing more than qualified guesses at best, backed up by numbers rather than words. Some philosophers of science would argue that the social sciences are not yet (or can never become) deterministic in the way that the natural sciences are (Flyvbjerg, 2001), and that trying to predict anything involving human choice could ultimately be impossible (Danermark et al., 2001; Næss, 2004). Such a perspective seems rather dire from a planner' point of view, and I would agree that prediction in the sense that it is used in the natural sciences will likely never be possible with social phenomena. However, it seems equally clear to me that there are at least some quite reliable trends to be observed in society, such as people choosing to buy their groceries in close proximity to their other daily transport activities or that transport demand goes up as fuel prices go down. These are not laws of nature and might be temporal and culturally determined, but the effects nonetheless occur frequently in most societies. I therefore hold the opinion that we can use models to produce reasonable estimates for future development, with the obvious limitation on accuracy that is connected with the uncertainty of tendencies for social phenomena.

Defining forecasted and actual traffic

Both during the initial phases of planning and during actual implementation of a given project there will often be additional demand forecasts produced, and as project completion draws near the latest forecasts might turn out to be more accurate than initial estimates. However, these forecasts seem of little relevance here as the aim of this project is to improve the available information at the time of making the decision on what (or if) to build, and later estimates are thus of no use to the study. It might be possible to make more accurate forecasts after this point, but as the decision to build has already been made it will not affect the basis of comparison for alternative projects.

Similarly, ramp-up effects have been observed to occur on regular basis after project completion (Nielsen & Fosgerau, 2005; Litman, 2009), meaning that the timeframe for observing actual traffic volumes need to be taken into consideration as well. Studies show that long-term (3-5+ years) induced transport effects are often double or triple those of short-term effects, and such development would need to be taken into account when observing actual traffic development. This is especially the case when data includes forecasts in which this effect might be accounted for in some projects, while in others it might have been ignored. For this study I propose that both actual traffic for the opening year as well as that after a three to five year period be included where possible. This would both allow for comparisons of forecasted vs. actual traffic volumes and for checking whether ramp-up effects have any significant influence on the validity of forecasts. However, whether this is possible in practise is another matter, as the most common practise seems to be using actual traffic for the opening year, and data might thus be readily available for this year while it could be harder to gain data for later years (Pickrell, 1989; Walmsley & Pickett, 1992; Flyvbjerg, 2005; Fouracre et al., 1990). Some authors also find that shortcomings in the opening year often lead to similar shortcomings in the following years (Pickrell, 1989; Flyvbjerg, 2005), and the inclusion of ramp-up effects might therefore be less significant in the comparison of forecasted vs. actual traffic.

2c. Objectives

This project is motivated by a desire to find out whether decision makers are well-informed about potential consequences when choosing between different transport solutions that are expected to affect transport volume. The main objective of this project can be formulated as an aim to answer the following research question:

- Can traffic models become significantly more accurate? If so, how?

To answer this question a set up sub-questions can be formulated that would also need to be answered (potential topics for these sub questions are added as bullet points):

- What is the role of transport models?
    - Extrapolating trends
    - Scenario construction
    - Justification
- Which type of transport projects experience forecasting inaccuracies?
    - Road vs. rail
    - Private vs. public
    - Capacity expansion vs. demand management
- What is the cause of inaccuracy in these projects?
    - Technical deficiencies
    - Psychological aspects
    - Political/financial incentives
- Do any methods exist to successfully address the identified causes?
    - Backcasting
    - Reference class forecasting
    - Accountability/quality control routines

2d. Methods

The study will include a quantitative analysis which seeks to compare the forecasted and actual traffic volumes for a large number of completed transport projects. The data for this analysis should include forecasts at the time of decision making and actual traffic volume after competition (opening year as well as the ramp-up target year) from different types of projects, that will be selected from a small range of countries in the developed world that are somewhat similar in terms of wealth and transport policy, while at the same time having employed different national transport policies (e.g. the UK, the Netherlands and the Scandinavian countries). In addition to this questionnaires will be sent to the planners in charge of the forecasting (or other relevant informants) where available, in order to provide additional information on project details (model type, underlying assumptions, adjustments, etc). The aim of the quantitative study is to form a sufficient amount of empirical data to identify the degree of uncertainty in the forecasts for different types of projects, and to check if there are any systematic biases in these inaccuracies.

If available data allows it would also be of great interest to include forecasts for the alternatives which were not chosen, just as the assumptions on which the zero-alternatives have been based would be very useful information. The former could be used to check the assumptions on which competing projects were based and the latter to check whether pessimism bias is applied to a zero-alternative in line with a theory of demand forecasts as self-fulfilling prophecies. This is argued to be the case in traditional predict & provide approaches to transport planning, where the forecasted traffic volumes are based on assumptions of having completed the same capacity expansions for which they are used to justify (Næss, 2006). This effect takes place, for example, when the models used to forecast traffic demand does not take the deterrent effect of congestion on further growth into account. Extrapolation of current trends will then result in traffic demand going above critical thresholds for congestion. This is a strong argument against doing nothing and thus for new capacity to be build. However, without this new capacity traffic demand would likely not have risen to such critical levels, since congestion deters people from increasing the volume of traffic. The forecasts are thus based on the premise that sufficient capacity is available for traffic demand to rise, i.e. that capacity expansions have already been implemented. Such predict & provide approaches have long been dominant in transport planning, and are still evident in Danish national transport planning (Nicolaisen & Næss, 2009).

The quantitative study will likely be supported by a qualitative study of a few selected projects (3 to 5), which aims to shed further light upon the causes behind any inaccuracies that may exist in the forecasts for these projects. This information could possibly be brought about through interviews with practitioners of demand modelling to identify deficient elements in the models themselves, the input fed to them or the process of constructing them. These case studies will hopefully allow for a deeper understanding of the practices that produce the large inaccuracies often found in traffic forecasts, in order to identify the sources of deficiency and hopefully also potential remedies for these. The social conditions in which models are used might be as important as the technical factors that they include, and both the quantitative and qualitative study should thus also explore this context.

2e. Significance

The project is expected to offer either improvements to traditional traffic forecasting or recommendations for alternatives to these (or both), as the current practise is dominated by a high degree of inaccuracy and potentially biased in a way that benefits only a few informed stakeholders. Reducing or eliminating systematic biases and model uncertainties will be a valuable improvement to traffic forecasts as a decision-making tool, as decisions are often made on the basis of faulty and incomplete data. Conversely, finding alternatives to traditional transport models could provide significant reductions in terms of resources required to produce estimates and improved transparency in the models. The impact is expected to be recognized internationally as this seems to be a universal problem to the planning profession, and so far little attention has been devoted to the potential of non-technocratic solution approaches.

2f. Time schedule

Towards February 2010 the aim is to form a basis for both theoretical and methodological foundations of the projects as well as a paper devoted to a discussion of the desirability of current methods for transport modelling. In addition to this the questionnaires to be used in the quantitative study should be ready within this first milestone period, so feedback can be gotten from the respective respondents in due time for analysis. After the first milestone the data gathering will continue, and in the same time the qualitative studies should be started up. These will likely continue throughout 2010 and into 2011. In this period data from the quantitative studies will be analysed as well, and papers on the results from these analyses will be written as progress advances.

Courses will be taken as they become available, but most should be covered in the first half of the project period. Teaching is expected to consist of supervision of relevant project groups on the UEEP B.Sc. programme and the UPM M.Sc. programme, as well as lectures in cases where a course curriculum overlaps with research topics. Most teaching is expected to be done in the middle of the project period, and especially semesters 5 and 7 could prove relevant in this regard. All data collection, analyses, Ph.D. courses, teaching and foreign stays are expected to be completed early 2012, after which focus will be on writing the main thesis. A visual overview of the proposed time schedule can be seen on the following page.

2g&h. Outline & papers

The thesis is expected to take the form of a monograph, in which the content of individual chapters is expected to form the basis of a set of journal articles to be published as the study progresses. The thesis will likely start with an introduction to the societal context of transport modelling, as well as considerations on the role of planners and models in general, the potential accuracy of forecasts and an assessment the future need for forecasts. Along with a discussion of the projects methodology this could form the outline of the first paper, which would thus aim at the theoretical foundation of forecasting and how to identify and deal with inaccuracies herein.

The results from the quantitative and qualitative studies could form independent chapters for the thesis, as well as independent papers. The focus in these papers would thus be on communicating these results and other experiences from the transport sector, in order to add to the pool of knowledge regarding the degree of uncertainty in transport models as well as the causes behind them.

As the goal of the project is to improve the available data at the time of decision making, it would be desirable for the thesis to include recommendations for how this can be done, based on the results from the quantitative and qualitative analyses. This is hopefully also of great relevance to academics, politicians and planning practitioners in the field of transport modelling, and as such articles can be aimed at a wide range of journals based upon such recommendations.

Time schedule

<table>
<tr><td>1</td><td rowspan="2">Data gathering for quantitative study</td><td>Forming questionnaires</td><td>Literature reviews, document studies</td><td>Identifying courses, data, collaboration, respondents, etc</td></tr>
<tr><td>2</td><td>Processing questionnaires</td><td rowspan="2">Interviews for qualitative study</td><td>Paper: Methods in demand modelling and their potential bias</td></tr>
<tr><td>3</td><td rowspan="3">Data analysis for quantitative study</td><td>Supervision/ lectures</td><td>Paper: The role of planners & models</td></tr>
<tr><td>4</td><td>Stay at foreign research institute</td><td rowspan="2">Data analysis for qualitative study</td><td>Paper: Results A</td></tr>
<tr><td>5</td><td>Supervision/ lectures</td><td>Paper: Results B</td></tr>
<tr><td>6</td><td colspan="3">Thesis</td><td>Paper: Recommended course of action</td></tr>
</table>

Figure 1: A rough sketch of the time schedule for the project. The left-most column represents the six milestones (6 month periods, similar to a regular semester, with the first starting from 01/09/2009 and ending 01/02/2010). Data gathering and

analysis for both the quantitative and qualitative studies are likely to overlap as these are iterative processes, and the separation should thus mainly be seen as a visual illustration of the expected progress.

3. Agreement

Student and main advisor have previously had quite successful experience in working together over longer projects, and the general approach from such experience is to be the foundation of the relationship during the PhD studies as well. No problems have arisen in the past and both student and main advisor have been satisfied with the roles they undertook, the collaboration between them and the feedback produced. As such the actual agreement will be somewhat informal. Meetings will take place at a regular interval every 2 weeks, for which new material will be forwarded to both advisors in a few days advance, to allow for initial feedback to serve as a basis for the meeting agenda.

Secondary advisor will be unable to take part in most of these meetings due to distance, but will receive all drafts as they are ready and any minutes from meetings with student and main advisor, in order to allow for comments as the project progresses. Face to face contact will be arranged with secondary advisor as schedule allows, and student and secondary advisor will seek to meet with regular (albeit longer) intervals in either Denmark or the UK.

4. PhD courses

Below is a suggested list of relevant courses. Along with conferences and workshops it should not prove difficult to reach the required 30 ECTS credits over the three year period.

Course	Place	ECTS	Course type
Writing, reviewing and presenting scientific papers	AAU	1-2	Workshop
Management of research and development	AAU	2.5	General
Critical Realism and Interdisciplinary Research	AAU/Oslo	5-7	General
Method and Social Science Theory	AAU	3.5	General
Philosophies of science	AAU	2.5	General
Transport model theory vs. practice	?	3-5	Project related
The roles of planners and models	?	3-5	Project related
Futures studies	AAU/Stockholm	3-5	Project related
Colloquiums related to overall project	AAU/DTU	?	Project related

Total credits	21-30

5. Dissemination

At the moment the plan is to focus primarily on conferences and journal articles, but magazine and newspaper articles will also be written. Relevant journals include:

- Environment & Planning
- Environmental Monitoring & Assessment
- Impact Assessment and Project Appraisal
- Journal of Public Administration Research and Theory
- Journal of the American Planning Association
- Transport Policy
- Transport Reviews

6. Immaterial rights

The student claims no immaterial rights to patents.

7. External collaboration:

Already now several options for external collaboration have presented themselves. The Centre for Major Programme Management at University of Oxford would be an obvious foreign research institute, as it is headed by secondary advisor Bent Flyvbjerg. TØI in Norway would also be an option, as Arvid Strand has expressed interest in the project and possibly has easy access to relevant data from Norwegian transport projects. Collaboration with project members from DTU will likely also be relevant in order to help frame the more technical aspects of both questionnaires and interviews.

8. Financing

The project is funded by the Danish Council for Strategic Research and Aalborg University. The project period is 36 months and the total gross salary budget is 1,297,881 DKK. From this salary 865,254 DKK is financed by the Danish Council for Strategic Research and 432,627 DKK is self-financed by Aalborg University.

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