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Infrastructure Finance

TRAFFIC RISK IN START-UP TOLL FACILITIES

Standard & Poor's
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BUILDING ON A TRADITION OF ANALYTICAL EXCELLENCE

Welcome to Standard & Poor's latest research on traffic risk in start-up toll facilities. The publication of this study reflects the continued commitment of the European Infrastructure Finance Ratings team to coverage of the highway sector. It is intended to enhance our enviable reputation as the world's leading provider of timely, objective credit analysis and provides original insight into arguably the major risk factor affecting toll toad companies and project-financed toll road transactions.

This is an exciting and challenging time for the industry. The European toll road sector is experiencing a period of major change, as major investments are still required to build or upgrade road infrastructure. These investment requirements are supported by various public policy commitments by both national and regional governments. In some European countries, such as Spain, the sector has reached a level of maturity allowing refinancing possibilities which can ultimately drive credit quality. In other countries, such as the U.K. and Portugal, the use of non-recourse project financing through the Private Finance Initiative has led to some interesting innovations, such as the use of shadow tolling.

Understanding how traffic risk affects credit quality and future sector trends has never been more challenging. As a result, Standard & Poor's recognizes that it is particularly important for investors to be able to rely on high-quality and independent credit research to make well-informed and effective financial decisions.

Based in London, Paris, Frankfurt, Madrid, Milan, Stockholm, and Moscow, our 23 regional infrastructure analysts' credentials place them at the forefront of their profession. The key transport infrastructure analysts are listed below and welcome your feedback on their work. Please do not hesitate to contact me or any of the analysts listed below if you require further information.

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CREDIT IMPLICATIONS OF TRAFFIC RISK IN START-UP TOLL FACILITIES

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The project financing of toll and shadow toll highways, bridges, and tunnels brings traffic risk to the forefront of credit analysis. Traffic-related revenue streams dictate a project's available future cash flow profile--sometimes constrained within boundaries predetermined through concession agreements--and hence the strength and timeliness of its debt-servicing capabilities. With concession terms of about 30 years (sometimes longer), back-loaded debt structuring, and a reliance often placed on traffic growth over the medium-to-long term to render the project viable, the need for reliable traffic forecasts has arguably never been greater. Reviews of the predictive ability of traffic models reveal mixed results.

Standard & Poor's experience indicates that optimism bias is a consistent trend in toll-road traffic forecasting. Bondholders and lenders should, therefore, view these forecasts with some degree of caution as they attempt to identify the inherent risks that these forecasts pose for credit quality. As part of an ongoing review of the sector, Standard & Poor's has conducted some original research and developed an analytical tool--the Traffic Risk Index--that aims to identify and quantify the biggest pitfalls affecting traffic studies.

The purpose of this commentary is to provide guidelines for evaluating toll-road traffic and revenue forecasts. It is neither intended as a definitive guide to the production of accurate traffic or revenue forecasts nor a template against which all forecasts will be evaluated. There is no substitute for experience and the application of sound judgment by experts in objectively analyzing traffic data for the purposes of preparing forecasts.

However, in the past, many consumers of toll-road-traffic forecasts and traffic and revenue reports have used arbitrary rules to adjust these forecasts to take account of optimism bias and/or to stress-test financial models. Often with little empirical support, these rules can be highly subjective, may be inconsistently applied, and remain difficult to communicate meaningfully or justify to others.

Toll-Road Research

Standard & Poor's has a long history of reviewing traffic forecasts and working with the consultants who prepare them, as well as the recipients/users of these forecasts. The requirement to continually monitor project performance--often as part of an annual rating surveillance obligation--provides the opportunity to examine forecast performance. Aside from bond-financed toll facilities, Standard & Poor's also evaluates the performance characteristics of toll roads funded through bank loan debt, particularly through the credit evaluation of increasingly popular collateralized loan obligations (CLOs). The analytical review that follows builds upon this broad--perhaps unique--perspective.

Few industry commentators have attempted a retrospective, cross-sectional analysis of toll-road-forecast performance to extract lessons that could be used to better inform the predictive process. One notable exception, now a little dated but still with some important conclusions, is a 1996 study compiled by J P Morgan ("Examining Tollroad Feasibility Studies", J P Morgan, Municipal Finance Journal, Vol. 18, No. 1, Spring 1997). Examining 14 recently constructed urban toll roads across the U.S., the study found that only one of the toll roads exceeded its revenue prediction. Three of the roads missed the mark by up to 25%, and for four of the facilities actual revenue was less than 30% of the forecast. Standard & Poor's wider global research, discussed below, reveals broadly consistent findings.

Standard & Poor's is aware of project characteristics that present particular challenges to forecasting practitioners, the sensitivity of the forecasting process to input data quality and detail, and general trends and concerns within the toll-road sector. In short, a toll-road offering can incorporate more or less uncertainty depending upon its specific attributes--and that uncertainty appears to impact directly on forecast reliability.

Standard & Poor's Case Studies

A top-down and bottom-up approach was used to explore project uncertainty and traffic forecast performance in the context of 32 toll-road case studies. These highway, bridge, and tunnel case studies were drawn from various regions around the world. The case studies are summarized in Table 1.

These forecasts were start-of-operations (first-year) forecasts. From a credit perspective, this is a logical focus as the probability of default is typically at its highest during the early project years--known as "ramp-up" years. However, it does mask the fact that in some (but by no means all) cases, forecast performance improved in subsequent years as the discrepancy between predicted and actual traffic narrowed. In other cases, projects defaulted or underwent major restructuring to avoid default, making a comparison of actual versus forecast traffic in later years less valid.

Table 1

Toll Road Case Studies					
Id No.	*Region*	*Facility type*	*Toll regime*	*Forecast commissioned by*	*Forecast performance**
1	Eastern Europe	Highway	User paid	Bank	0.78
2	Caribbean	Bridge	User paid	Bank	0.87
3	North America	Highway	User paid	Bank	0.45
4	Eastern Europe	Highway	User paid	Other	0.77
5	Latin America	Various	User paid	Other	0.45
6	Asia	Highway	User paid	N/A	0.87
7	Northern Europe	Bridge	User paid	Bank	1.08
8	Eastern Europe	Highway	User paid	Other	0.75
9	Northern Europe	Highway	User paid	Bank	0.84
10	Northern Europe	Highway	Shadow Toll	Bank	1.06
11	Southern Europe	Bridge	User paid	Other	0.62
12	Asia	Bridge	User paid	Other	0.59
13	Asia	Highway	User paid	Other	0.47
14	Northern Europe	Bridge	User paid	Bank	0.82
15	Northern Europe	Bridge	User paid	Bank	0.70
16	Southern Europe	Highway	Shadow Toll	Bank	0.90
17	Asia	Tunnel	User paid	Other	0.95
18	Northern Europe	Tunnel	User paid	Other	0.45
19	Northern Europe	Highway	Shadow Toll	Other	1.19
20	North America	Highway	User paid	N.A.	1.05
21	North America	Highway	User paid	Other	0.31
22	Latin America	Highway	User paid	Bank	0.83
23	North America	Highway	User paid	Other	0.54
24	North America	Highway	User paid	Other	0.60
25	North America	Bridge	User paid	Other	0.55
26	North America	Highway	User paid	Bank	0.70
27	North America	Highway	User paid	Other	0.83
28	North America	Highway	User paid	Other	0.75
29	Asia	Highway	User paid	Bank	0.50
30	North America	Highway	User paid	Other	0.48
31	Southern Europe	Highway	Shadow Toll	N.A.	0.94
32	Northern Europe	Highway	User paid	Bank	0.77

*Ratio of actual traffic volume divided by the respective forecast. A forecast performance of 0.5, for example, means that actual traffic was half that forecasted. N.A.-Not available.

Over-Optimistic Traffic Forecasts

It is possible to fit a distribution to the case study data set presented in Table 1. A suggested distribution is superimposed on the data set in Chart 1. The lateral shift, downward from unity, reflects the consistent tendency for forecast over-prediction. The mean of this distribution (0.73) indicates that, on average, traffic volumes were about 70% of their predicted value.

Standard & Poor's Toll-Road Case Studies

Traffic studies commissioned by banks are typically referred to as "conservative" forecasts, and financial models often use these figures as their base-case. To determine whether this

Chart 1

Standard & Poor's Toll-Road Case Studies

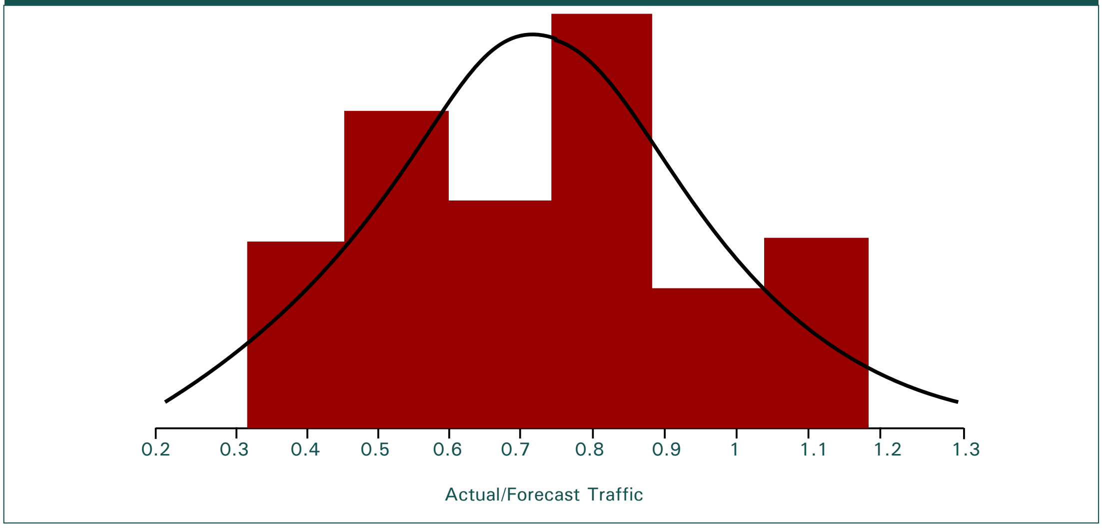


Table 2

Disaggregate Forecast Performance

	Standard & Poor's study		Forecasts commissioned by J P Morgan study
	Banks	Others	
Minimum	0.45	0.31	0.18
Average	0.82	0.66	0.58
Maximum	1.08	1.19	1.17

conservatism better reflected realism, Standard & Poor's noted the type of agency that had commissioned each of the various traffic studies. This was quickly collapsed into "Banks" and "Others"-- the Others category encompassing agencies such as project sponsors and bidders whose interests would be served best if higher traffic volumes were predicted.

The results from this disaggregation are reported in Table 2. Figures from the J P Morgan study are also shown for comparative purposes. A value of 0.5 indicates that the actual traffic was half that forecasted. Values greater than 1 indicate that actual traffic exceeded its forecasts.

The table shows similar patterns between the two studies. Furthermore, making a distinction between Bank forecasts and those prepared on behalf of Others appears to be justified. The figures suggest that these are two different data sets with significantly different means and ranges. The Banks' average error (18%) was nearly half that recorded for the Others (34%), and the range was narrower.

Of the 32 case studies analyzed by Standard & Poor's, 28 forecasts over-predicted traffic. Only four of the case-study forecasts underestimated traffic. The number of shadow-toll-road case studies was too few to derive meaningful conclusions, however it was interesting to note that, given their small number (4), half of the under-predictions resulted from forecasts prepared for shadow toll roads.

Some of the case studies were accompanied by commentaries providing reasons for the predictive failures. Almost without exception, the reasons lay external to the traffic model itself--and stemmed from inaccurate or inappropriate assumptions made regarding key input variables.

Typical reasons included:

- High toll tariffs and a miscalculation regarding users' willingness to pay (especially frequent users such as commuters);
- Recession/economic downturn;
- Future-year land use scenarios that never transpired (including development build-out along the corridor that was less and/or slower than predicted);
- Time savings that were lower than expected;
- Improvements to competitive (toll-free) routes;
- Considerably lower usage by trucks; and
- Lower off-peak/weekend traffic.

Some of the poorest-performing toll roads were noted to have characteristics in common, many of which directly reflected considerable future-year uncertainty. This prompted the top-down and bottom-up analysis of this uncertainty to

Chart 2

determine the nature and extent of its relationship with forecast accuracy.

The top-down analysis considered the project-specific forecast errors and the characteristic(s) of the project that led to predictive inaccuracy; its nature and extent. The complementary, bottom-up analysis looked from the forecasting practitioner's perspective at issues acknowledged as compounding the forecasting challenge. No direct link was necessarily intended between these two approaches, however common denominators quickly emerged.

The resulting Traffic Risk Index is presented in Table 3. An extended discussion regarding this table and its contents will be published shortly and made available to subscribers of Standard & Poor's RatingsDirect at: http://www.ratingsdirect.com.

A notional scale running from zero to 10 is presented along the top of the table, reflecting increasing inherent uncertainty from left to right. Below, against different attribute categories, a spectrum of scenarios is described--more stable and predictable to the left, more challenging and volatile to the right. Note that this is not an attempt to collapse or capture all project-related uncertainty within some simple arithmetic framework. Rather, it is a starting point for considering toll-project traffic uncertainty in a logical and consistent manner.

The Index also represents a checklist that can be used to examine project-specific uncertainties and prompt appropriate enquiries (allowing the analyst to draw his/her own conclusions about the likely reliability of the resultant forecasts).

Employing the Traffic Risk Index

The traffic forecasting case studies were "scored" against the Traffic Risk Index (see Chart 2). The more conservative forecasts associated with bank commissions are clear from the chart. The final score represented an average of the individual scores against each line item, unless a dominant factor suggested that this average should be adjusted up or down as appropriate.

Clearly, this type of scoring is highly subjective and depends, to a large extent, upon the detail of data available to the analyst. In the absence of such detail, judgment was applied based on a broad understanding of the history and success of tolling in particular counties. Curve-fitting software was then used to superimpose lines of best fit over the individual data points. The results of this exercise are shown in Chart 3.

The lines of best fit were selected such that the majority of the data points lay on or above the respective curves. This technique was chosen as the curves were to be used to suggest stress tests that could be applied to project revenues to take account of the inherent uncertainty in particular projects.

Traffic Ramp-Up

A ramp-up period reflects a toll facility's traffic performance during its early years. This period may be characterized by unusually high traffic growth, often from a base that is considerably lower than expected. The end of a ramp-up period is denoted by annual growth figures that appear to have stabilized and are more in line with traffic patterns observed on other, broadly comparable,

Table 3

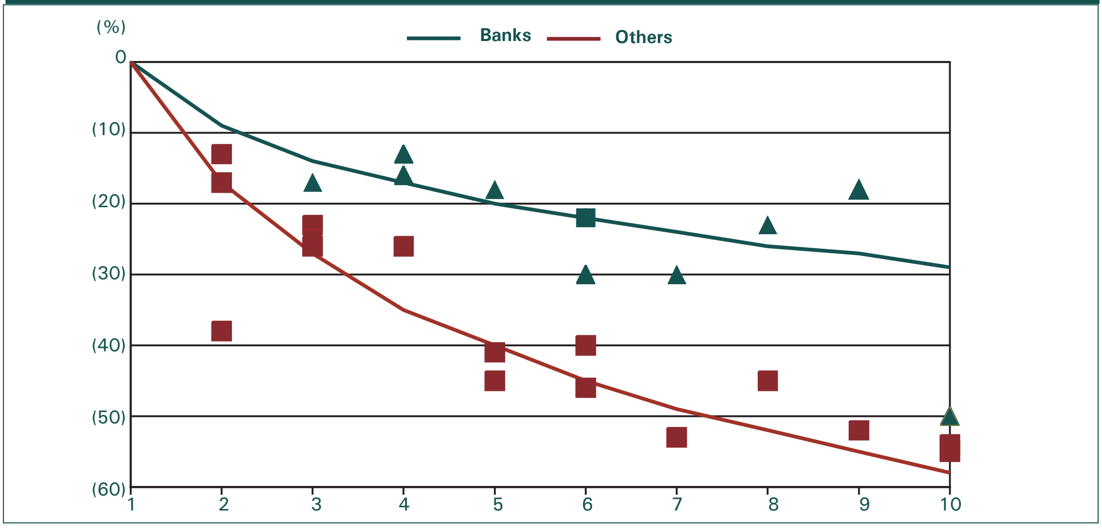
Project Attributes	Traffic Risk Index: 0 1 2 3 4 5	6 7 8 9 10
Tolling regime	• Shadow tolls	• User-paid tolls
Tolling culture	• Toll roads well established - data on actual use is available	• No toll roads in the country - uncertainty over toll acceptance
Tariff escalation	• Flexible rate setting/escalation formula, no government approval	• All tariff hikes require regulatory approval
Forecast horizon	• Near-term forecasts required	• Long-term (30+ year) forecasts required
Toll-facility details	• Facility already open	• Facility at the very earliest stages of planning
	• Estuarial crossings	• Dense, urban networks
	• Radial corridors into urban areas	• Ring-roads/beltways around urban areas
	• Extension of existing road	• Green-field site
	• Alignment: strong rationale (inc. tolling points & intersections)	• Confused/unclear road objectives (not where people want to go)
	• Alignment: strong economics	• Alignment: strong politics
	• Clear understanding of future-highway network	• Many options for network extensions exist
	• Stand-alone (single) facility	• Reliance on other, proposed highway improvements
	• Highly congested corridor	• Limited/no congestion
	• Few competing roads	• Many alternative routes
	• Clear competitive advantage	• Weak competitive advantage
	• Only highway competition	• Multimodal competition
	• Good, high-capacity connectors	• Hurry-up-and-wait
Surveys/ data collection	• 'Active' competition protection (eg. traffic calming, truck bans)	• Autonomous authorities can do what they want
	• Easy-to-collect (laws exist)	• Difficult/dangerous to collect
	• Experienced surveyors	• No culture of data collection
	• Up-to-date	• Historical information
	• Locally-calibrated parameters	• Parameters imported from elsewhere (another country?)
	• Existing zone framework (widely used)	• Develop zone framework from scratch
Users: private	• Clear market segment(s)	• Unclear market segments
	• Few, key origins & destinations	• Multiple origins & destinations

Table 3 (cont)

Project Attributes	Traffic Risk Index 0–5	Traffic Risk Index 5–10
	• Dominated by single journey purpose (e.g. commute, airport)	• Multiple journey purposes
	• High income, time sensitive market	• Average/low income market
	• Tolls in line with existing facilities	• Tolls higher than the norm - extended ramp-up?
	• Simple toll structure	• Complex toll structure (local discounts, frequent users, variable pricing etc.)
	• Flat demand profile (time-of-day, day-of-week etc.)	• Highly seasonal and/ or 'peaky' demand profile
Users: commercial	• Fleet operator pays toll	• Owner-driver pays toll
	• Clear time and operating cost savings	• Unclear competitive advantage
	• Simple route choice decision-making	• Complicated route choice decision-making
	• Strong compliance with weight restrictions	• Overloading of trucks is commonplace
Micro-economics	• Strong, stable, diversitied local economy	• Weak/transitioning local/ national economy
	• Strict land-use planning regime	• Weak planning controls/enforcement
	• Stable, predictable population growth	• Population forecast dependent on many, exogenous factors
Traffic growth	• Driven by/correlated with existing, established and predictable factors	• Reliance upon future factors, new developments, structural changes etc.
	• High car ownership	• Low/growing car ownership

Chart 3

Traffic Risk Index
Case Studies (with Best-Fit Lines)



parts of the highway network.

The ramp-up period reflects users' lack of familiarity with a new highway, bridge, or tunnel and its benefits--an information lag--and a community's general reluctance to pay tolls, particularly high tolls. Ramp-up has three dimensions:

- Scale of the ramp-up (magnitude of the departure from forecasts);
- Duration of the ramp-up (from instantaneous to beyond five years); and
- Extent of catch-up (having experienced low usage upon opening, to what extent can observed traffic volumes catch up with later-year forecasts?).

Ramp-up traffic volumes were available for a subset of the case study data described earlier--typically projects that had been operating for a number of years. In general, the data clustered around one of two extremes. Where the ramp-up effect was small in size, it typically spanned a limited duration and quickly caught-up (if not exceeded) future-year forecasts. If, however, the departure from forecasts upon opening was considerable, a protracted ramp-up period was observed, leaving projects struggling to catch up. This latter scenario was closely linked with projects that scored toward the upper end of the Traffic Risk Index. Chart 4 shows the ramp-up profiles from 10 of the case studies.

Taken together, the Traffic Risk Index and the alternative ramp-up observations suggested profiles of revenue adjustment that could be applied as stress tests to project-financed toll facilities. These empirically derived profiles are summarized in Table 4.

Research Conclusions

Standard & Poor's research highlights four important conclusions:

- Toll-road projects with high levels of inherent uncertainty appear to be more susceptible to large forecasting errors.
- Instead of being random errors, however (with the possibility of canceling each other out), these

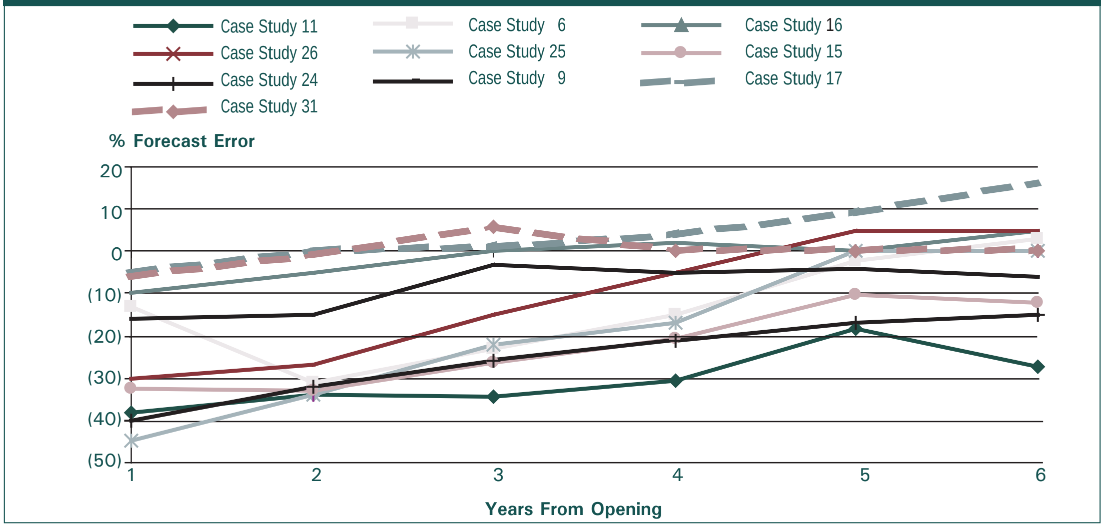
Table 4

Suggested Revenue-Adjustment Profiles

	Extent of traffic risk					
Forecasts commissioned by	Banks			Others		
	Low	Ave.	High	Low	Ave.	High
Year 1 revenue adjustment (%)	(10)	(20)	(30)	(20)	(35)	(55)
Duration of ramp-up (years)	2	5	8	2	5	8
Extent of catch-up (%)	Full	(5)	(10)	Full	(10)	(20)

Chart 4

Case Study Ramp-Up Profiles



are systematic errors reflecting optimism bias.

- Bank-commissioned forecasts consistently appear to be less prone to large errors than those commissioned by project sponsors and/or bidders.
- Ramp-up profiles also appear to reflect project uncertainty--in scale and the extent of catch up. The ramp-up duration, however, remained project-specific (that is, unaffected by the type of agency commissioning the traffic forecasts).

Recommended Adjustments

Again, the purpose of this commentary has been to provide guidelines for toll-road credit assessment. It is not intended as a definitive guide to the production of accurate traffic or revenue forecasts. The practical reality of current toll-road forecasts, however, suggests that a meaningful approach to adjusting the output of traffic and revenue models should be incorporated into the analysis. Data suggest here that an appropriate starting point for stress tests are highlighted in the profiles outlined in Charts 5 and 6.

From its mid-point, the Traffic Risk Index can be adjusted up or down to reflect the attributes of specific toll roads and the particular circumstances

Chart 5

Revenue Stress Tests: Banks

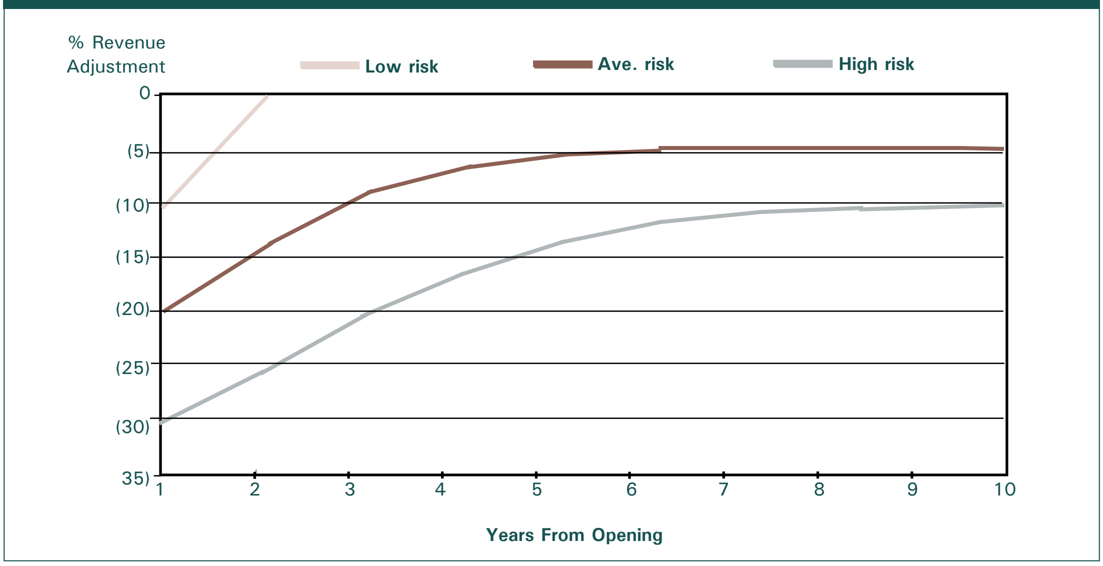
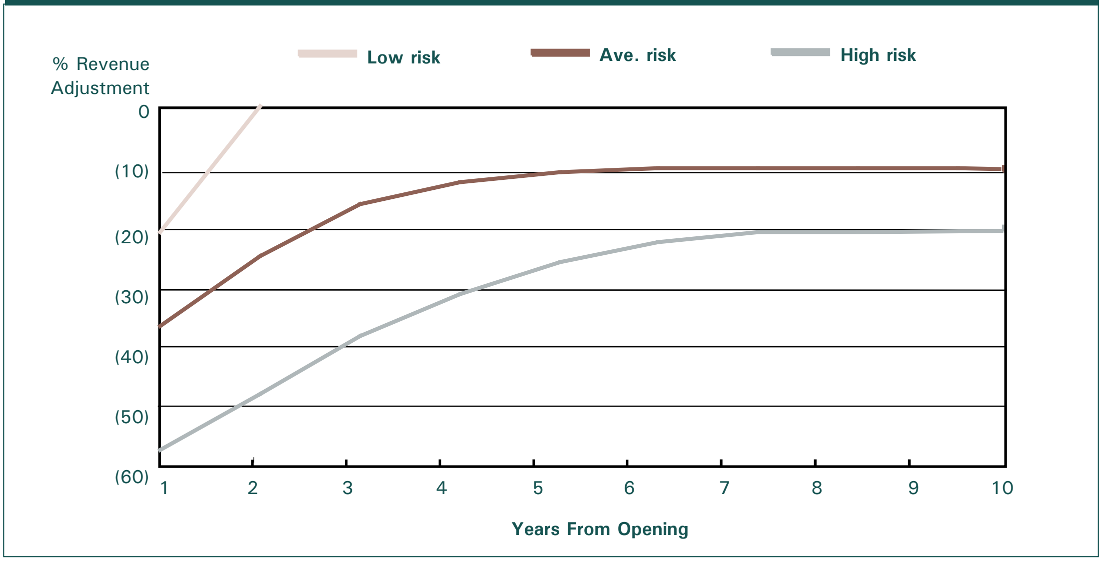


Chart 6

Revenue Stress Tests: Banks



under which the forecasts have been prepared. The corresponding ramp-up revenue adjustment--and its impact on the economics of a project--can then be examined.

Standard & Poor's believes that a systematic approach to the analysis of traffic and revenue risk is necessary. The Traffic Risk Index is one tool, a useful supplement that builds on available data and experience that can be used as part of the overall process of project finance credit analysis.

CREDIT IMPLICATIONS OF TRAFFIC RISK IN START-UP TOLL FACILITIES: APPENDIX

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Introduction

This article provides supporting information to a report entitled "Credit Implications of Traffic Risk in Start-Up Toll Facilities", published on RatingsDirect, Standard & Poor's Web-based credit analysis system, on Aug. 15, 2002. As part of an ongoing review of the toll road sector, the original article highlighted research conducted by Standard & Poor's and the development of an analytical tool--the Traffic Risk Index--that aims to identify and quantify the biggest pitfalls affecting traffic studies.

In particular, this appendix relates to each item summarized in the Traffic Risk Index, which is outlined in Table 3 of that commentary (reproduced on page 8 and 9), and provides further detail in support of that item's inclusion. Toll road examples are used to illustrate the nature and extent of the uncertainty that each item can create in a traffic forecast, and the circumstances in which such uncertainty can adversely affect the forecasting process.

Tolling Regimes

Shadow toll regimes.

Under a shadow toll regime, the toll concessionaire is reimbursed directly from a government agency. The reimbursement formula is commonly tied, in part at least, to the nature and extent of asset use. No point-of-use fee is levied directly on users. In this respect, route choice decisions (i.e. whether to use the shadow toll facility or not) are made in ways consistent with how drivers choose to use toll-free roads.

User-paid tolls.

The imposition of point-of-use pricing (user-paid tolls) adds a very important, and particularly challenging, layer of complexity to the traffic forecasting process. On top of the need to understand general driving behavior and replicate it within some simplified mathematical modeling framework, which is not a trivial issue in itself, is the requirement to take account of how direct charges are factored into drivers' route-choice decision-making. This challenge (estimating the price elasticity of demand) should not be underestimated, and it introduces a key concept in the vocabulary of forecasting practitioners: Willingness to pay.

An extended discussion of drivers' willingness to pay tolls is beyond the scope of this commentary. For present purposes it is sufficient to recognize that drivers' willingness to pay tolls depends on costs and the perceived benefits (mainly, though not exclusively, time savings). This central issue will be referred to a number of times in this commentary.

The propensity to pay varies among drivers. A positive correlation with personal income is commonly observed. Willingness to pay will also vary for any single driver, depending on such factors as journey purpose, time of travel, frequency of trip, and vehicle occupancy. The complexity surrounding willingness to pay is the reason why user-paid tolls score more highly on the Traffic Risk Index than shadow tolls.

Tolling Culture

A history of tolling in a particular country, region, or state reduces the uncertainty associated with traffic forecasting, particularly where tolls have been established and accepted for a considerable period (30 years, for example). Near neighbors can vary considerably in this respect. In the Caribbean, Puerto Rico established its first toll road in 1971, whereas Jamaica has no such legacy. It is, therefore, less difficult to predict how Puerto Rican drivers will respond to extensions of their island's considerable toll network than it is to forecast the response of Jamaican drivers to completely new facilities. Most importantly, Puerto Rican drivers can be observed actually making route-choice decisions. The value they place on saving time can therefore be estimated through "revealed preference" survey methods, whereas there is no equivalent trade-off behavior that can currently be witnessed in Jamaica.

The maturity of the toll road sector in a host country does not only affect the reliability of traffic forecasts in the long-term. The ramp-up period--the facility's "take-off" curve--may differ in nature and extent from that of a facility in another country. The ramp-up period reflects users' lack of familiarity with a new highway (and its benefits) and a community's general reluctance to pay tolls, particularly high ones. Consistent-tariff toll roads are observed to ramp up almost instantaneously in Puerto Rico, whereas in countries that have only recently adopted tolling (in central and eastern Europe, for example) ramping-up has been observed to be a slow and often extended process.

Ramp-up is a subject area worthy of a detailed commentary in itself, but few published works have sought to explore the issue in depth. In short, there appears to be little transferability of experience between projects (particularly those in different countries). Ramp-up tends to be project-specific. Ramp-up is considered further in the context of the Forecast Horizon, discussed later in this commentary.

Tariff Escalation

Tariff-setting flexibility and escalation formulae are generally assumed to be of primary interest to financial analysts and those concerned with project structuring. This, however, reflects a narrow understanding of the issue. Transport models usually assume that toll tariffs remain constant or can be inflated in real terms through the forecast horizon. Behind this belief lies a further assumption: That tariff-setting is beyond external influence. This is often not the case. There are many examples of concessions (the Second Tagus Crossing in Portugal was a well-publicized case in point) where a government exerted its influence over the tariffs, often in response to protests or local political or community sensitivities.

The issue here is less to do with traffic, and more to do with revenue. If a concessionaire is fully compensated for the "revenue foregone" when a government decides to lower rates or restrict future increases, the revenue projections may be realized. If, on the other hand, zero or partial compensation is offered, the revenue base will be eroded. In either case, traffic volumes will depart from those predicted.

Forecast Horizon

With most forecasting activity, the shorter the time horizon, the more reliable the prediction. Although this holds true for toll roads in general, there is a very important characteristic of toll road financings that make them highly sensitive to inaccuracies in short-term traffic forecasting: The ramp-up profile.

Exposure to a possible slow, unpredictable, and/or extended ramp-up period will erode the credit quality of a toll road. Credit determination rests not only on the ability to repay debts, but also the timeliness of those repayments. This timeliness can be jeopardized by short-term revenue deficits, just when project liquidity is at its weakest. Toll roads are arguably at their most default-sensitive during their earliest years of operation, which often is the most difficult period to forecast accurately.

There are also longer-term implications for projects that are slow to ramp up. Although a number of toll roads in the U.S., for example, have performed poorly upon opening, the majority (but by no means all) have subsequently shown signs of traffic and revenue "recovery". Other facilities, however, have struggled through their ramp-up period and then have to try to catch up with original projections. This is often achievable only through annual rates of growth that are unlikely to materialize. In many such cases, the original projections have consequently been revised downward.

Toll Facility Details

A number of project attributes specific to individual toll roads, bridges and tunnels are discussed under this heading. In terms of a full project description, the list presented in the original traffic risk index table is incomplete. However, for the purposes of gauging much of the uncertainty surrounding projects (and, therefore, the reliance that can be placed on forecasts) the list contains what appear to be the key factors.

Already open facilities.

More reliability can generally be placed on forecasts made from or about facilities that are already open than ones about projects that are still being planned. In part, this is a function of the planning regime in any one country, which dictates the lag between infrastructure planning and provision. In the case of highways, the period from early planning to the opening of a road can exceed 10 years. Progress through some planning regimes is more predictable than others, although even in countries where the planning processes are mature and understood, the increasing involvement of citizen participation programs and heightened environmental concerns can cause unexpected delays. This can be compounded in devolved jurisdictions where local governments, often with high degrees of autonomous power, can seriously impede progress.

Dense, urban networks.

Experience in the U.S. suggests that the reliability of toll road traffic forecasting has not improved significantly over the years. In part, this masks a change of emphasis in new projects: To high-tariff congestion-beaters on the fringes of metropolitan areas with numerous alternative routes, from interurban expressways with limited competition. Accurate traffic forecasting in dense, highly congested urban areas will always lie at the opposite end of a reliability spectrum from a river crossing with a clear competitive advantage over limited alternatives.

Beltways.

The provision of high-capacity orbital roads (or "beltways"), whether tolled or not, has been accompanied by a series of consistently inaccurate traffic projections. A highway constructed for one purpose, such as the M25 around London, which was designed to cater for long-distance, through traffic, frequently serves a multitude of different purposes, including local trip-making, in which users may join the ring road only for short, but highly congested, sections. The orbital road network around Madrid presents similar challenges for forecasting practitioners. In contrast, the traffic patterns associated with well-defined, strong radial corridors appear to be less heterogeneous and more easily understood, with the result that increased reliability can be placed on their traffic forecasts.

Greenfield sites.
The challenges associated with forecasting the use of a new toll facility developed on a greenfield site, can be considerable and highlight a seldom-acknowledged limitation of traditional traffic models. Traffic models are simple mathematical representations of the supply and demand characteristics of travel markets. They range in sophistication from spreadsheet-based methods focused on the short term to "synthetic" four-step models (details of the various approaches that can be taken with these are well documented).

Irrespective of the approach adopted, a considerable amount of time and effort is usually devoted early in the process to calibration and validation of the model. Two-thirds of a study budget can be dedicated to these tasks. The aim is to fine-tune the model to reflect base-year (usually existing) conditions accurately. The accepted wisdom is that a validated base-year model represents a robust platform from which forecasts can be made. However, this fails to reflect the fact that this simplified mathematical platform may be more "robust" in terms of predictive ability under some scenarios than others.

Most traffic studies inherit a traffic model of some sort. This is usually a model developed by planning agencies or consultants for specific purposes. Those purposes may be unrelated to the forecasting task in hand. The role of the forecaster is to refine the model in the particular geographic area of interest and update it as required with gap-filling and/or new data. This updated model may still reflect its original design emphases in terms of the model specification, construct, and formulation, however.

Traffic modeling of future-year scenarios that depart significantly from base-year conditions represents particular challenges for forecasters. This could include significantly different land-use patterns and/or completely new sections of highway with characteristics that differ markedly from the rest of the local road network (a new, high-capacity, limited access, tolled expressway running through undeveloped land, for example).

In such circumstances, it may be more beneficial for forecasters to concentrate on what exactly this new future may look like, what opportunities it may present, and how drivers may respond. They may direct the study effort there rather than focusing on the rather mechanical (and somewhat less challenging) processes of model calibration and validation. In short, attempts to extend traffic models beyond their design criteria introduce additional uncertainty into the system. The forecasts that result should be interpreted with this in mind.

Highway alignment and configuration.
The proposed alignment of a new highway is commonly constrained by many factors, including land-use patterns, the nature and location of existing development, space availability, topography, geological conditions, engineering limitations, and political sensitivities. The preferred alignment, the number and location of intersections, and the design of toll collection facilities may be a compromise between some of the constraints listed above and a desire to provide fast, direct transportation links.

In certain circumstances, the influence of external factors can become so constraining that they start to erode the fundamental objectives of a new highway. The forecasts from highways that do not reflect how and to where people wish to travel should be treated with caution. Similarly, highway configurations that reflect political objectives above and beyond a strong economic justification are more likely to incorporate high levels of uncertainty about future use.

Future-year network configuration and reliance on proposed highway improvements.
Toll facilities are an integral part of the wider highway network and need to be analyzed in that broader context. Supply-side interdependencies often have a strong influence on drivers' route choice and, for that reason, forecasting practitioners will aim to understand not only how the wider network looks in the present, but also how it will look in the future. This introduces further scope for uncertainty. Where forecast horizons stretch for decades, it may be particularly difficult to describe with any degree of precision the exact network configuration in 10, 20, or 30 years.

If multiple future-year, supply-side scenarios exist, these need to be appraised by the forecaster. In itself, the process of compiling these scenarios and presenting them to decision-makers can narrow the number of future configurations to be considered. This will enable key network interdependencies to be established by forecasters, generally falling under one of two headings: Connecting roads and competing roads. Both of these types are described later.

Furthermore, forecasts prepared for toll roads that remain highly reliant on future-year network extensions or modifications (often outside the control of the toll road operator) should be treated with caution. Such forecasts should be subjected to downside scenario tests that assume that the completion of these extensions or modifications is delayed, perhaps indefinitely.

Traffic congestion.
Most traffic modeling software suites allow for congestion to be reflected in quite sophisticated ways. They usually employ iterative techniques to derive some equilibrium across the network. Somewhat perversely, low-volume, uncongested networks can actually cause more problems for traffic forecasters. Congestion causes traffic to distribute itself in a balanced fashion over the highway network, but its absence can lead to counter-intuitive results requiring modeler intervention. The clearest example of this is when all the traffic traveling between two locations uses exactly the same routing pattern, leaving competing roads in the model empty.

Reasonableness and logic checks need to be applied to all traffic models, but in low-volume corridors and networks, particular attention needs to be paid to routing patterns and the balance of traffic across the network.

Competition and competitive advantage.
The existence of a multitude of alternative routes compounds the traffic forecasting challenge. On the other hand, however, a tolled motorway with a single, toll-free, parallel facility or a river crossing with a circuitous competitor can be represented more fully in simplified models. The greater the number of alternatives, the more uncertainty there is in the system.

The lack of a clear competitive advantage, usually measured through time savings, also adds to the difficulties of reliable forecasting, especially when absolute time savings are low (or represent a small proportion of the total, end-to-end journey time). For example, commentators have suggested that drivers do not perceive time savings of less than two minutes, and there is a degree of empirical evidence to support this. Time savings and their value are considered later. Evidence from the U.S. suggests that perceived competitive advantage becomes even more critical (perhaps beyond simple, linear time/cost trade-offs), and drivers' responses more difficult to predict, when uncharacteristically high tolls are charged.

Finally, the existence of "multi-modal" competition to a tolled facility exercises forecasters. This can significantly extend the model's data requirements and complexity. Ferries may offer competition to bridges or tunnels. Rail and domestic air services can compete with interurban highways. The difficulties of modeling this competition and, in particular, any competitive response to the provision of the new service (such as reduced fares or increased service levels) has led to some well-publicized forecasting failures, such as those prepared in support of the U.K. 's Channel Tunnel.

Connectors: Links to the rest of the network.
Connectors linking a toll road to the rest of the (toll-free) network can have a major influence on the attractiveness of the toll road itself. A toll road with expressway links to a broader highway network will be viewed differently from a facility, perhaps terminating in a downtown area, with long queues waiting to join the urban road network. In American parlance, this not uncommon latter scenario has been called "hurry-up-and-wait": The time savings enjoyed while traveling on the facility may be eroded at one or both termini.

In a similar vein, connectors that involve travel over some distance (or travel in a counter-intuitive direction) before reaching a toll road will detract from the perceived attractiveness of the facility. For the purposes of this discussion it is important to note that these factors, which erode the potential benefits of using the toll road, are commonly difficult to model and, therefore, affect the reliability that can be placed on resulting forecasts.

Finally, missing or substandard links, or the future provision of connectors that is outside the control of a toll road operator are all reasons to interpret traffic forecasts with extreme caution.

Competition protection.
It is not uncommon for concession agreements to contain details of a government's commitment to the success of a toll road. This can take many forms, but one of particular interest to forecasters is competition protection. The protection provided can be passive or active. Passive protection usually involves statements to the effect that competing facilities will not be built or will not be upgraded. Some diligence needs to be exercised here as statements like these have been reneged upon in the past. These assurances, however, have the potential to enhance forecast confidence.

Active protection involves government action. In the past, governments have elected to implement traffic-calming measures on competing roads, close or degrade the capacity of alternative routes or impose truck bansforcing commercial traffic to use the toll road. These measures may, to varying degrees, reduce the uncertainty surrounding the traffic usage of new, tolled facilities. In France, for example, to support the Lyon bypass concession the local administration narrowed a number of streets in the city.

Surveys and Data Collection

The majority of toll road traffic studies involve some survey activity or a program of data collection. Traffic and driver surveys are generally expensive to conduct--they may account for 50% of a study budget--and are based on sampling procedures that introduce into the modeling framework a host of well-documented uncertainties and potential sources of error. Investment-grade traffic studies will contain details of sampling methodologies used, justifications for particular approaches and a commentary on the limitations of the collected data.

Ease of data collection.

Survey data represents the building blocks on which traffic models are constructed. Weaknesses within this data set will become magnified as factors are applied to expand sample data sets and these data sets are carried forward (possibly involving further expansion) to represent future-year conditions.

The ease with which data can be collected, particularly at the roadside or from household interviews, will guide the survey methodology. Potential danger to surveyors is of paramount concern. For this reason, even in relatively "safe" regions, automatic data recording methods will generally be used during the hours of darkness. Under certain circumstances, this can introduce bias because details of the movements of trucks (which may be encouraged to travel at night) may be underrepresented.

In countries acknowledged to be less safe, for example Colombia and parts of South Africa, there are sensible precautions that survey coordinators can build into their data collection programs to limit personal exposure to risk. The use of a local survey field force and a police presence at all times are common requirements, although such factors act as constraints on data gathering.

The geometry of a highway or an intersection may also constrain the locations available for survey data collection. It is clearly not possible to collect survey information from drivers in moving vehicles. Locations where drivers are required to stop (such as intersections with signals) therefore tend to be selected. This often represents a "second-best" approach and the challenge for the survey coordinator will be to devise a program of second-best approaches that, when taken together, provides the data required.

Alternatively, it may be possible to stop drivers for the explicit purpose of conducting surveys. In many jurisdictions, this requires not only the permission of law enforcement agencies, but their presence throughout the survey period. In some countries, that permission may be difficult, very slow, or simply impossible to obtain. In others, it may be too expensive.

The purpose of the above discussion has been to indicate some of the many constraints that can affect data collection and data integrity. The very presence of a survey team at the roadside (complete with fluorescent safety jackets and police officers in attendance) may be enough to deter some drivers from passing the survey point or encourage the reporting of inaccurate information. Irrespective of the sophistication of any subsequent modeling, "front-end" data limitations often erode the confidence that can be placed on traffic forecasts.

Up-to-date information.

In general, up-to-date information is used to populate the databases underlying traffic models. Models that rely on old or historical data tend to hold less credibility. Forecasters will conduct an audit of available data sources to determine where any deficiencies lie and their significance. This "gap analysis" approach is often used to guide the collection of new data through, for example, the survey program.

The compilation of up-to-date data and its incorporation within a base-year modeling framework is usually the focus of much of the traffic study effort. A cautionary note was sounded earlier regarding a possible over-emphasis on validated base-year models as appropriate forecasting platforms in all circumstances. That caution should be heeded when considering the extent of the resources allocated to the collection of existing travel behavior information.

Imported parameters.

Developing or transition economies pose particular problems for traffic forecasters. Data deficiencies are common and time, resources, and other practical constraints may limit the opportunities for gap-filling by surveys. In such cases, one of the few avenues left to forecasters is to import key model parameters from elsewhere, perhaps data from a study conducted in a neighboring country.

Imported data can be used to calibrate local model parameters such as the vehicle mix, growth profiles, road capacities, speed/flow relationships, vehicle operating costs, mode choice parameters, and trip rates. Most commonly (and most sensitively) values-of-time are imported from other studies. The important concept of the value-of-time is discussed below. Without great care and considerable experience, significant errors can be introduced into the modeling framework through inappropriate importation of model parameters. Forecasting confidence should ultimately reflect this potential for error.

Zone framework.

Most traffic models reflect aggregate travel demand. For this, individual trip-making behavior is clustered into geographically homogenous sectors or "zones". Zoning systems for traffic studies are arguably at their most evolved in the U.S., where a nationwide system of traffic analysis zones (TAZs) has been specifically developed. These TAZs are entirely consistent with census data collection areas, which allows socioeconomic information to be carried forward to a traffic-modeling framework with a minimum of data manipulation.

Outside the developed world, zone frameworks may simply not exist. They have to be created by the traffic forecaster, often using limited information. This introduces further uncertainty into the modeling environment.

In other countries, a zone framework may exist (and all data may be collected and aggregated to that framework). It may, however, be entirely unsuitable for the forecasting task in hand. For example, it may not contain enough detail in the study area. Once the information has been aggregated, it may be impossible to return to the disaggregated "raw" data, which leaves forecasters with considerable (and highly subjective) data manipulation responsibilities.

Users: Private

The majority of toll road users around the world are the drivers of private cars. It is not uncommon for private cars to represent more than 90% of the traffic mix. Owing to tariff differentials, however, they usually contribute less than 90% of the toll revenue (see the "Commercial Users" section below). Nonetheless, given their numerical domination, from a forecasting perspective it is important to understand when and how car drivers will use the facility, for what purposes, with what frequency, and, most importantly, how sensitive they are to tariff levels. The failure of a traffic study to explore and explain any of these usage patterns will lower the confidence that can be placed in its traffic forecasts.

Clear market segments.

Toll facilities that benefit from clear, if not dominant, market segments are easier to understand, more straightforward to model and less demanding to communicate to potential investors. The Teodoro Moscoso Bridge in San Juan, Puerto Rico, for example, caters for airport-bound traffic and users going to a high-income residential community to the north of the city. The A2 in Poland meets the needs of east-west traffic running into Warsaw, a significant proportion of which is international trade traffic. On the mainland U.S., SH130 in Texas will serve to bypass the highly congested I35, predominantly for traffic avoiding Austin traveling to and from Mexico. These clear market segments constitute the bulk of traffic on each of these roads and, by concentrating on these segments and understanding their trip-making characteristics, more confidence can be placed in forecasts.

- The original forecasts for the Teodoro Moscoso Bridge were overestimates, but the high traffic prediction resulted largely from an overestimates of Puerto Rican drivers' willingness to pay a toll that was significantly higher than the island-wide norm. The market analysis reported by the original traffic consultants, however, accurately reflected the purposes for which the bridge is being used today.

Key origins and destinations.

It is not uncommon for toll facilities to be dominated by users traveling from one particular region or sector to another. Of all the possible origin and destination combinations (of which, in theory, there will be many) several key areas may account for between 50% and 70% of all trips. This allows practitioners to "collapse" their analytical focus and concentrate on core market segments.

The concept of a core market may enable forecasters to talk with some confidence about this market, its sensitivities, perceptions and preferences. Other, less dominant markets may be layered on top, perhaps with reduced levels of confidence attached. This particularly useful form of market analysis can feed through to a project's financial structuring, where, notionally at least, different tranches of debt are correlated with these different market segments.

At the opposite end of the spectrum are

facilities that have either no clear market or a multitude of less-dominant origins and destinations. These present forecasters with particular challenges that introduce additional uncertainty into the forecast.

High-income, time-sensitive markets. When users choose to drive a toll road, they are making a decision that reflects the fact that the perceived advantages to them--usually time savings, although other factors can play a role--outweigh the monetary cost. The situation is complicated by users who do not pay with their own money (business people, some truckers etc.), but that discussion lies oustide the remit of this commentary. One of the keys to the preparation of accurate forecasts, therefore, is to be able to quantify these advantages. This is achieved by calculating the local values, expressed in monetary terms, that people place on saving time.

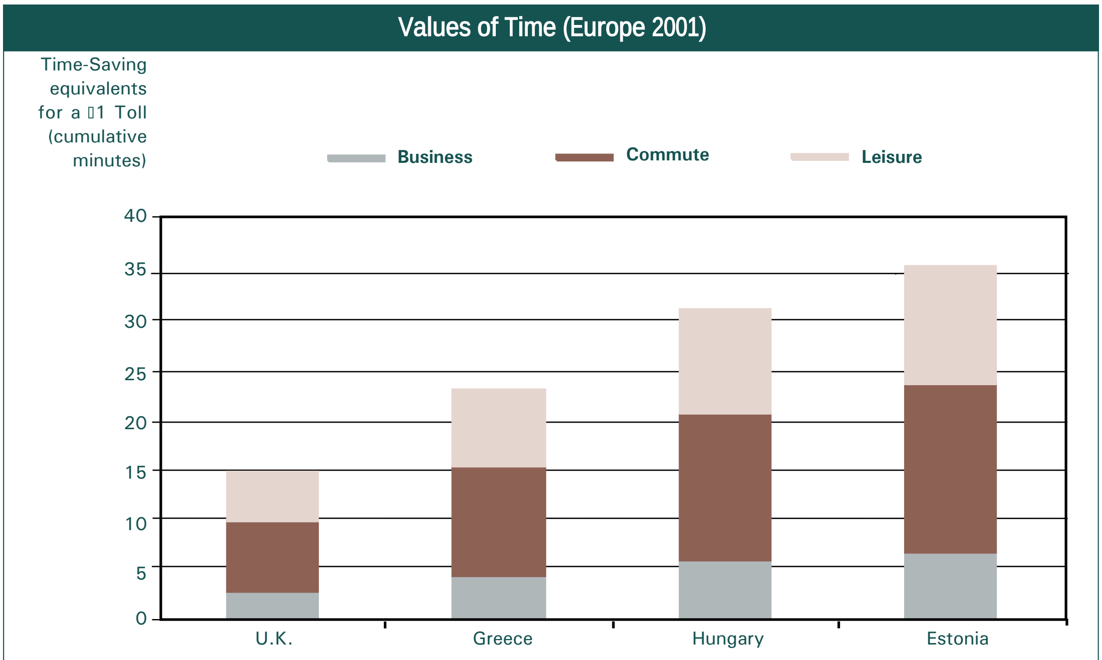
One simple technique for calculating the value of time savings, admittedly only available in countries with existing toll roads, often appears to have been overlooked by forecasters. This is the "revealed preference" approach. Revealed preference studies observe people making actual, everyday choices and derive values from the trade-offs that are made. A simple example is presented below:

- Drivers are faced with a simple binary choice: to use a toll road or the toll-free alternative. Traveling by the toll-free road takes 30 minutes. eTraveling by the toll road takes only 10 minutes, but costs $1.00. Drivers who choose to use the toll road are, therefore, valuing the time saving (20 minutes) at equal to or more than the toll. These drivers have, therefore, values-of-time equal to or greater than 5 cents per minute.

Chart 1 shows the values-of-time for three key journey purposes across four countries in Europe. Note by how much the values vary within a country for the different purposes, and across countries for the same journey purpose. A U.K. business traveler has only to save three minutes before a toll of € becomes worth paying, whereas a tourist in Estonia would need a 12-fold increase in that time saving before the expenditure of € becomes justified. This considerable range of values and the different journey purpose sensitivities within that range illustrate how critically important it is for forecasters to calculate values-of-time in any country accurately. Many of the largest traffic forecasting errors can be traced back to miscalculations of values-of-time. This is clearly one aspect of any traffic study that should be addressed in detail, ideally with measures of confidence attributed to the results.

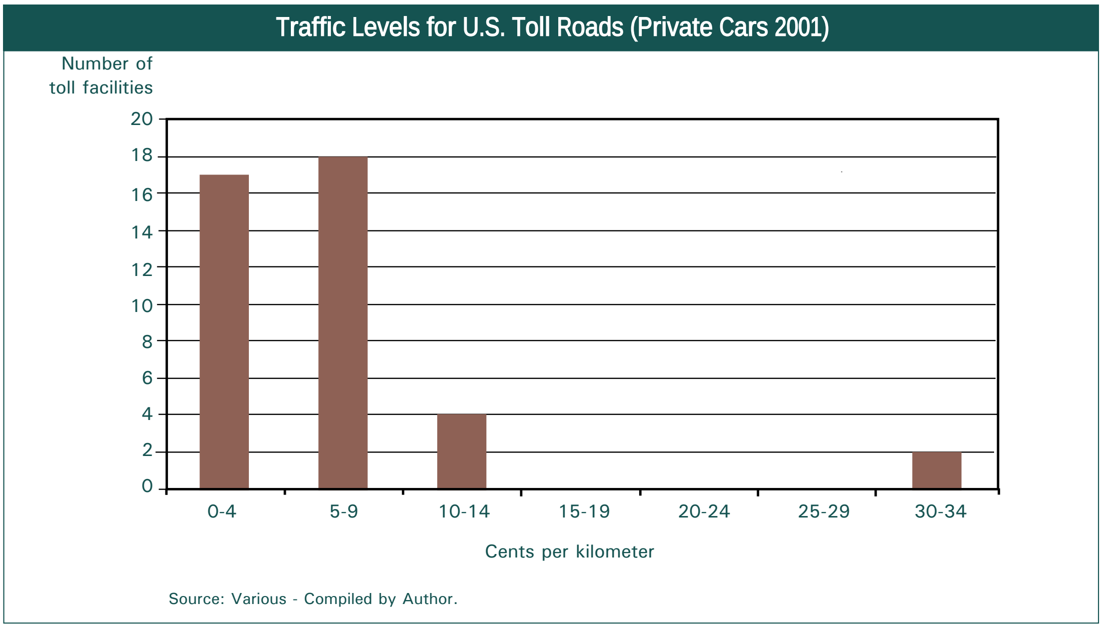
In terms of time-sensitive journey purposes, travel to airports is clearly one example of a journey when people would place a premium on fast and, possibly more important, reliable journey times. It is also a journey made by a high proportion of visitors to a country and levying a

Chart 1



Source: Competitive and Sustainable Growth Program, UNITE, 2001

Chart 2



toll may therefore lead to less local resistance than on other roads. Business-related traffic and certain categories of freight movement, however, can also be highly time-sensitive and therefore more predisposed to pay for a higher level of service. All of these issues remain central to the preparation of accurate toll road traffic forecasts. A deeper understanding of these issues will be reflected in a higher level of confidence attached to future-year predictions.

High toll rates.

There are a number of reasons why toll road operators charge tariffs that are higher than average. A number of such projects have attracted particularly over-optimistic traffic forecasts. Aggressive financing plans, sometimes dictated by short concession periods (imposed by government or optimistically negotiated by concessionaires), have prompted debt-recovery profiles that necessitated high tariffs. A notable example is the Mexican toll road program of the early 1990s. Twenty-five out of 32 concessions reached less than 75% of projections and more than half reached traffic levels less than 50% of the forecasted volumes. In Hungary, which has some of the highest tariffs in Europe, traffic under-performance quickly resulted in project default and reversion to state ownership.

Other reasons for high tolls reflect expensive construction programs, particularly for some of the more recent western toll roads developed in urban areas where construction costs per kilometer can easily exceed five times the equivalent of an interurban motorway (Source: "The Highway Economic Requirements System Technical Report", Federal Highway Administration, July 1999; rebased to 2000;).

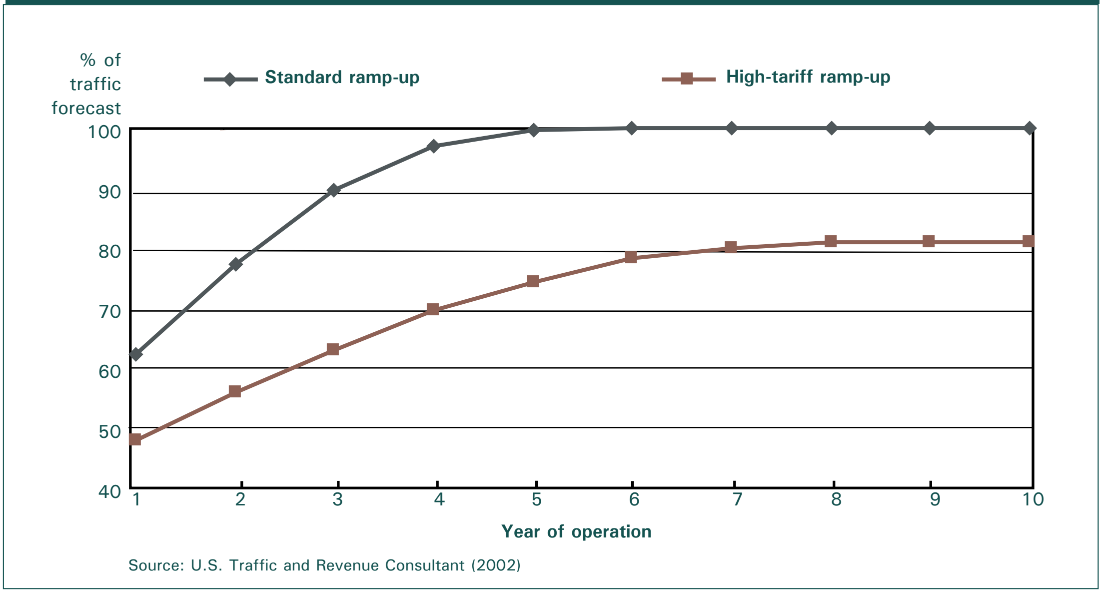
Chart 2 shows American toll tariffs (car per km) from 2001, illustrating their wide range. U.S. tolls average around 7 cents per kilometer (10 cents per mile).

High tariffs prompt analysts to decrease the confidence that can be attached to traffic forecasts. Drivers appear to be particularly sensitive to the perceived benefits associated with such roads, implying that forecasters have to be very careful about making accurate value-of-time calculations. Some commentators have suggested that, as a precautionary measure for high-tariff facilities, the time saving benefits expressed in monetary terms should be at least double the toll charged. One implication of this is that only those high-tariff roads offering considerable time savings to users are likely to achieve investment grade credit ratings.

A final observation in the context of high-tariff toll roads is that they appear to be particularly susceptible to slow and extended ramp-up profiles. Chart 3 shows an example of a ramp-up profile currently employed by forecasters together with a more exacting, high-tariff ramp-up stress test that would appear to be supported by the data analyzed by Standard & Poor's. Note that the high-tariff stress test holds subsequent years to values around 80% of those forecasted, reflecting the related problem of "catch up".

Chart 3

Ramp-Up Profiles
Suggested Stress Tests



Simple toll structures.
Traffic models tend to reflect toll charges fairly crudely, by imposing additional costs or time penalties on tolled links in a network. Although this approach appears to reflect drivers' perceptions of alternative routes and their relative attractiveness, it does not lend itself particularly well to the modeling of complex tariff regimes. As toll pricing becomes more sophisticated, road operators are increasingly providing frequent-user programs, discounts for local users, charges that vary by time of day or day of the week, etc.

This raises complex modeling issues for forecasters who may decide to lift revenue calculations out of the traffic model into a simplified spreadsheet-based framework. This can introduce further uncertainty into subsequent forecasts. The increasing popularity of electronic toll collection technology gives toll operators greater scope for flexible pricing regimes, and revenue forecasting looks likely to become yet more complicated in future years.

Demand profile.
Traffic models typically concentrate on particular time slots during the day. Different model runs may be conducted for an average morning peak hour, an inter-peak hour, an average evening peak hour and so forth. The results from these runs are then factored up to give 24-hour traffic flows (which are subsequently factored to give annual figures). The final figures can be highly sensitive to the choice of factor used. These factors are usually derived from other toll roads, or from roads in the study area with broadly similar characteristics, but small absolute differences in the factors used can lead to significantly different results when aggregated to annual figures. This is best illustrated through a simple example:

- A toll road is forecast to carry 3,000 vehicles in an average weekday morning peak hour. It is assumed that the peak hour represents 7% of the total daily traffic. An annualization factor of 330 is applied to the resulting daily total (43,000) to derive the yearly total (14.1 million vehicles). The peak hour, however, turns out to represent 8% of the total daily traffic (giving only 37,500 vehicles per day) and the appropriate annualization factor is 300, not 330. These slightly different factors suggest a yearly total of only 11.25 million, which is 20% lower than the traffic estimate.

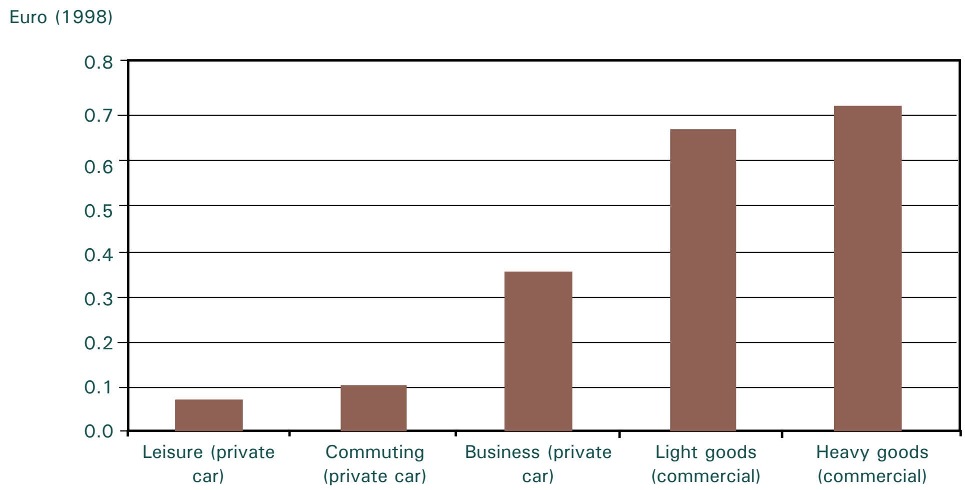
The exposure of a toll road to factoring errors is related to the shape of its demand profile. Roads that serve relatively flat, consistent patterns of demand across the day and throughout the year are far less susceptible to factoring errors than those that have marked peaks through the day and/or experience highly seasonal traffic patterns. Forecasting confidence should reflect the uncertainties that factoring, under these different circumstances, can introduce.

Users: Commercial
Commercial users--trucks--represent an important traffic component for many toll roads. Even

Chart 4

Values of Time (per Person-Minute) by Road-User Category

Western European Average



Source: Competitive and Sustainable Growth Program, UNITE, 2001

where truck volumes are relatively small, the higher tolls they pay (commonly some axle-based multiple of the toll charged for private cars) can contribute significantly to the revenue stream. A revenue-to-traffic ratio of nearly three to one is not uncommon, which means that if trucks represent 10% of all traffic, they can contribute up to 30% of total revenues.

Furthermore, depending on the nature of freight being transported, these commercial users can exhibit very high values-of-time. Recent European research suggests that commercial users have, on average, values-of-time more than double that for the most time-sensitive private car driver: See Chart 4.

Who pays the toll?

Acknowledging that, particularly in a deregulated environment, the trucking community is far from homogenous, forecasters will often interview trucking representatives to gauge their propensity to use a new toll facility. An important determinant is how the toll is paid, and by whom. For example, in some developing economies, the charge for trucks traveling long distances on interurban toll roads can approach or even exceed the driver's daily wage. Fleet owners who give drivers the toll money often find that drivers keep the money and continue to use toll-free alternative routes. Under such circumstances, road operators are quick to offer accounts to commercial users to stem this revenue leakage.

In general, if the trucking market likely to use a new toll road is composed of a large number of small, owner-driver general hauliers less reliability should be placed on forecasts. In contrast, markets consisting of several, very large haulage companies transporting high-value or time-sensitive commodities are likely to be less volatile, especially when these fleet operators are encouraged to become frequent users and/or account holders.

Vehicle operating cost savings.

The decisions of private car drivers about whether or not to use a toll road tend to be dominated by time-saving considerations. Trucks, on the other hand, typically take vehicle operating costs as well as time savings into account. These vehicle operating cost savings can be significant.

The general framework for calculating vehicle operating cost savings usually derives from the World Bank's detailed Highway Development and Management (HDM-4) Model. The general principal is that the improved alignment and surfacing associated with toll roads, particularly in developing countries, enable savings to be realized in terms of fuel usage and general vehicle wear -and tear. These savings are factored into commercial users' route-choice decisions. Where time and operating costs are significant, truckers will generally use toll roads. However, if a toll road's competitive advantages are weak or misperceived, toll road traffic volumes are likely to be reduced. The lesson, once again, is that forecasts made for toll roads with clear competitive advantages are likely to be at the more reliable end of the uncertainty spectrum.

Simple route-choice decision-making.
If time and operating cost savings are the dominant factors behind truckers' route choice decisions, most modeling frameworks are able to incorporate this reasonably accurately. There are many cases, however, when other factors affect route choice.

An absence of law enforcement (particularly for over-laden trucks) and the multitude of inexpensive roadside facilities (like truck stops) along toll-free corridors may influence routing patterns. In short, the simpler the decision, the more easily it can be modeled. The resulting forecasts will tend to be more reliable.

As an aside, overweight trucks, particularly smaller ones where the load is distributed over a limited number of axles, present a dilemma for the grantors of some toll road concessions in developing countries. The government may wish to encourage these trucks to use toll roads, diverting them from the less suitable national road network and keeping them safely out of towns and villages along the route. Concessionaires, however, may be less keen to attract such traffic because of the disproportionate damage they cause to the road surface. Forecasters need to understand such policies if they are going to reflect the commercial use of toll facilities accurately.

Macroeconomics
The macroeconomic environment in a particular country bears heavily on traffic volumes and traffic growth. In developed countries, passenger transport and freight moved have grown broadly in line with increased economic activity, which is commonly measured through GDP. In some countries traffic has grown at rates faster than economic activity, while in others traffic growth has been observed even during times of economic downturn or recession. By way of illustration, the relationship between GDP and traffic in the U.K. (measured in terms of vehicle miles traveled) over the past 30 years is shown in Chart 5.

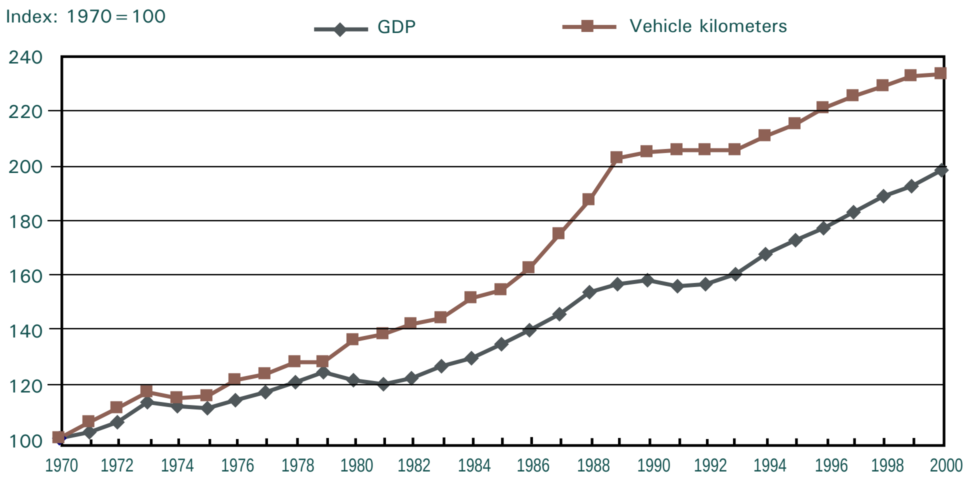
On a year-to-year basis, the relationship between GDP and traffic growth may be more difficult to predict. This seems to be particularly the case for countries with transition economies and countries coming out of recession. Recent figures from Finland and Turkey, for example, suggest a lag between economic upturns and traffic growth. The precise nature and extent of that lag can cause problems for forecasters.

Across developing nations, the demand for both freight and passenger transport is observed to be growing at rates between 1.5 and 2 times GDP growth. The individual growth rates for freight and passenger transport are broadly similar. The majority of this increase is for road transport.

Given the strong relationship between population and GDP growth, it will come as little surprise to find an equally strong relationship between population growth and traffic growth. It

Chart 5

GDP Growth and Traffic Growth (U.K.)
Motor vehicle kilometers



Source: U.K. Government Department for Environment, Food, and Rural Affairs is the nature of this relationship, however, that is of most interest. Chart 6 shows data from the United States for 67 cities over 15 years. This shows that, on average, traffic growth outstripped population growth by a ratio of two to one. This trend is even more marked in other countries where ratios of three to one or higher have been observed.

Considered globally, the strength of macroeconomic influences on traffic growth should be clear. However, from a traffic forecasting perspective, strong, stable economies with more predictable economic growth trends lend themselves to the production of more reliable traffic predictions. Weak and/or transition economies may also experience strong traffic growth, but the presence of turning points, lagged effects, and the often considerable regional disparities that exist make the traffic forecaster's tasks all the more difficult.

Finally, land use planning, controls and development not only influence traffic growth, but also influence where that traffic growth will occur. The precise relationship between land use and traffic patterns is complex, however, and a number of toll roads have underperformed because predicted development has either failed to take place or has lagged significantly behind increased regional accessibility. In the U.S., the E470 in Colorado and the Seminole Expressway in Florida both suffered from lagged development effects.

In general, countries that have strong (and therefore more predictable) land use planning regimes present forecasters with a clearer view of what future-year development planning may occur and where. This aids forecasting. Countries in which development is more market-led may have uncertainties about where and when development may occur. Less confidence can be placed on long-horizon traffic forecasts in such situations.

Traffic Growth

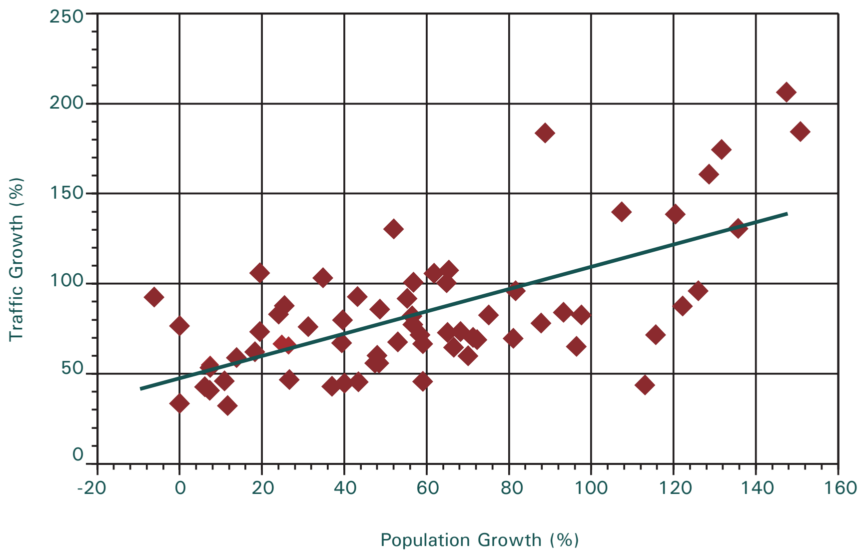
Many traffic forecasts are predicated on assumptions about increasing car ownership in future years, particularly in developing economies. The relationship between car ownership and income is well documented, but a lesser-known theory that appears intuitively to be correct and is supported by some empirical evidence, is that there is a threshold income level above which car ownership levels accelerate considerably. That threshold (probably an average annual income level of around $5,000) was reached, for example, by South Korea in the 1980s, and there was a subsequent dramatic increase in car ownership.

Chart 7 shows the relationship between GDP and car ownership for 26 countries around the world. It is not difficult mentally to superimpose a 'S'-shaped curve over the data points with three distinct gradients.

There would appear to be a gradual increase in car ownership at the lower end of the GDP axis, possibly to around $5,000 as suggested above.

Chart 6

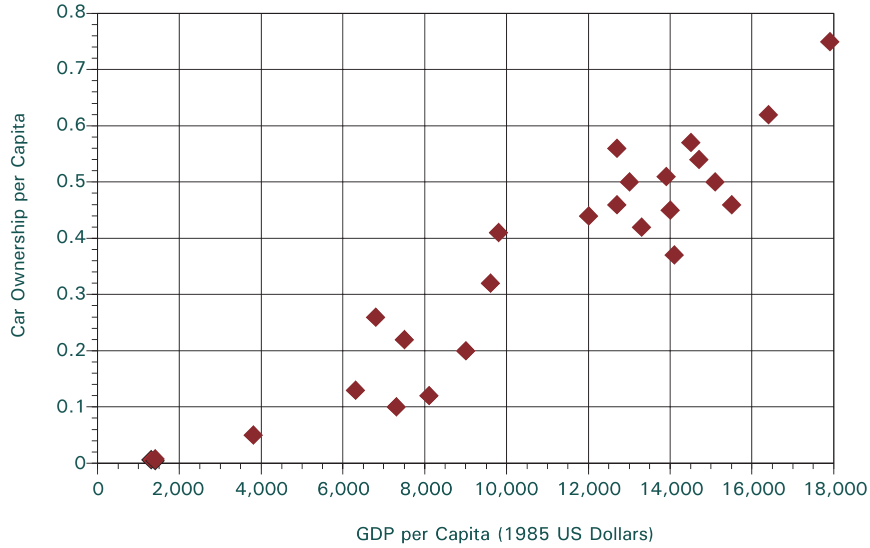
Population Growth and Traffic Growth in 67 U.S. Cities 1982-1997



Source: http://www.transact.org/Reports/constr99/sheeti.htm

Chart 7

GDP and Car Ownership in 26 Countries Worldwide



Source: Income's effect on car and verhicle ownership, New York University, 1997

The gradient of the curve then steepens sharply, maintaining that slope until about $12,000 is reached. Above $12,000, the curve's gradient reduces again. An interpretation of these three slopes is provided in the table below:

Table 1

GDP Per Capita		
Less than $1,500	***$1,500 to $12,000***	***More than $12,000***
India, China, Pakistan, Russia and Indonesia	Southern & Eastern Europe, parts of Asia and Latin America	Northern Europe, North America and Japan
Countries with huge potential for future car ownership growth.	Countries currently experiencing significant growth in car ownership.	Countries where replacement dominates new car sales.

In terms of future traffic demand, Indonesia, China and India will probably experience the greatest rates of car ownership growth. That does not equate, however, with the reliability of traffic forecasts. When that growth will happen and how quickly it will take off are major areas of uncertainty.

Parts of Asia, Latin America and Eastern Europe are currently experiencing strong car ownership growth. There are, however, questions about the maintenance of this trend in future years, particularly given these countries' exposure to less stable economic conditions. Car ownership is most stable in northern Europe, the U.S. and Canada and therefore more confidence can be placed in forecasts from these countries.

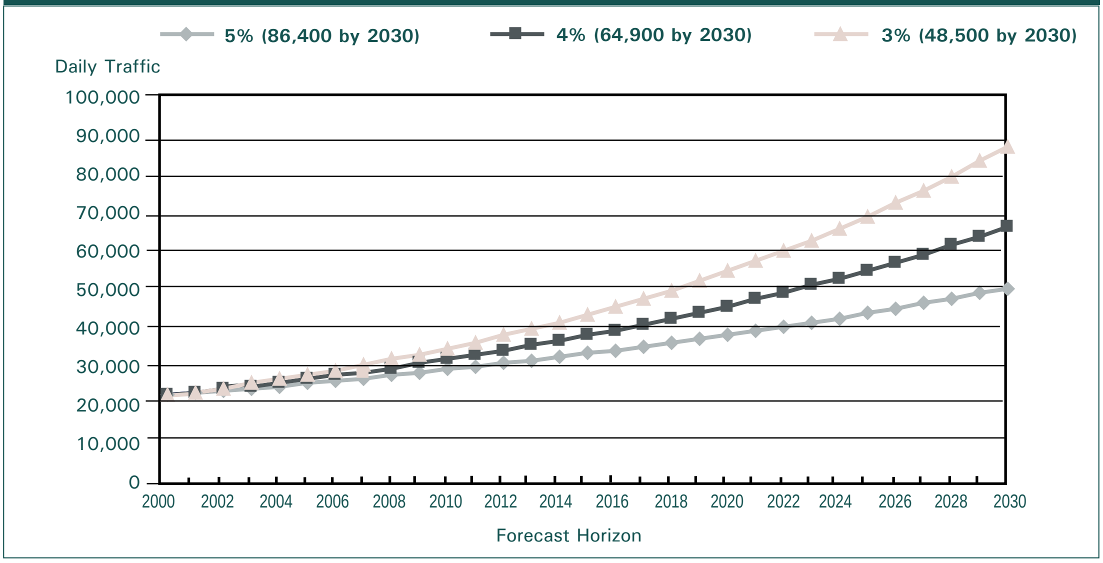
There is a seemingly obvious but apparently often overlooked "fact" about traffic growth: Owing to of the long forecast horizons, the cumulative impact of small percentage differences between growth assumptions can lead to significantly different future-year traffic projections. Constant growth rates projected over long periods, therefore, should be treated with considerable caution.

Chart 8 shows the cumulative result of imposing different growth rates on a traffic volume of 20,000 vehicles. Although the growth rates only differ by one percentage point, the resulting traffic forecast lies between 48,500 and 86,400 vehicles per day, which is a huge range.

This highlights again the importance of interpreting traffic forecasts with caution. The economic viability of a toll road project may rest entirely on modeling assumptions that, if marginally altered, would give very different results.

Chart 8

Cumulative Impact of Alternative Growth Scenarios



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