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# Sources of Errors and Biases in Traffic Forecasts for Toll Road Concessions

Thèse pour le Doctorat ès Sciences Economiques

Mention Economie des Transports

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# Errors and Biases in Transport Demand Forecasts

> "The field [of transport demand forecasts] still suffers from bad reputation as many analytically advanced studies continue to disappoint, leaving significant wedges between realized and forecast traffic"
>
> Trujillo, Estache and Quinet (2002)

Forecasting stands at the heart of the transport planning process. Decision makers, in transport, use forecasts to select projects and to decide whether invest or not. From a public sector perspective, socio-economic evaluations are driven by demand forecasts, which gives the basis for choose and hierarchy public projects in order to maximise social welfare. From a private sector perspective, traffic forecasts are the base of financial evaluation and toll setting.

The planner's problem consists in maximise the social welfare subject to certain private revenue. The demand forecast is then the key variable in both equations. From both public and private perspectives, poor forecasts can lead to disastrous decisions. Despite its importance, many recent ex-post analysis have been showing that forecasts are sometimes very inaccurate and, especially in the case of toll roads, overestimated. As note Trujillo et al. (2002), while public-private partnerships in the delivery of transport infrastructures and services is expanding, there is also growing evidence of the lack of appreciation of the importance of demand forecasting in preparing and monitoring these partnerships.

This increasing evidence of discrepancy between actual and forecast demand may have numerous reasons in the context of growing participation of private sector. First, for the first time, ex-post demand really matters, traffic counts are systematic and before-after studies become a good practice in many countries.

Second, transport demand forecasting faces many methodological difficulties. Moreover, forecasting transport for toll roads faces much more difficulties than for a public/free road. The hypothetical willingness to pay used to monetize time savings is now used to estimate the actual out of pocket money; failing to identify the right value of time distribution in the population can lead to erroneous market shares. Also, competition matters. Improvements in concurrent roads or other modes may have strong effects on the demand market share.

Furthermore, the diversity of objectives across actors increases. Trujillo et al. (2000) argue that in practice, at least four groups of actors are involved: consumers, operators (in a large sense, that is including sponsors and financiers), the government (which represents the taxpayers and the voters) and the regulator and it is important to understand how their concerns differ. Users will worry about prices, service quality and reliability. All influence demand. The operators typically worry about profits, risks and market power. All are influenced by demand. Governments, who are often the dominating players in the context of the reform of the sectors covered here, are generally interested in reducing the fiscal burden imposed by the public enterprises of the sector and often also try to generate a flow of resources through the reform process. They generally want to please tax payers by cutting taxes and respond to some environmental and distributional concerns. These concerns can both influence demand and be influenced by demand. In this context, many of the players have a strong incentive to play strategically.

In this context, minimizing errors by understanding their sources and improving methods and procedures accordingly is important in the delivery of robust appraisals.

## 1.1 What is Forecasting?

A forecast can be defined as a prediction or estimate of an actual value in a future time period or for another situation. It is related to estimating in unknown situations and then with the notion of risk. Forecasting is important in many aspects of our lives. As individuals, we try to predict success in our marriages, occupations, and investments. Organizations invest enormous amounts based on forecasts for new products, factories, retail outlets, and contract with executives. Government agencies need forecasts of the economy, environmental impacts, new sports stadiums, and effects of proposed social programs (Armstrong, 2001).

The ability to define what may happen in the future and to choose among alternatives lies at the heart of contemporary societies. The modern conception of risk is rooted in the Hindu-Arabic numbering system that reached the West seven to eight hundred years ago. But Arabic numbers were not enough to introduce Europeans to explore the radical concept of replacing randomness with systematic probability and its implicit suggestion that the future might be predictable and even controllable to some degree. That advance had to wait the realization that human beings are not totally helpless in the hands of fate, nor is their worldly destiny always determined by God (Bernstein, 1996).

Most cultures have been concerned with forecasting. Sometimes the forecaster was held in high regard, as was the oracle at Delphi. Often, however, forecasting is regarded as a necessary evil and is frowned upon. According to a current sage (Drucker, 1973, p.124), "...forecasting is not a respectable human activity and not worthwhile beyond the shortest of periods." Sometimes it has been illegal. For example, in Rome in 357 A.D. Emperor Constantius issued an edict forbidden anyone "to consult a soothsayer, a mathematician, or a forecaster... May curiosity to foretell the future be silenced forever" (Armstrong, 2001).

In recent years, however, forecasting seems to have become a respectable activity and there is a growing need for more reliable methods (Figure 1.1 lampoons this idea). Nowadays, a formal forecast is needed for all decision-making. Demand forecasts precede almost every new product or service launching. Public projects like transport, energy and sanitation are preceded by forecasts including demand, socio-economic impacts as well as environmental effects.

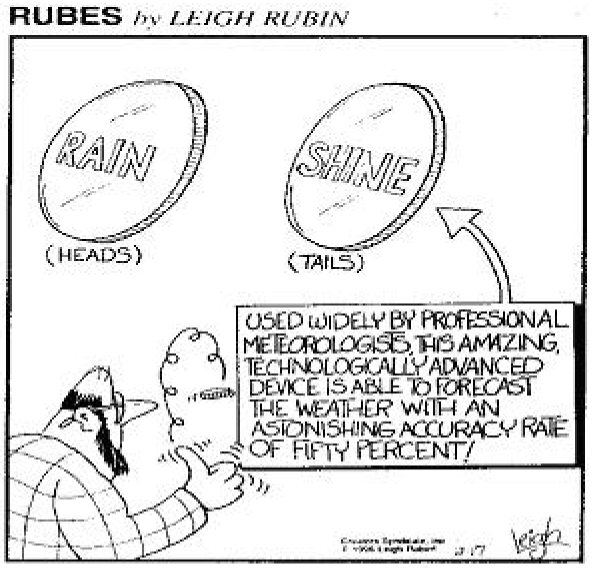


Figure 1.1: Caricature of weather forecasts

## 1.2 Forecasting in Transport

Transport forecasting is the process of estimating the number of vehicles or travelers that will use a specific transportation facility in the future. A forecast estimates, for instance, the number of vehicles on a planned motorway or bridge, the ridership on a railway line, the number of passengers patronizing an airport, or the number of ships calling on a seaport.

Demand forecasts are used for several key purposes in transport policy, planning, and engineering: to calculate the capacity of infrastructure, e.g., how many lanes a bridge should have; to estimate the financial and social viability of projects, e.g., using cost-benefit analysis and social impact analysis; and to calculate environmental impacts, e.g., air pollution and noise.

Transport forecasts have three main characteristics; they are unconditional, circular, and influential. Unconditional (or ex-ante) forecasts are estimates of what will happen in a situation when no actual data from that situation are used to produce the forecast; they use only information that would have been available at the forecast origin.

The circularity is an inherent characteristic of public projects and policies forecasts. Circularity arrives when choosing an action affects the future in a way that makes difficult or impossible the assessment of the action's impact. The demand which is later observed might have been "correctly" forecast, or might have been instigated by the forecast and the action which it spurred (Wachs, 1982). Consider a toll motorway for which a high traffic level is forecast. Later, having huge capacity they advertise, create frequency cards and lower the tariffs. Do the earlier forecasters of great demand now have the right to claim that their forecasts were accurate?

Forecasts in transport are influential. Influential forecasts occur when the forecast itself determines whether the forecast is tested. Forecasts for new products and new projects are often influential because a low forecast may cause the project is not launched and then the actual demand will not be observed. Although market (and transport) forecasts are often influential, many forecasts are not. Economic forecasts, for example, seldom influence evaluation. In forecasts for GDP or employment, we observe the outcomes, whatever the forecast. Not validating all forecasts causes two effects: Survivor's Curse and Prophet's Fear (Ehrman and Shugan, 1995). Statistically unbiased forecasts should appear optimistic because some forecasts remain untested. This effect is called the Survivor's Curse and reviewed in section 1.4.3. Prophet's Fear encourages pessimistic forecasts because these forecasts cause hidden opportunity losses while optimistic forecasts cause observable actual losses.

The development of traffic demand models began in the fifties in the United States, in the context of the pioneering Detroit and Chicago Transportation Studies. In the sixties, traffic models began to be used in England. From England it spread to the rest of Europe. There is an extensive literature on traffic modelling and forecast. The main reference is Ortuzar and Willumsen (2001); good reviews of the classic models as well as recent innovations are provided by Hensher and Button (2000). Bonnel (2004) provides a review of the main transport forecast techniques and the history of the transport planning in France.

Traffic forecasting begins with the collection of data on current traffic. Together with data on population, employment, trip rates, travel costs, etc., traffic data are used to develop a traffic demand model. Feeding data on future population, employment, etc. into the model results in output for future traffic, typically estimated for each segment of the transportation infrastructure in question, e.g., each roadway segment or each railway station. The basic idea behind this procedure is that transport is a derived demand, so what is to be forecast is not the transport itself, but what drives people to travel or not, where, when and how.

### 1.2.1 The Classic 4-step Model

The history of transport demand modelling has been dominated by the modelling approach which has come to be referred to as the four step (or four stage) model. The steps are: trip generation, trip distribution, modal split and network assignment.

Trip generation determines the frequency of origins or destinations of trips in each zone by trip purpose, as a function of land uses and household demographics, and other socio-economic factors.

Trip distribution matches origins with destinations, to develop a "trip table"; a matrix that displays the number of trips going from each origin to each destination, often using a gravity model or an entropy maximizing model.

Mode choice computes the proportion of trips between each origin and destination that use a particular transportation mode. They are estimated by either aggregated of disaggregated choice models, the later have recently been brought into widespread use.

Network assignment allocates trips between an origin and destination by a particular mode to a route. Often (for highway route assignment) Wardrop's principle of user equilibrium is applied (equivalent to a Nash equilibrium), wherein each traveler chooses the shortest (travel time) path, subject to every other driver doing the same.

One of the main criticisms regarding the four step model is the assumed stability over time. Once a travel model has been validated to base year conditions, forecasts for future years are generally made by replacing base year input data with forecast of those same model inputs. However, base year forecasts parameters (e.g. trip generation and mode choice coefficients) are generally assumed to hold over time because analysts have difficulty predicting the magnitude and the extent of parameter change. This builds an implicit assumption of system stability into the forecasts that may not be correct.

The science and art of travel forecasting is immersed in a period of transition, equally for the dissatisfaction with models performance as for the inherent interest in building a better mouse trap. However, the conventional modelling process is so firmly institutionalized that only a full replacement for the system, or modular and integrable component parts, could be accepted in practice and satisfy institutional constraints. This institutional inertia placed much of onus for model improvement in academia, where well-defined contributors to the state of the art often provide only marginal value to the state of the practice or to any comprehensive innovation (McNally, 2007).

## 1.3 Errors in Traffic Forecasts

> "Forecasters generally do a poor job of estimating the demand for transportation infrastructure projects" (Flyvbjerg et al., 2006)

Very little ex-post analysis has been done on the accuracy of forecasts; First because data that allow the calculation of inaccuracies in traffic forecasts unfortunately are relatively rare. For public sector projects, often the data are simply not produced. And even where the intention is to produce the data, projects may develop in ways that it is difficult or impossible to compare forecast with actual traffic (Flyvbjerg et al., 2006). Quinet (1998) argues that when the topic is traffic, it is difficult to compare comparable things; the situation in which the project is implemented is often different from that defined for the forecast.

Flyvbjerg et al. (2003) performed the largest study on forecast accuracy for roads, including 183 road projects worldwide (and also 27 rail projects). Figure 1.2 show the distribution of the forecasting error (for the first year of operation) in their sample.

Moreover, and despite the improved knowledge in transport demand models, it does not seem to reduce the errors in estimations over time. Flyvbjerg

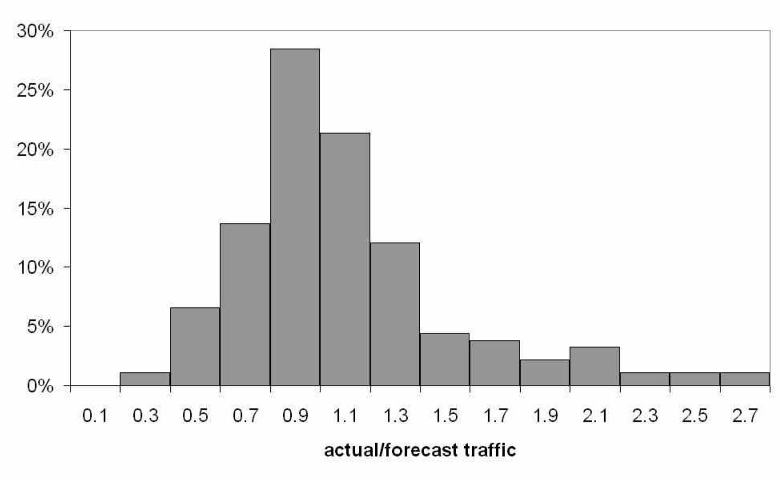


Figure 1.2: Errors on Flyvbjerg et al (2006) sample

et al. (2005, 2006) also show that there is no indication that traffic forecasts have become more accurate over time (figure 1.3).

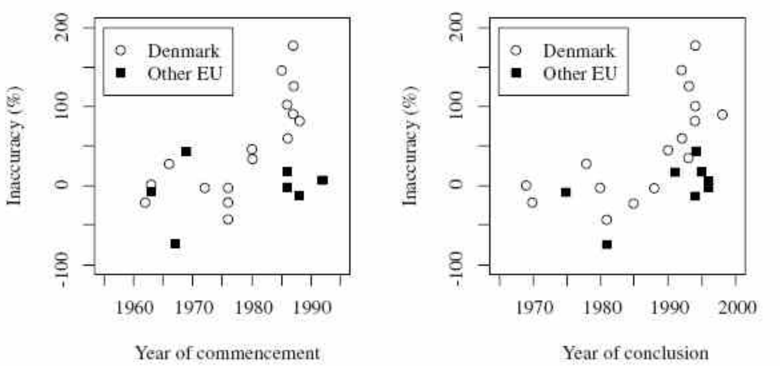


Figure 1.3: Errors variation over time on Flyvbjerg et al. (2003) sample

Standard and Poor's (2002, 2003, 2004, 2005) review a sample which increases from 38 in 2002 to 87 in 2005.

In chapter 3 of this thesis we analyse a sample of 49 road concessions worldwide and show also significant traffic forecast errors.

These studies show that errors in forecasts are much more the rule than the exception and lead to the question about the possible sources of these errors.

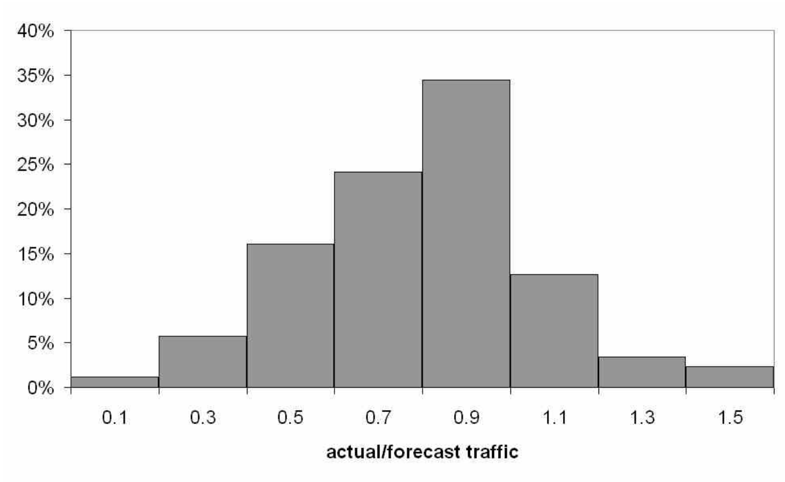


Figure 1.4: Errors on Standards and Poor's (2005) sample

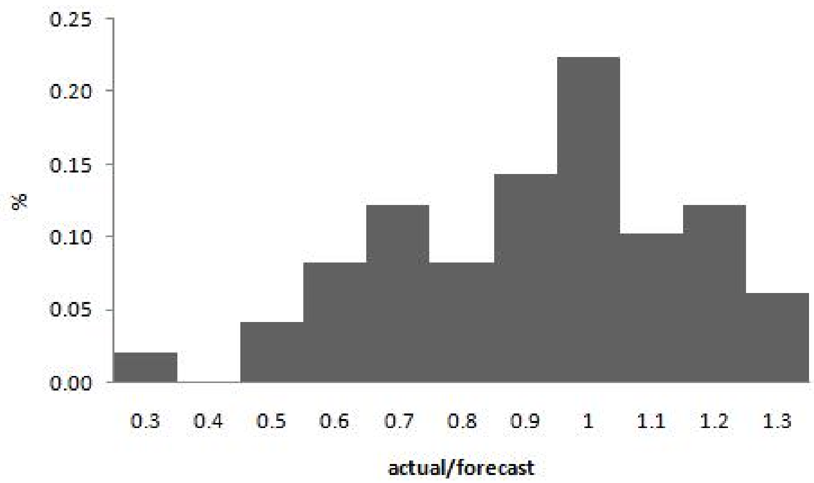


Figure 1.5: Forecasting error in 49 road concessions (chapter 3 sample)

## 1.4 Sources of Errors

Transport forecasts result from the combination of different models, for different purposes and of different nature, in which each one has number of parameters, data sources, estimation procedures and hypothesis.

Quinet (1998) distinguishes three sources of inaccuracy: the inadequacy of the model structure; the inaccuracy of the current data; and the uncertainty of prediction of the future value of exogenous variables.

Flyvbjerg et al. (2003), in a different way, classify the sources of inaccuracy in seven groups: methodology applied; poor database; discontinuous behaviour and the influence of complementary factors; unexpected changes of exogenous factors; unexpected political activities or missing realisation of complementary policies; implicit appraisal bias of the consultant; and appraisal bias of the project prompter.

In this work, we distinguish three main groups of sources of inaccuracy in traffic forecasts: the pure uncertainty, related to the fact that the future is uncertain by its nature; data and methodological sources, associated with the availability and quality of data and the models and assumptions used; and the behavioural sources, namely optimism and opportunism.

### 1.4.1 Uncertainty About the Future

One of the problems with the forecast assessment of models is that it is very difficult to predict the future values of the explanatory variables. Growth factors are used to estimate future year trip matrix. The development of appropriate growth factors depends on forecasts of demographic and economic variables such as population, employment, household income and gross domestic product for the study area. Errors in such assumptions can have a significant impact on growth forecast.

Morrison and Winston (1995), for example, indicate that poor predictions of income are the main reason why U.S. airline companies often overinvest during periods of macroeconomic expansion.

The work of the U.K. Ministry of Transport's Mathematical Advisory Unit in the 1960's offers a rather quirky example of what this can lead to. At the time, trend-based car ownership forecasts were proving more accurate than those of National Income. Since the link between income and car ownership had been established, efforts were made to generate GDP forecasts derived from the trend-based car ownership model. Causality was seen as less relevant than forecasting performance.

Sudden changes of exogenous factors can hardly be controlled by demand modelling and scenario techniques. For instance abrupt social and political changes such as the breakdown of the communism regimes in the east-west relationship in Europe are not predictable. Another example is the development of energy prices, which underlies influences that are hard to predict, as for instance in the cases of the two oil crises in 1973 and 1979 (Flyvbjerg et al., 2003).

The 21st century has been characterised as a period in which new forms of mobility both produce and change societies (Thrift, 1996; Urry, 2000). Low-cost airlines, widespread car ownership, and new mobile communications allow people to travel further, more quickly, and more frequently, and enable transactions that previously required face-to-face contact to be undertaken at a distance or even on the move. It is argued that these processes of time-space compression and time-space convergence (Gregory, 2000; Harvey, 2000, 1990, 1973; Thrift, 1990) are producing new challenges both at societal and at individual levels as people, organisations, and governments adjust to the consequences of new mobilities (Adams, 1999; Cairncross, 1997; Urry, 2000).

In this sense, forecasting the future of technology is a dangerous enterprise. Schnaars (1989) examined hundreds of technology forecasts. He found that there is a myopia, even among experts, that causes them to focus upon the future in terms of present conditions. Cerf and Navasky (1998) give interesting examples of errors in expert judgments about the future of technology. Perhaps the most famous is the 1899 call by the US Commissioner of Patents to abolish the Patent Office on the grounds that there was nothing left to invent.

### 1.4.2 Methodology, Assumptions and Data

#### Model Weaknesses and Inadequacies

Models are simplifications by definition. The level and way of simplifying the reality can strongly affect the results a model is able to produce. Different models are used in transport demand modelling, which one with its own limits and weaknesses. Each parameter, each functional form specification will impact the results in a certain way. Moreover, models rely on numerous hypotheses about human behaviour that are seldom validated.

The treatment of models as black-boxes can also be a danger. Many users settle for the direct application of commercial models without a correct understanding of its models and assumptions.

Furthermore, the sequential and aggregate nature of transportation forecasting has come under much criticism. While improvements have been made, in particular giving an activity-base to travel demand, much remains to be done.

### Errors in Assumptions

Ascher (1978) has pointed out that forecasting is critically dependent on the use of assumptions. He wrote that:

> The core assumptions underlying a forecast, which represent the forecaster's basic outlook on the context within the specific forecast trend develops, are the major determinants of forecast accuracy. Methodologies are basically the vehicles for determining the consequences or implications of core assumptions that have been chosen more or less independently of the specific methodologies. When the core assumptions are valid, the choice of the methodology is either secondary or obvious. When the core assumptions fail to capture the reality of the future context, other factors such as methodology generally make little difference; they cannot "save" the forecast.

Mackie and Preston (1998) report that the M65 was built on the assumption that Central Lancashire New Town would be fully developed and the Concorde was developed under the assumption that supersonic flights would be granted access to inland air space throughout the world.

Some kind of mix between exogenous source and error in assumptions are the impacts of political activity. Unexpected political activities or unfulfilled promises for political actions have become a problem since the scenario-technique of forecasting became popular. Usually scenario forecasts are prepared in a way where the political side describes that part of the future world that is influenced direct by political actions. Examples are taxation policy, regulations and complementary activities for the project under investigation (for example access roads, urban/spatial development or international agreements).

But stated political preferences and actual political activities are often very different. We find a central example of such differences in the European Union. While the Green and White papers on the common transport policy promote sustainable development in words, actions that would match the words still lag behind and actual developments proceeds in the opposite direction from the established policies. The state of discussion for CO2 taxation or driving regulations for lorries are cases in point. Consequently, ecological oriented forecasting scenarios may very well fail for the transport sector, as happened in both Germany and Denmark (Flyvbjerg et al., 2003).

Ieda (2003) proposes a distinction between "be" and "do" forecast, where "be" forecast represents that would be naturally realized, or the estimated value and the "do" forecast which could be realized only through policy efforts, or the target value. This forcibly clarifies the type of "policy effort" which is necessary in order to achieve the target, and monitors whether enough "policy efforts" are put in or not, based on the commitment. Figure 1.6 illustrates this idea.

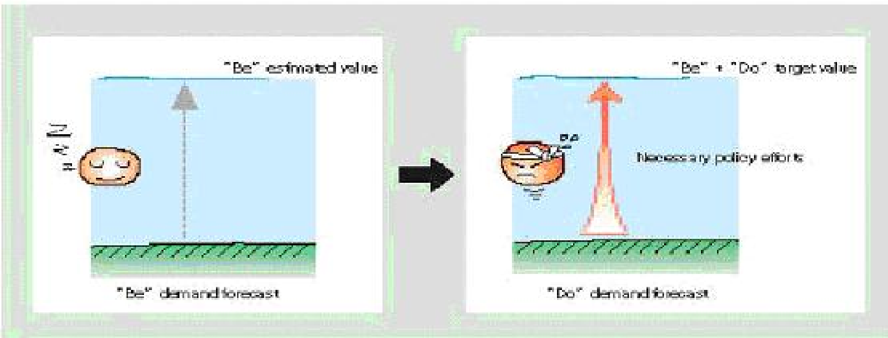


Figure 1.6: From "be" forecast to "do" forecast

### Data Availability and Quality

In the field of transportation research, nothing is more valuable yet simultaneously more limiting to the valuation of theory and models than are data (McNally, 2007). Data are seldom or never of the quality we would like them to be. The quality of data as traffic forecast model input represents one of the major sources of potential forecasting error. These data include traffic counts, transportation networks characteristics, travel costs, the location and size of households and car ownership to list a few.

Flyvbjerg et al. (2003) claim that poor data is a more important reason for prediction failures than methodology. They argue that in many countries there is no continuous generation of field data. This means that traffic demand models can not be calibrated on the basis of observed traffic behaviour (the revealed preference approach). This gap can partly, but not completely, be close by stated preference analysis. The problem is that actual behaviour of people may, and often does, deviate substantially from the stated preferences.

### 1.4.3 Behavioural Sources

Although the forecasting exercise is about understanding and modelling human (users) behaviour, some biases and errors are directly related to the agents involved in the forecast processes. In this sense, transport forecasts can include or reflect some forecasters' or decision makers' biases. Whenever this occurs, the forecast produced will not represent the forecaster's true expectations as assumed.

Before discussing the behavioural sources of errors and biases we want to clarify an important aspect of demand overestimation. Many authors argue that in absence of strategic or optimism biases, traffic forecast errors should be equally distributed above and bellow zero error:

- "Significant errors, and furthermore biased in the sens of overestimation, show strategic biases from analysts." (Quinet, 1998).
- "Although scientific uncertainty should be, a priori, evenly distributed between under and over-estimation[...]"(Trujillo et al., 2002).
- "Instead of being random errors, however (with the possibility of canceling each other out), these are systematic errors reflecting optimism bias" (Standard and Poor's, 2002).

Although at first sight unbiased estimations should be symmetric distributed around the zero error, the influential characteristic of transport forecasts makes this assumption wrong. Statistically unbiased forecasts should appear optimistic because some forecasts remain untested. This effect is called the Survivor's Curse (Ehrman and Shugan, 1995). Suppose (1) we supply unbiased forecast (zero reporting bias) for a series for projects each having the same expected sales, (2) the client launches some but not all of those projects and (3) launched projects average higher forecast than unlaunched. Then, the unbiased forecast, for launched projects, appear optimist and biased. Mathematically, let $f_A$ be the average forecast for all projects, fL be the average forecast for launched projects and $f_N$ be the average forecast for projects not launched.

Since $f_N$ is the average of independent normal variables, $f_N$ is normal with mean $\mu$ and variance $\sigma^2$. According to David (1957), $E[f_N|f_L > f_N] = \mu-(\sigma/\sqrt{2})$. But $E[f_N+f_L|f_L > f_N] = \mu$, so $E[f_L|f_L > f_N] = \mu+(\sigma/\sqrt{2}) > \mu$. Finally, $f_A$ is a convex combination of $f_L$ and $f_N$, so $f_L > f_N$ requires $f_L > f_A$.

This implies that even when forecasters make unbiased forecasts, the forecast traffic for launched projects will tend to overstate their actual traffic. Survivor's Curse works as follows. Most forecast contain some error. Positive errors enhance the probability of launching projects and the forecast survives to be tested. Negative errors enhance the probability of not launching and the forecast remains untested. Those projects surviving the screening process, by exceeding the critical value, are more likely to have positive errors because projects with negative errors may not survive to be tested. Here, the bias (expected error) across all forecasts is zero, but the bias for tested forecasts is positive. So survivors tend to disappoint.

### Opportunism

Forecasts rely upon so many assumptions that it is usually possible to adjust forecasts to the extent that they meet such demands. The question here is to know in which measure the field of traffic forecast is a world of honest numbers.For example, Wachs (1982) affirms that most of the forecasts used in the planning of America's rail transit systems are statements of advocacy, rather than unbiased estimates.

This problem takes a particular importance in the case of road concessions. Private promoters may have incentives to adjust the level of traffic in order to make the project more attractive or to have the best bid. This situation is exacerbated in regulatory frameworks in which renegotiations are easier. The opportunistic strategy consists in bidding a low price[1] by increasing the forecast traffic level.

Once an enterprise has been granted a concession in an infrastructure sector - and the eventual bidding competitors are gone - that enterprise may correspondingly be able to take actions that "hold up" the government, for example through insisting on renegotiating the contract ex post. The extensive informational advantages that the enterprise possesses over the government and its perceived leverage vis à vis the government in a bilateral negotiation is a powerful potential factor to seek renegotiation of the contract and secure a better deal than the initial one.

When bidders expect a high likelihood of renegotiation that renders it possible to avoid any losses, they have strong incentives to submit bids containing promises difficult to satisfy, with the sole purpose of being awarded the tender (Spulber, 1990). Uncertainty in forecasts is then used in a strategic way by the bidders. This is exacerbated by the information asymmetries in concession projects. Moreover, traffic overestimation may represent an equilibrium in the short-term. In fact, while candidates submit opportunistic bids to increase their probability of success, the more aggressive the bids, the better it would be for the public procuring authority, since it is more efficient in the short-term. Besides, financial agencies and lenders, suspecting that traffic forecasts are strategically increased, find a risk-sharing agreement that cushions them against any losses.

### Optimism and Overconfidence

> "There are two kinds of forecasters: those who don't know, and those who don't know they don't know." *J. K. Galbraith.*

[1] as reviewed in chapter 3, lowest toll is the most wide used criteria in auctions for transport infrastructures.

The tendency to be overoptimistic is perhaps the best documented of all psychological errors (Montier, 2002). Psychological studies demonstrate that most individuals are overconfident about their own abilities, compared with others, as well as unreasonably optimistic about their futures (e.g., Taylor and Brown (1988); Weinstein (1980). When assessing their position in a distribution of peers on almost any positive trait such as driving ability or income prospects, most of people say they are in the top half (Svenson, 1981).

Russo and Shoemaker (1992) find that professional managers perceive their judgment to be too exact. CEOs who have chosen an investment project are likely to feel illusion of control and to strongly underestimate the likelihood of project failure. (Langer, 1975; Weinstein, 1980; March and Shapira, 1987). Cooper et al. (1988) look at entrepreneurs who overestimate their chances of success with their business. In their sample of 2994 entrepreneurs 81% believe their chances to survive are better than 70% and 33% believe they will survive for sure. In reality 75% of new ventures did not survive the first 5 years.

Schultz (2001) addresses the point that despite dramatic progress in consumer research product failure rates have remained on a high level. He argues that overconfidence might account for the fact that managers constantly overestimate the success chances of their projects which leads to constantly high product failure rates despite better marketing research techniques.

### 1.4.4 The Particular Case of Road Concessions

Since the seminal paper by Demsetz (1968),competition for the field has been considered as a tool of government to allow private sector participation and benefit from efficiency advantages of competition while retaining some degree of control and guaranteeing the respect of community service obligations (Baldwin and Cave, 1999; Engel et al., 2002). The fact is that in the last couple of decades, many countries have promulgated directives on public procurement so as to bring in competitive tender mechanisms, e.g. the Federal Acquisition Regulations' mandate to use auctions in the U.S. public sector, the 1989 European directive on the obligation of competitive tendering, the 1988 Local Government Act in the United Kingdom or the 1993 "Sapin Act" in France.

Although traffic forecasts are fundamental in public (socio-economic) evaluation, in order to choose the most valuable projects for the hold society, avoiding waste public funds and improve social welfare; the growing participation of the private sector in infrastructure provision brings a financial perspective since in private applications, forecasting errors can easily have multi-million dollar impacts.

Trujillo et al. (2002) argue that the introduction of private finance and operation of motorways brings two main changes; the amplification of information asymmetries and the payment of a toll.

Politicians will want to look good during their tenure and support policies that maximize short run fiscal payoffs and/or minimizes tariffs. They can do so quite consciously and knowing perfectly well that requiring high payments and expenses from the operators while imposing low tariffs are generally not consistent and sustainable policies. Willingness or ability to pay and hence the real potential value of a business are seldom analyzed very analytically in this context.

The political gain for them to announce a new infrastructure is much higher than the political loss of having to increase taxes; furthermore these concerns and the eventual renegotiation of the deal is left to their successors since they generally imply political costs. But it is clear that private operators happily play in this game. For many of the best deals, their main concern is to get the contract signed by the government, knowing quite well that there is generally significant room for renegotiation. Patience in this field is often rewarded once the contract is won.

In sum, there are enough reasons and there is enough evidence to argue that in the context of privatization, it is not easy to achieve convergence on the views of what a good demand forecast should be because both firms and government have some interest in playing strategically with the demand forecast.

This should make a convincing case to ensure that regulators do their best to come up quite early on in their tenure with independent assessments of demand. This assessment will be useful at almost every stage of a regulator's activity. Demand is important in most types of conflicts that have to be resolved through tariffs or quality adjustments. Demand is important when assessing financial support requirements for projects requiring subsidies. Demand is also important in understanding the distributional consequences of any regulatory decision. Demand is finally important every time there is a renegotiation and this means it will often matter because most contracts end up being subject to some degree of renegotiation.

Table 1.1 shows the policy and regulation issues related to the demand forecast in the context of private participation.

## 1.5 Objectives of this Research

One can think of transportation as a technological behemoth bedeviled by human behaviour. Transportation research contributes technological and management innovations that drive this beast forward, and can also offer insights into the limits that human actors and institutions can impose on implementation of an efficient transportation system. Transportation is affected by human behaviour through its consumers (drivers, riders, vehicle buyers, and shippers); through its managers and workers; and through the policy-makers and voters who determine transportation infrastructure and policy (McFadden, 2007).

Demand forecasting is all about behaviour. The success of any product or service will be determined by its potential to meet customers' expectations. In this sense, a good forecast shall understand the individual choice criteria and model it properly. The behavioural side of transport has been focusing in disaggregated users' choice (particularly modal choice, but also departure time, location, among many others). Also, drivers behaviour has been extensively studied in psychology and accident analysis.

However, in transport demand forecasts, in addition to user's behaviour, the behaviour of at least two more actors should be taken in account. First, the forecaster behaviour. Forecasters can have some individual influence on the study, either by his own opinion about the project, by the external pressure he receives, or by his opinion about his own judgment capacity. Despite of the highly quantitative aspect of demand forecasting, the individual opinion about the chances of success (or failure) of a project can influence the modeling exercise in a way the results best fit the forecaster's expectation. Furthermore, if the forecaster overestimate his own capacity of decide whether a project is good or not, his individual evaluation will be biased.

Second, in particular when there is competition for the market, the project promoter behaviour. Project promoters want to maximise they chances to get the project. In a competition for the field scheme (bids), the bidder may overestimate the demand in order to be reduce the toll included in the bid. This strategic behaviour can introduce a high bias in forecasts

Then we study the user's behaviour at two levels. First, at the aggregated level, we analyze the long term traffic growth and its relationship with the economic growth.

Second, at the disaggregated level, we study the value of travel time savings, the main variable guiding individual mode choice and probably the most important value in socio-economic evaluation as well as in demand and revenue forecast.

In this sense, this thesis intends to represent a small contribution to the understanding and reduction of errors and biases, sources of traffic forecast overestimation in toll motorways. The infinity of sources of errors and biases that can affect traffic forecasts constraints our research to the study of some particular points; the objective of this research is to examine some key points in forecasting. Although many points merit special attention and need developments, our choice in this thesis was guided by the practical needs we have faced in the studies for Cofiroute S.A. (Vinci Concessions) and by the author's insights, focusing in academic innovative topics but which present a high interest for practitioners and decision makers.

Table 1.1: Transport Modelling

| Stage | Transport decisions | Policy and regulatory issues in the context of privatization | Modelling |
|---|---|---|---|
| Trip generation | How many trips does the user in some specified location wants to take in day/week/month? | Is there an obvious unmet willingness to pay for and zoning improvements in services which could be met by a new project or a concession to improve existing services? | Land planning and zoning |
| Trip distribution | Where is the user going with each trip among all possible destinations of interest to the transport service provider? | What would be the optimal size of the project to be packaged for private sector participation? | Origin-Destination matrix |
| Modal distribution | Which transport mode does the user adopt for each trip? What are the factors influencing that decision and to what extent? | What price-quality combination should the privatization commission aim at and how much margin should the regulator give to the private operator to adjust price and quality given the overall objectives of the "privatization". Also, how much coordination is needed between different modal regulators (if these are at different government levels for instance)? | Demand models (aggregated or disaggregated) |
| Route allocation | Which route between the origin and the destination does the users pick under various types of service packages? | How do pricing (including access pricing) and quality rules influence the efficient use of the transport infrastructure? | Network simulation models |