Demand forecasting

Traffic forecasting

Traffic forecasting is a critical part of the PPP planning process. Traffic demand is a direct determinant, with toll rates, of project revenue. Over optimistic demand forecasts will therefore almost certainly lead to financial problems. Sometimes, in practice, over-demand estimates can impact in the first years of project opening.

Therefore, with experience, demand forecasts are often ramped down i.e. only a percentage of estimated demand is used in the first few years say 50%, 70%, 90 % of the original estimates for the first three years respectively, especially for interurban routes.

The use of sensitivity and risk analysis are also essential to consider the project impacts if traffic does not materialize as forecast.

As will be described in Module 5 the need for experienced advisors and good TORs are paramount in the preparation of feasibility studies (F/S), within which traffic forecasting as described above, will be critical. Even in preliminary F/S studies, the need for well prepared traffic studies remains important, even if some other project parameters are still at a preliminary stage.

Such forecasts will be prepared by the public sector and their advisors as a basis for the tendering process. There can be a tendency for the private sector, in order to win a bid, to unrealistically increase their forecasts in bids. The public sector itself may not dissuade from such considerations because for example higher forecasts could lead to an initial demand for lower subsidies and other notional advantages to government but only at the bid stage.

However, the danger is that in accepting bids with higher than realistic forecasts, the project will run into financial problems causing extreme financial and political problems for the government subsequently. The demand forecasts in bids should be therefore critically reviewed to see if any difference in demand forecasts from the original government study have a logical basis or are just an attempt to win the bid with unrealistic forecasts. See Renegotiation Section.

Demand forecasting and techniques for projects are discussed in detail in Module 5 -> Due Diligence and Feasibility Studies -> Technical Evaluation.

Future “demand” or level of use of the transport system may change as a result of two types of factors:

- “Background” increases in population, economic activity, automobile ownership, total trip-making, and other factors that drive transportation activity, occurring independent of transportation improvements;
- Increases in these same factors that are caused (or made possible) by the transportation improvement. This second category is often known as “induced” or “latent” demand. It is of particular importance in the case of significant improvements such as construction of a new highway or a major upgrade in

highway performance. Induced demand is closely related to the impacts on economic growth caused by the highway improvement.

In addition to increasing overall traffic, transport investments may affect the distribution of existing traffic by changing the relative cost of travel on various transport routes. Hence, while this is true for all modes, road transport distributions can change very quickly in response to new or expanded roads, changes in tolling levels and especially so for say new bridges or tunnels. Hence the importance of network forecasting and traffic distribution models in the highway sector.

Demand forecasting involves a set of analytical procedures to estimate future levels of transport system use as a result of changes in population characteristics, economic activity, and transport network conditions, and of subsequent changes in travel patterns. Demand forecasting serves different purposes depending upon the level of the study. For strategic planning, forecasts are needed to evaluate the overall viability of alternative strategies and the demand for individual components of these strategies. For corridor planning, forecasts are needed to determine the adequacy of existing facilities and services in the corridor and the potential need for expanding these facilities and services. For facility planning, forecasts are needed to determine the appropriate capacity of new facilities that may be built and of existing facilities that are being considered for expansion.

Methods for demand forecasting can range from very simple to very complex. At the most basic level, past trends in traffic growth can be extrapolated to predict future levels of traffic in any given year. This method supposes that the past tendencies will pursue in the future; unless there is a strong evidence for this, such method should be avoided. Transport is a derivate demand, which means that is explained by other variables and not driven by past trends.

A more sophisticated approach will estimate future traffic based on projections of the underlying drivers of traffic - for example population, economic activity, vehicle ownership and land development.

Either of these methods can be applied at a national, regional or corridor level to provide a broad estimate of future transportation demands. More sophisticated methods of forecasting the underlying variables are likely to result in more accurate traffic forecasts and are fundamental to a network plan.

Population, employment and land use forecasts provide a basis for estimating future origin-destination or “background” flows on the system. The future transportation network can then be varied to describe proposed improvements to the road and highway system. This will predict the changes in the distribution of future traffic over the network, and to some extent will predict increases in travel caused by reductions in transportation costs. Network demand forecasting methods have primarily been developed for urban applications, but these same methods are increasingly being adapted for state, regional and national highway planning. See the following references for additional information on demand forecasting:

Modeling Transport. Ortuzar and Willumsen. 3rd edition. Wiley. 2001.

Why is demand forecasting important in a PPP?

It must be remembered that demand forecasting is a necessary step in any road project appraisal, whatever the implementation or institutional scheme. But some issues are more specific to PPPs and will be developed below.

While public-private partnerships in the delivery of transport infrastructure and services are expanding, there is also growing evidence of the lack of appreciation of the importance of demand forecasting in preparing and monitoring these partnerships. Financial viability and the success of the project will largely depend on robust traffic forecasts.

However, weak forecasts can also give an opportunity to the private operators of transport services to complain; soon a business starts operations related to the financial impact of underestimations of demand based on the initial information provided by governments. It tends to result in an excuse for the private operators to try to renegotiate the contract to improve its terms. Either by design or accident, it is quite common for both regulators and concessionaires or bidders to devote much more money to the construction cost studies than to the demand analysis. This is an important reason why the public sector needs to prepare sound traffic forecasts during the project preparation. (Module 5).

Forecasting the Demand for Privatized Transport, Trujillo-Quinet-Estache, World Bank (draft). 2000.

The lack of focus on good demand forecasting in the context of the increased role of private operators and investors in the transport sector may be somewhat counter-intuitive. Transport planners have a long tradition of concern for demand. The analysis of demand has been at the core of the assessment of national or sector policy options, including the introduction of new transport modes. But these concerns have generally been addressed through more “macro” or network oriented modeling.

Traffic volume forecasts are the most fundamental data in the analysis of roads from the planning stage onward. They will influence many fundamental decisions on project feasibility, design and management, for example whether the road should be a toll road and which decisions have to be made about toll levels and collection periods.

Global Toll Road Study, Knowledge Data Base level 2 (draft), MOCJ - EXTEC (2000), page 13

How does transport demand assessment take place in the relationship between the public and private sectors?

The restructuring of the public sector has been influenced by PPP development. However, the increased role granted to the private sector does not mean that the role of the public

sector will diminish. In many ways its roles as a sector planner and as an (independent) regulator are strengthened.

Regulators, which are often Government officials or political appointees in many cases, need to balance everybody's concerns fairly, accounting for many aspects of demand which may be ignored in the PPP development process. It includes a reasonable comparison of the willingness and ability to pay in order to avoid unfair exclusion of some segments of the population, particularly in the case of passenger transport. Adjustment of tariffs during the project operation stage can also influence demand depending on circumstances.

A particularly important aspect of the choice in the context of PPP development is the trade-off between the incentives given to the operator to perform well and the risks that the particular operator is expected to take. The specific assignment of responsibility and of the choice of regulatory mechanisms are the main reasons for the strategic use of demand forecasting by the key players involved in the PPP development process.

Regulatory trade-offs in designing concession contracts for infrastructure networks, Crampes and Estache, Utilities Policy (1998)

Demand forecasts can never be precise. However, the more precise or robust the demand forecasts, the lower the risk, and the easier it is to agree more favorable contracts for the public sector. In addition, the reliability of demand forecasting allows the government authority to better assess the actual efforts of the operator to improve efficiency. Thus the authority will have at its disposal accurate data comparable to that of the operator, enabling it to check on the correctness of operator's provided information in its tender documents.

In the context of PPP development, it is not always easy to achieve convergence on the views of what a good demand forecast should be, because both private operators and government authorities have to some extent divergent interests with regard to the demand forecast. Once the government has decided to rely on private operators to provide transport services and transport infrastructures, discrepancies in demand forecasting will lead to tougher negotiation with the private operators and increase the incentive of operators to contest the regulatory decisions on the basis of the doubtful value of the supporting analysis. Even if management instruments that allow the correction of forecasting mistakes exist, these corrections are generally not challenge-free.

However in terms of risk, conversion of an existing toll highway to PPP using approximately the same level of tariffs is relatively less risky than a PPP development with a change in tariffs. The most risky, both relatively and absolutely is a new facility developed under PPP, such as a concessioned highway, that is now tolled where both the facility and a tariff did not exist before.

A few things transport regulators should know about risk and the cost of capital, Alexander, Estache and Oliveri, Utilities Policy (2000).

What kind of mistakes can be made and how it is possible to deal with them?

It should be realized that the impact of incorrect traffic forecasts have a number of dimensions;

- Impact on the facility; underused or over capacity
- Impact on the financial viability of the project and/or impact on government finances
- Short term impacts (i.e. traffic will come back on track) or a long-term problem (i.e. will likely not come back on track within say 10 years)

To be realistic, it is well known that limiting the errors in demand prediction is always a challenge. The best that can be achieved is a robust set of forecasts, within a robust PPP framework, that provide the basis for sufficiently accurate financial forecasts that can reasonably stand up to the actual outturn, especially in the earlier years. That is why the decision makers and contractors linked to this process must be prepared to face overestimates or underestimates of transport demand when the project is in operation.

However, it should be noted that the financially critical 'bottom line' i.e. the cash flow results are dependent on a number of factors, such as types of traffic, toll rates and/or government support, O&M costs and debt service including interest rates. Therefore one variable such as traffic forecasts that are overestimated can be accommodated, to some extent, assuming other variables can be adjusted and/or a lower rate of return accepted.

Some recent surveys show that overoptimistic demand forecasting is common. Recent references are: Inaccuracy of traffic forecasts and cost estimates on large transport projects, Skamris and Flyvberg, Transport Policy Vol. 4, No.3, pp141-46, 1997; Traffic Forecasting Risk Study Update. Standards and Poor's. 2005.; Sources of Errors and Biases in Traffic Forecasts for Toll Road Concessions. Nunez, A. PhD Thesis, University of Lyon.

The conclusions of these sources are that (i) traffic forecasts inaccuracies are much more the rule than the exception (ii) these inaccuracies tend to occur in the sense of traffic overestimation.

Mitigating Toll Road Forecasting Risks, Scott Trommer, Fitch Ratings, 2006

Toll Road Revenue Forecast - Quality Assurance/Quality Control. Samuel Zimmerman, World Bank, 2006

Why does over-investment arise?

The first reason in the context of PPP development is that one of the changes often made by the private operators is the introduction of cost-reflecting prices and a switch from tax-payers to users for the responsibility of paying for the service. If the use of toll roads is deemed too expensive, many, but not all, users look for free alternative routes and this is why the existence of toll free alternatives must be reflected in the demand forecast. Even when no effective alternative to a toll road is available, the reluctance

of potential users to pay may lead to social pressure and adversely affect the transport demand.

Whatever the case may be, when there is no or little tradition of payment of fair, and/or cost reflecting, prices, the introduction of such pricing policies can result in significant differences between actual and predicted demand on specific links-even though the overall sector forecasts may still be correct. If planners rely on trends, and it is a common practice, to forecast demand, this can lead to significant over-estimation. Traffic trends are more accurate at say a corridor level than related to individual toll road links.

What can be done to cope with over-optimistic demand assessment?

An over-optimistic demand assessment implies that the actual/observed demand is lower compared to the provided transport system capacity. A possible solution to redress the situation, leading to an increase in transport demand, may be to apply a tariff reduction. The optimal tariff reduction or subsidy will depend on the specific objective of the government. One option is to allow the use of two part tariffs designed to allow the recovery of both operational and capital costs. The idea is to set a unit price equal to the short run marginal cost and at the same time to levy a fixed charge to recover the capital cost. What is interesting from the viewpoint of the government concerned is the risk of having to pay subsidies. Viability Gap Funding is an increasingly popular way to provide targeted subsidies and government support to group/s of users based on an assessment of ability to pay. Such strategies can allow the operator to explore alternative forms of price discrimination between its users. The government should focus subsidies on the poorest users of the infrastructure to ensure the need to achieve a financial balance does not result in the exclusion through price of the poorest users. The results can be doubly beneficial:

- avoiding exclusion of the poor from the use of the new infrastructure, and
- increasing traffic flows and thus increasing viability.

It is may also be considered that contracts can be better drafted to allow for more conservative traffic forecasts which may result in subsequent adjustment in favor of the government.

It is also possible that traffic forecasts within tenders will be better scrutinized and compared to the government's own estimates.

And in case of underestimated demand?

In the case of underestimated demand, the actual/ observed demand is higher compared to the forecasts and/or the provided transport system capacity. Although this situation is less common in the general context of transport PPP development, it does occur. In the case of such an over-pessimistic transport demand forecast, the main outcome can be a lack of transport capacity leading to congestion. This can be quite dramatic in the short-run when it is impossible to revise investment plans to adjust quickly to the larger than expected demand. This is a common problem in urban transport modes.

If, for whatever reasons, demand is temporary or occasionally stronger than expected but a long-term adjustment in capacity is not needed, the short-run solution generally recommended by economists is a temporary rationing through prices. Part of the demand may disappear as a result of this pricing strategy and never return if the prices are not adjusted downward again. This also illustrates the importance of proper project preparation including financial and cost-benefit analysis in projects with detailed analysis of willingness to pay under various conditions.

The problem with the pricing solution is a political one in the context of PPP development. There are many cases in which toll or fare increases have led to riots and therefore regulators or politicians are reluctant to undertake price changes that are politically sensitive. Other types of action may have some impact but may only have limited impact and may only be applicable in some country contexts e.g. limiting trucks at peak hours, car pooling lanes, limiting access etc.

Influence of tolling on transport demand

It is very important to understand the link between financial and economic viability in toll roads because a distinctive feature of toll roads is that the realization of the economic benefits expected from the investment depends heavily on the financing option chosen. In other words, there are trade-offs between the economic and financial viability of a toll road, which often tend to be overlooked.

The socio-economic profitability is decreasing on the level of toll (in absence of congestion), since higher tolls mean less traffic on the road (due to the price elasticity of demand) and a smaller economic surplus for the remaining users.

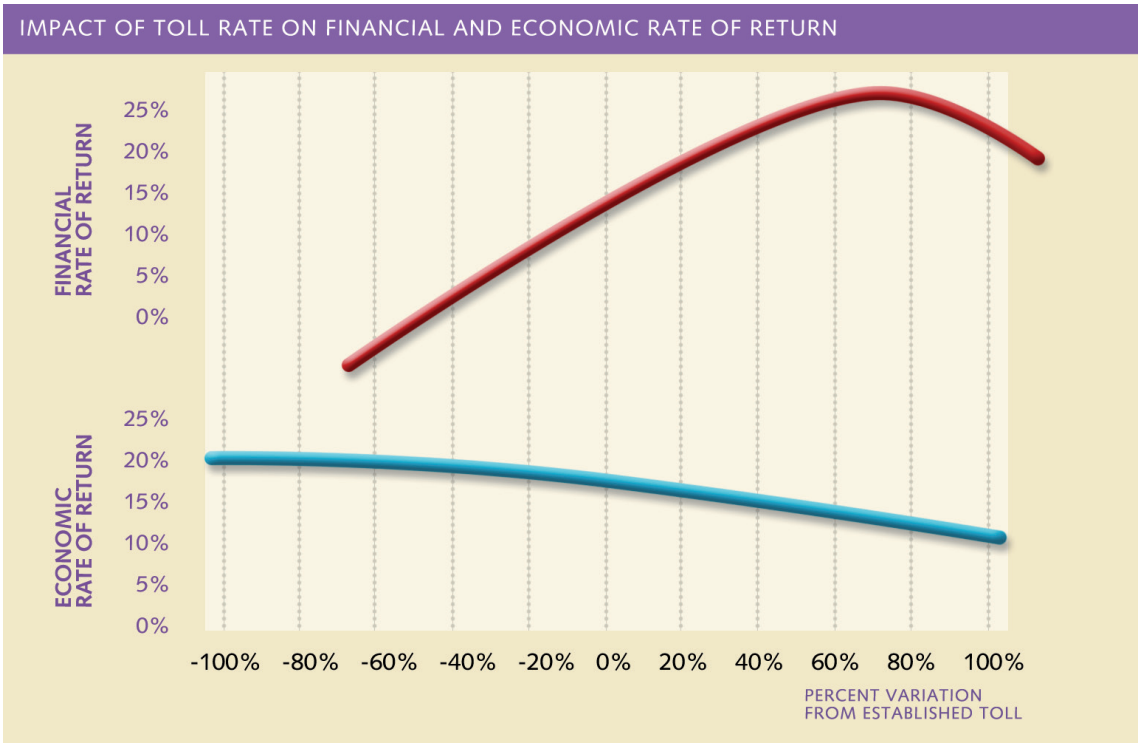
From a financial point of view, two effects counteract. Higher tolls mean higher revenue per user but fewer users on the road. The result is that the revenue increases until a certain level (the optimal private toll or monopoly pricing) and decreases after that.

These tradeoffs could be seen in the report: The Study on Public-Private Partnership Scheme for Trans Java Toll Road in the Republic of Indonesia, January 2007, prepared by Katahira & Engineers International, PriceWaterhouseCoopers and PwC Advisory Co.,Ltd.

In this study, different tariff levels were used in the economic and financial analysis. This resulted in two substantially different traffic forecasts. This methodology is not necessarily incorrect but is certainly not easy to understand. For the economic analysis, the socially acceptable level (SAL) of Rp200/km (about USCents 2.0/km) in 2010 was used, and for the financial analysis the maximizing revenue level (MRL) of Rp400/km.

Based on project costs, expected traffic and financing structure (interest payments, debt/equity ratio), the level of toll rates that meet debt service and financial returns may cause traffic diversion to an alternative route. This may be a highly inefficient outcome in terms of traffic allocation in the corridor. In such a case, the free-access public road, which is likely to be of less capacity, lower level of service and less well maintained, carries more traffic than is economically efficient while the newly built toll road is under-used and represents wasteful investment.

This can be illustrated by the chart below:



Colombia - Toll Road Construction Project, 1998 - New highway - Variation of ERR and Financial Revenue depending on the toll rate
Source: A. Menendez

Why worry about "willingness-to-pay"?

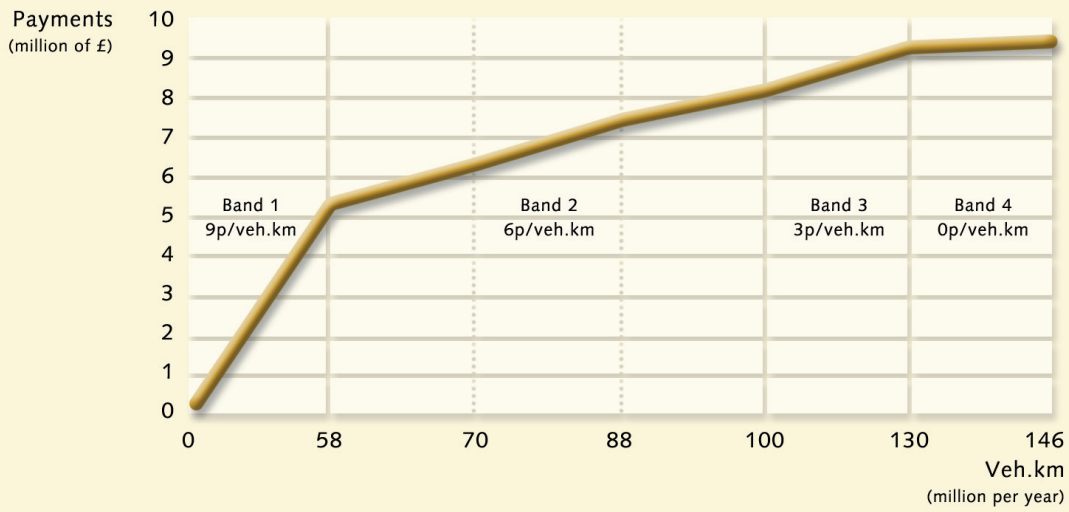
In the case of a toll road project, an accurate estimate of the toll fee the potential users are ready to pay - the willingness to pay - is in theory a prerequisite of toll level setting. In practice, this parameter is very difficult to assess, particularly in countries where the experience of toll roads is limited or simply non existent. In transition or developing countries, the rapid changes occurring in income distribution and overall wealth make willingness to pay even more difficult to assess over the relatively long periods considered for economic appraisal. Users' willingness to pay tolls is largely a function of their wealth, the value they assign to time savings and other toll road benefits as well as the cost and quality of competitive alternatives. Assessing willingness to pay is in fact trying to figure out the elasticity of transport demand.

Nonetheless, data on the value of time and the willingness to pay for various types of transport service users exist for numerous countries. These indicators may be used when pricing new services to be provided by private operators. It makes sense to compare the calculated tolls or tariffs with these rough estimates of the willingness to pay for some services or with the value of time revealed by the post-mortem analysis of comparable projects increasingly found in literature (see Quinet on Marseille (1998), Small and Winston (1999) on the Dutch data base). Surveys themselves are frequently

difficult to undertake accurately with many road users questioned likely to deliberately underestimate their willingness to pay.

The use of 'shadow' tolls or annuities are possible ways to mitigate traffic risk to be borne by the private sector when the motorists' willingness to pay is unknown. These mechanisms entail paying the investor based on an agreed formula which may or may not include receiving toll revenue. This is discussed in Financial Framework in this Module.

EXAMPLE FOR A 100KM LONG SECTION



Source: Analysis of highway concessions in Europe. Frank Bousquet. French Highway Directoroute - 1999

To find out more about time valuation and relation to willingness to pay, see

On the social valuation of travel time savings, Galvez and Jara-Diaz, International Journal of Transport Economics, Vol. XXV, No. 2, (June 1998).

Transport Policy. Hensher D and Goodwin. Using values of travel time savings for toll roads: Avoiding some common errors. Vol.11:2, pp. 171-181, 2004

Also some useful references and methodologies are contained within:

Good Practices for Estimating Reliable Willingness-to-Pay Values in the Water Supply and Sanitation Sector Herath Gunatilake, Jui-Chen Yang, Subhrendu Pattanayak, and Kyeong Ae Choe, ADB 2007.

What is the relation between "stated preference surveys" and the "willingness-to-pay"?

The main objective of a stated preference survey is to estimate the utility function for each mode or route, which will determine the probability of drivers switching to a toll road from a free route under different rates of toll. The utility function allows to estimate the perceived value of time, and then the average toll which drivers would be prepared to pay.

Drivers are interviewed using questionnaires specifically designed to avoid the usual difficulties met when trying to obtain sound estimates of time values and willingness to pay. The first part of the survey often consists of general questions about the journey being made. These questions are intended to collect some information on which to base the stated preference situations and to provide a basis for data segmentation. The questions include the following:

- The type of vehicle being driven,
- The reason for being at the journey destination,
- The number of passengers,
- The frequency of making the same trip,
- The country of vehicle registration,
- The driver's approximation of the total distance of the journey,
- The journey origin,
- The distance to be travelled on the toll road,
- The reason for being at the journey origin,
- The driver's anticipated journey time on the toll road,
- The journey destination,
- The driver's age, sex, economic status (employment category) and level of education.
- The stated preference survey itself consists of a predetermined set of pair questions whereby drivers are asked to state whether they would use "'definitely" or "probably" the toll road or the toll-free road. The usual variables are toll level, total journey time and freeway standard.

Then questionnaires are usually processed using dedicated discrete choice analysis software, such as, ALOGIT and BIOGEME. General statistical packages can also deal with these surveys.

It should be noted that in order to predict modal split and route choice (which is particularly important for toll roads) the distribution in values of time is essential, not just average values that can be calculated by most discrete choice software. An increasing number of programs can estimate distributed parameters; for example BIOGEME (Bierlaire's Optimization Toolbox for GEV Model Estimation) or specific codes developed for R or Matlab.

How is it possible to assess how toll charging will affect traffic assignment?

Three methods are commonly used:

- **Time saving principle:** the proposed toll rate (monetary value) is divided by the time value of vehicles (monetary value per time period). The resulting "time value" (e.g. hours) represents the equivalent toll rate in time units. Therefore, for traffic assignment purposes, road links are assumed to "cost" more time when tolled compared with the travel time on the same links in a toll-free situation.
- **Generalised Cost Modelling:** In highway network modelling, each link has various characteristics which impact time, cost and other factors. For each vehicle type, the model will reduce these characteristics to a total generalised cost for each link and the toll road will have the toll fee added to the cost of that link (or links). Application of the OD matrix to the network results in assignment of traffic to routes according to various criteria according to toll fee scenarios, type of traffic, time of day and other.
- **Diversion ratio curves:** these are derived from relation between the ratio of the toll rate and the time saving (resulting from using a toll road instead of an existing toll-free road) and the percentage of vehicles that will divert from the toll-free road to the toll road. These diversion ratio curves are calculated for by type of vehicle. The time value for each type of vehicle can be obtained by calculation but should eventually be based on experience. Time values and diversion ratio curves will have to be revised repeatedly in accordance with the actual traffic volumes measured along toll roads as the years pass.

To estimate route choice it will also be necessary to collect data on perceived marginal vehicle operating costs.

Conclusions on mitigating the impact of over estimated demand

Forecasts will remain a key input but consideration of the following may mitigate their impact if overestimated;

- Should include a comfortable margin (robustness).
- While there are technical improvements and lessons learned, forecasting errors will remain and therefore other variables such as toll rates etc. need to be flexible as well as the financial structures of the contract.
- Is the project a new Greenfield project or expansion?
- Are key forecasting variables at top end of range such as value of time, population, GDP etc? Or bottom end, e.g. operating costs?
- Common sense; consider increase in traffic from base year to first year of project. Is it believable?
- Does traffic depend on other network and/or land use developments, planned but not yet in place?
- Use of ramp up in first three years of forecast.
- Compare with other projects in country/region.

- As with all projects, make sure senior decision makers and Consultants have undertaken adequate site visits.
- Ensure the financial structures are adequate to withstand reasonable overestimates in traffic i.e. adequate equity and liquidity etc.
- If available, apply for guarantees that would be available at difficult points in the cash flow/debt repayment cycle.