

How Will Upswings in Price Inflation and Interest Rates Change Toll Road Risk Profiles? A Study of Developing East Asian Economies with Broader Implications

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Abstract

The resurgence in private sector involvement in toll roads since the 1980's coincided with secular decreases in price inflation and interest rates. Recently, these decreases have started reversing and in accordance the Kondratieff Wave (long-wave business cycle) are expected to increase.

With a primary focus on developing East Asian economies, the likely implications of such changes were tested using Monte Carlo risk simulation: combining economic scenarios with construction and operations costs, plus traffic and revenue for a simple, notional toll road case, linked with a financial model. This concluded that there would be a significant change in the nature and extent of project finance risks in response to increasing price inflation and interest rates. Whilst the increased demand associated with increasing price inflation (competition for commodities) and interest rates (competition for capital) would on average increase likely toll road returns, there was also an increased chance of project bankruptcy, i.e. both upside and downside risk increased.

These results were compared against data from practitioner questionnaires regarding inter alia expectations of the future, identifying gaps between expectations and likely outcomes. Moreover, these surveys also supported literature review evidence of the prevalence of bias and serial error in toll road forecasting, which in fact could exacerbate some of the down-side risks.

This Paper is based upon research undertaken in partial fulfilment of an MBA from Henley Business School (Di Bona, 2006).

1. Introduction

The resurgence in private sector involvement in toll roads since the 1980's coincided with secular decreases in price inflation and interest rates. Recently, these decreases have started reversing and in accordance Kondratieff (1926) and Schumpeter (1939) are expected to increase. Given most transport privatisation and associated literature and experience are based on declining price inflation and interest rates, reviewing these based on increases conditions could be timely.

The specific hypothesis tested therefore was: *"There is a significant change in the nature and extent of project finance risks for private stakeholders in East Asian toll roads during a period of increasing price inflation and interest rates"*

The economies selected were developing East Asian economies in which the author had project experience and which were large enough for inter-urban tollway networks, namely: Cambodia, China, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam.

Though tested with a primary focus on developing East Asian economies, lessons drawn could be of broader significance.

2. Environmental Analysis

2.1 PESTLE Analysis

PESTLE analysis was used to gauge potential risk and opportunity by country for toll roads, identifying external dynamics affecting the market. Table 1 summarises the findings, showing a growing desire overall for inter-urban transport. The key driving-force is economics; however, political/ legal constraints include corruption.

Table 1: Key Findings of PESTLE Analysis

Element	Description
Political	Stability concerns in many countries, though not always deterring infrastructure investment
Economic	Economies generally growing relatively rapidly, although wealth levels varied.
Social	Generally much/ growing inter-urban travel, in parallel with rapid urbanisation. Demand suppressed in some cases by poor infrastructure. Some countries have developed foreign private financing more than others. In general, the scope for this sector's contribution is acknowledged, but deep-seated nationalism can restrict foreign equity shares, sometimes creating management control issues.
Technological	Tolling is largely manual, excepting a few major routes.
Legal	A wide variety of legal systems, but with corruption often rife.
Environmental	Economic development predominates over environmental considerations

2.2 Vehicle Ownership

Khan and Willumsen (1986) note correlation between car ownership and roadspace in developing countries: statistically one proxying the other. ADB et al (2005, p.3) suggest the following broad correlation between GDP and roadspace:

$$\ln\left(\frac{km_of_PavedRoads}{LandArea_in_km^2}\right) = -0.5 + 0.5\ln(US\$ofGDPperCapita) \quad (1)$$

However, no goodness-of-fit is given (graphical presentation suggests low R²).

Regressions for the Study Area 9 countries, plus 5 others¹ for benchmarking suggest S-curve relationships for paved roads, railway and airports in terms of kilometres/ number of airports per km² or per capita. Figures 1 and 2 show equations fitted for roads per capita and per km² respectively, with respect to GDP per capita, suggesting substantial road build-out/ vehicle ownership growth are likely as economies grow. These also suggest clustering as follows:

- Relatively developed networks, in countries with significant prior experience of transport infrastructure privatisation: China, Indonesia, Malaysia and Thailand;
- Relatively undeveloped networks, also correlating to a relative lack of infrastructure privatisation: Cambodia, Laos and Myanmar; and,
- Intermediate countries: with some problematic experience of privatisation (Philippines) or nascent interest in privatisation (Vietnam).

¹ The other five countries were Mexico, Poland, South Korea, UK and USA

Figure 1: Relationship between Wealth and Roads per Capita

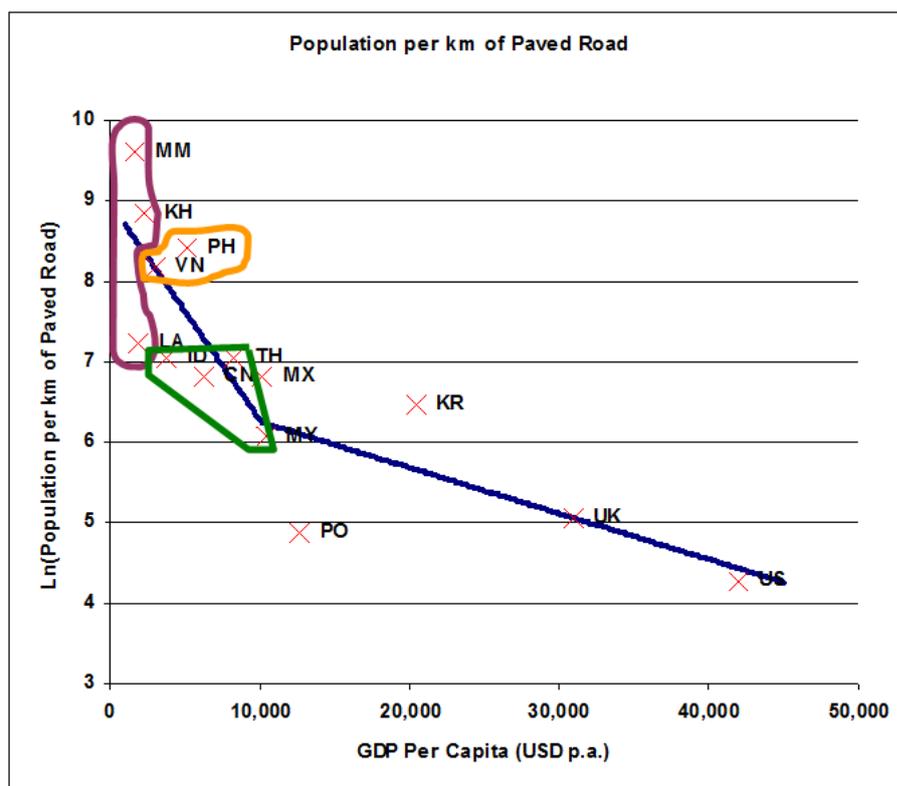
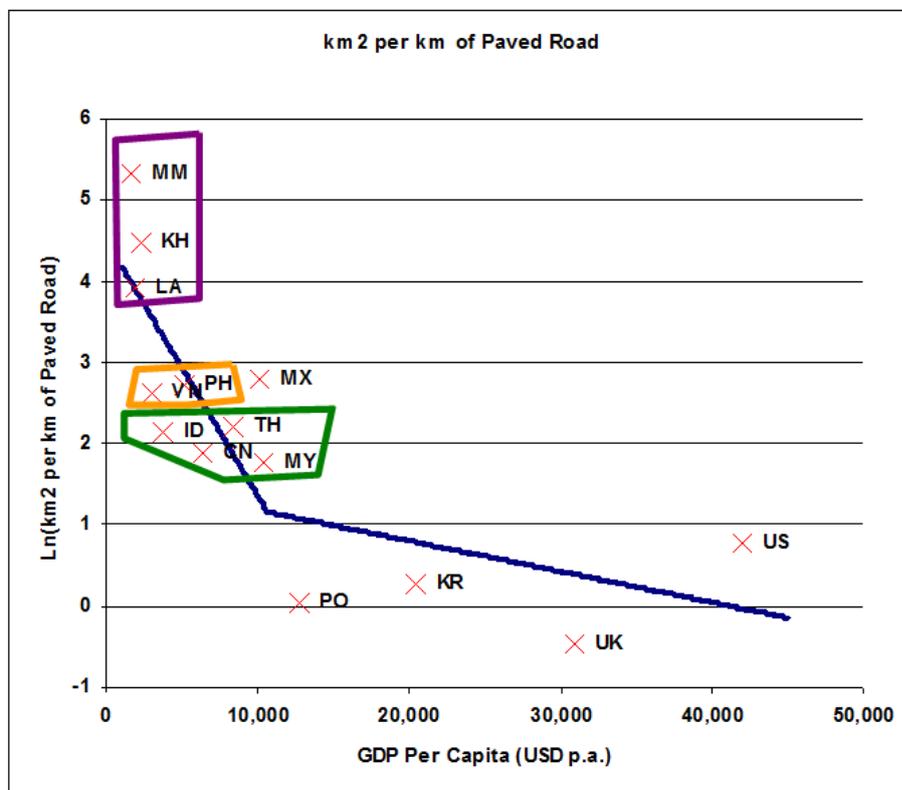


Figure 2: Relationship between Wealth and Road Density



3. Cost of Capital, Business Cycles, Interest Rates and Inflation

3.1 The Weighted Average Cost of Capital

Higson (1995) notes that according to the Fisher-Hirshleifer theorem firms should undertake projects if return is greater than investors' required return. Highways require substantial up-front investment and traffic flows often take a few years to build-up to "break even" levels; attractiveness is greatly affected by timing of revenue receipts and the discount rate, as well as by initial investment size. Projects can be valued based *inter alia* on Net Present Value (NPV) or the Internal Rate of Return.

The Capital Asset Pricing Model (CAPM; *ibid.*) suggests the return on a risky project r_j is:

$$r_j = r_i + \beta_j(r_m - r_i) \quad (2)$$

Where: r_i is the return on riskless borrowing/ lending

r_m is the return on the money market as a whole

The risk premium for j is a proportion β_j of overall market risk-premium, as follows:

$$\beta_j = \frac{\sigma_{jm}}{\sigma_m^2} \quad (3)$$

Required return can also be calculated as the Weighted Average Cost of Capital (WACC):

$$WACC = \frac{(E_{MV} \times K_e) + (D_{MV} \times K_d)}{(E_{MV} + D_{MV})} \quad (4)$$

Where: EMV is total market value of equity employed

DMV is total market value of debt employed

K_e is cost of equity, given by (5)

K_d is cost of debt, given by (6)

$$K_e = \left(\frac{\text{Dividend}}{\text{Share Price}} \right) + \text{Expected Dividend Growth} \quad (5)$$

$$K_d = \left(\frac{\text{Interest Rate}}{\text{Debenture Price (\% of Face Value)}} \right) \times (1 - \text{Tax Rate}) \quad (6)$$

From Equations (2) and (4), the Fisher-Hirshleifer theorem is restated as pursue projects if:

$$r_i + \beta_j(r_m - r_i) \geq \frac{(E_{MV} \times K_e) + (D_{MV} \times K_d)}{(E_{MV} + D_{MV})} \quad (7)$$

3.2 Schumpeterian Cycle Theories and Definition of the Kondratieff Wave

Orthodox economics assumes given policies produce similar results at all times; Ormerod (1999, pp.96-102) notes experience contradicts this, due to periodic exogenous shocks. Others postulate cycles responding to exogenous shocks. But to some cycle adherents, such shocks are largely endogenous. Schumpeter (1939) consolidated others' preceding work, specifying three inter-related cycles:

- Kitchin (1923): based on fluctuations in business inventories (39+/- months)
- Juglar (1863): based on business investment in plant and equipment (7-11 years)
- Kondratieff (1926): based on development of new technologies/ sectors and impact of their adoption on socio-economic conditions (48-60 years; a.k.a. "K-Wave")

The K-Wave postulates periodic "Creative Destruction" (Schumpeter, 1950, Chap.VII) intrinsic to industrial-capitalism. Kondratieff's empirical work identified a number of patterns within each cycle. Further analysis by Schumpeter (1939), summarised by Faber (2002, pp.116-138) notes:

- Before and during the beginning of Upswings there are profound changes in industrial techniques (based on new technologies) and/or involvement of new countries in the global economy and/or development of new transport technologies.
- Social upheavals and international conflict are more likely during Upswings.
- Agricultural prices decrease during downswings; industrial prices hold steady or fall slightly. During upswings, commodity price increases can create broader price inflation. Interest rates also follow this cycle, as appears to have been the case in recent years.
- Upswings are characterised by brevity of depressions and intensity of booms; the opposite being true during downswings.

There are also separate transitional phases at peaks and troughs (often correlated to economic and financial crises). Appendix 1 shows K-Waves since 1787. Maddison (1995) estimated real global GDP per capita rose 2.90% p.a. from the 1950s-1970s (K-Wave upswing); but declined to 1.11% p.a. until the 1990's (K-Wave downswing).

3.3 Interplay of Economic Growth, Price Inflation and Interest Rates

As noted in 3.2 above, K-Wave upswings include increased economic growth coupled with increases in price inflation and interest rates. This can be explained as follows: when economic growth accelerates, there is increased demand for goods and commodities (hence increased price inflation) and increased demand for capital to finance production and purchase of same (hence increased interest rates).

These in turn will affect the attractiveness of potential investments (Section 3.1), including toll roads, based on equation (7) as follows:

- Expected returns from riskless borrowing/ lending (r_f) will increase, placing barometric pressure on required returns from debt-financing any risky asset
- This will increase the cost of debt (K_d)
- Increased economic growth (and hence profits) together with price inflation will increase the cost of equity (K_e)

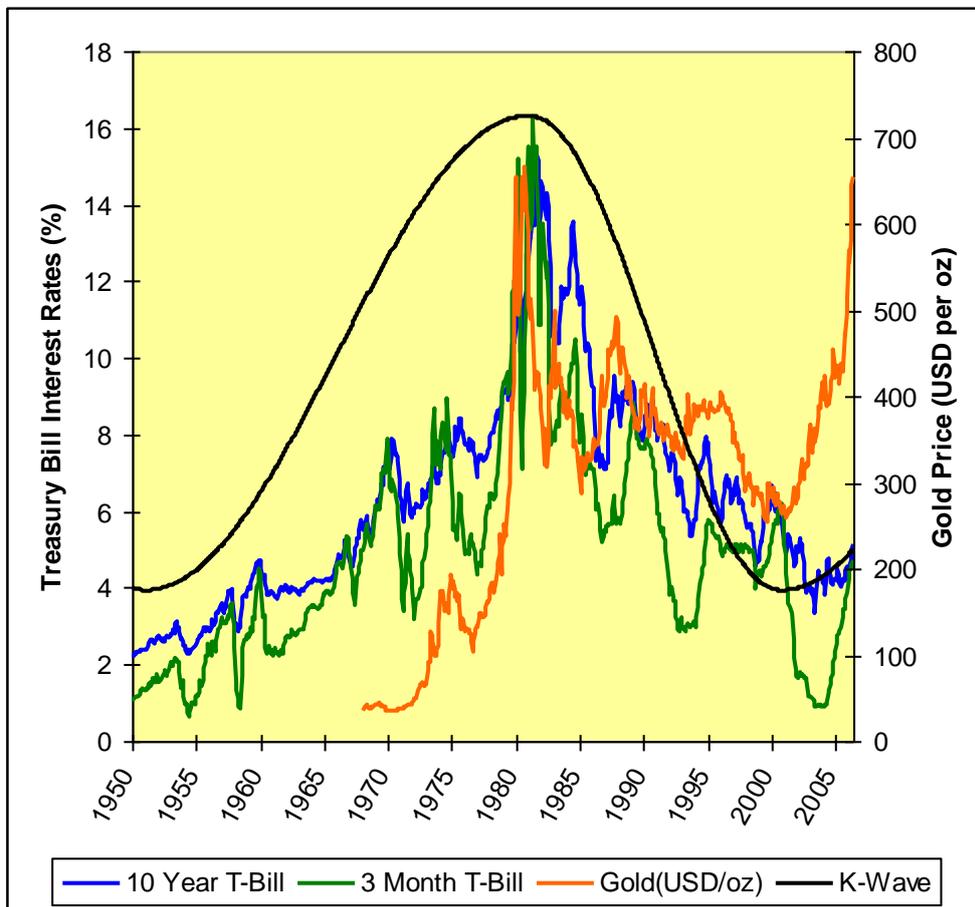
Ex ante project appraisal would normally be based upon contemporaneous values for K_d and K_e . These would likely subsequently increase. Consequently, should a project require re-financing after its initiation, the costs of such re-financing are likely to be higher than when the decision to proceed was taken. This is in contrast to K-Wave downswing conditions (e.g. 1980s and 1990s) when declining interest rates meant that re-financing would likely be cheaper than originally anticipated.

3.4 Postulated Position on the Kondratieff Wave

Based on a peak in interest rates in most leading economies in the early 1980's, along with a peak in commodity prices (especially gold) and inflation rates, the last downwave begun around 1980/1981. Equally, the bottoming out of many commodity prices at the end of the 1990's suggest an upswing began around the same time (more-or-less coinciding with the NASDAQ peaking in 2000). Recent increases in US interest rates and strong commodity markets support this assertion. Regarding inflation, Faber (2003, p.10) notes that in the classical definition of inflation (increased money supply), low interest rates and easy credit now available in many countries, but specifically the USA are evidence of inflation; price indices are likely to accelerate. Prolonged low real interest rates since the K-Wave bottom are likely to yield gold prices over-and-above what would normally be expected in the early stages of the upswing (Faber, 2005, 2006). Figure 3 plots US interest rates and nominal gold price, with a simplified K-Wave. The recent surge in gold prices is also shown.

A few transport planner-economists (e.g. Kilsby, 2006a, 2006b) have recently postulated and examined the implications of significant fuel price increases; though such work is not yet widespread.

Figure 3: Postulated Upturn in the Kondratieff Wave



4. Toll Roads from a Project Risk Perspective

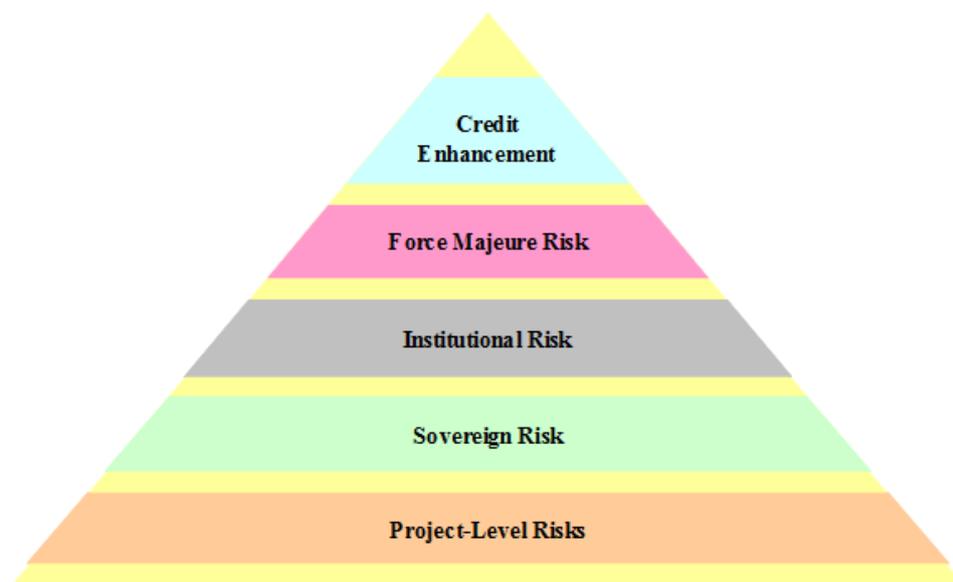
4.1 Project Risk Analysis

Rigby and Penrose (2001) of Standard & Poor's identify a pyramidal five-level framework for credit rating, which can be taken as a proxy for overall project investor risk, shown in Figure 4. Project-level risks comprise six broad elements, namely:

- i. Contractual foundations
- ii. Technology, construction and operations: both pre-construction (e.g. construction delay/ quality issues) and post-construction (e.g. Operations and Maintenance)
- iii. Competitive position of project within its market: including industry fundamentals, project's competitive advantage/ likely market share, threats of new entrants, etc
- iv. Legal structure, including choice of legal jurisdiction
- v. Counterparty risks: e.g. extent to which JV partners can contribute equity if/when debt funding exhausted, reliability of suppliers, political risk guarantees, etc
- vi. Cashflow and financial risks: in addition to expected cashflow, ability to cope with interest rate, inflation, foreign exchange, liquidity and funding risks

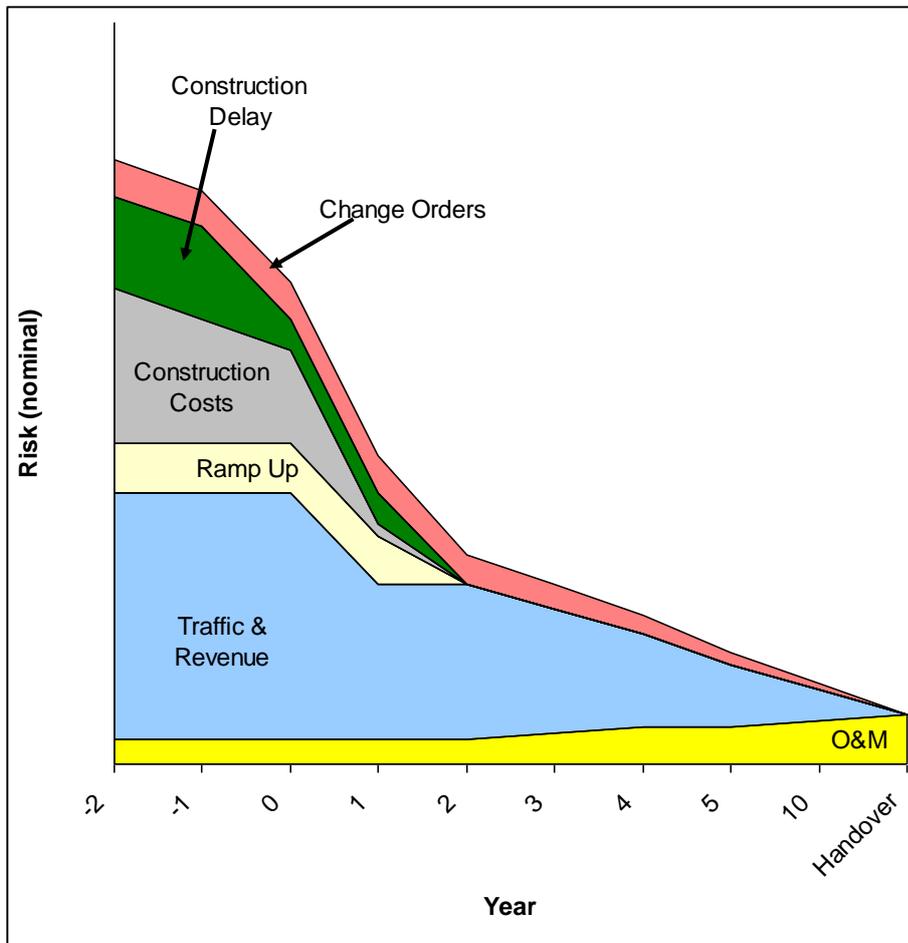
Whilst the initial research investigated all items, the primary focus of that research – and of this Paper – is on items (iii) and (vi) above.

Figure 4: Standard & Poor's Risk Pyramid



George et al (2004) note the uncertainty inherent in start-up tollways requires flexible financing approaches. Willumsen and Russell (1998) illustrate project-level risks over the duration of a project as shown in Figure 5, showing the predomination of traffic and revenue risks.

Figure 5: Transport Concession Risks



4.2 Traffic Risks, Forecast Accuracy and Potential Bias

4.2.1 Introduction

This Section identifies key risks pertaining to traffic forecasting which could be affected by changes in price inflation and interest rates, as well as some key forecasting issues which are pervasive irrespective of price inflation and interest rates. Bain and Wilkins' (2002) Traffic Risk Index (Appendix 2) summarises other forecasting issues and risks.

4.2.2 Accuracy Issues

Bain and Wilkins (2002) analyse toll-traffic uncertainty and traffic forecast error, showing strong inter-correlation. Average initial year traffic was 70% of forecast overall, 82% in lender-commissioned projections and 66% when commissioned by others, suggesting commissioning party influence on forecasts: debt-financiers relatively more concerned with down-side risk than equity-holders.

Whilst initial year errors might be due to ramp-up, which Streeter and McManus (1999) reckon can last 3-5 years, Bain and Polakovic (2005) note optimism bias is "constant through Years 2 to 5" as shown in Table 2, signalling other errors. They also note drastic differences in forecasts by different parties for the same projects, based in part on very different assumptions.

Brinkman (2003) and Kilsby (2004) identify forecasting issues, such as models' opaqueness, lack of resources to properly forecast, plus psychological and ethical factors, overlapping to

an extent with some of the “technical” issues above. This includes modellers deluding themselves as to the infallibility and neutrality of their forecasts, which are more often flawed and biased.

Table 2: Bain and Polakovic Forecast Performance Statistics

Operating Year	Mean Actual/ Forecast	Standard Deviation
1	0.77	0.26
2	0.78	0.23
3	0.79	0.22
4	0.80	0.24
5	0.79	0.25

4.2.3 Value of Time

With the exception of “shadow toll” projects (where the operator is reimbursed based on patronage, but the user does not pay tolls), the willingness of user to pay tolls is critical (where users might be vehicle drivers or their employers/ hirers).

The behavioural value of time is the equivalencing of time and money, defined by Bain (2009, p.91) as “*The monetary value attached to the possibility to save a determined amount of travel time.*” Therefore the objective of revenue-maximising toll road operators could be defined as setting tolls at which toll revenue would be maximised.

Whilst higher tolls are usually preferred sometimes they are too high (Wong and Moy, 2004). As Ortúzar and Willumsen (1994, p.413) note, quantification of the value of time (VOT) can be fraught with difficulty and has elicited substantial discussion. Goods vehicles typically have higher tolls than passenger cars and as such identifying the VOT can be important. However, Bain and Wilkins (2002) note in developing countries long-distance tolls often exceed drivers’ wages, giving incentive to use untolled routes (pocketing bosses’ toll money). Some studies (e.g. ADB, 2003) have failed to establish any VOT for goods vehicles.

In modelling practice, VOT may be calibrated as part of assignment modelling calibration. However, for forecasting there is also a debate regarding the pace at which VOT should grow relative to income, i.e. the income elasticity of value of time. As income rises, expenditure usually also rises on items previously purchased (“*income effect*”) but there is also often new expenditure on items not previously purchased (“*substitution effect*”), so the income elasticity of VOT should usually be less than 1.0, especially in long-run forecasts.

4.2.4 Competing Routes and Link Roads

Contractual guarantees can theoretically limit competing routes’ development, presupposing the contracting branch of government is willing and able to enforce such guarantees across multiple government layers. Jiangsu Expressway circumvented this risk by acquiring rights to highways parallel to their flagship Shanghai-Nanjing Expressway. However, when GZI Transport listed in 1997, it was assumed that the ferry parallel to the (then) soon-to-open Humen Bridge would cease operation. But being operated by a different local government, operation continued with fares undercutting bridge tolls.

Even if concessionaires get first refusal at parallel routes, overinvestment may result in excess infrastructure relative to traffic, as Buchanan (1999) argues happened in Malaysia during a period of rapid economic growth and development in the 1990s.

Provision of adequate link roads is also important. Congested approaches/ exits can result in “hurry up and wait” (Bain and Wilkins, 2002), reducing tollways’ attractiveness.

4.2.5 Toll Increases and Revenue Guarantees

Contracts typically allow periodic price-indexed toll increases, or at a percentage of price inflation. However, Forsgren et al (1999) note toll increase approval processes are often opaque and beset with delay. Bain and Wilkins (2002) note tariff escalation is often politicised, especially where there is little previous “tolling culture.” Sometimes social unrest follows tolls’ imposition (Orosz, 1998) or toll increases, especially during economic downturns (Dizon, 2002).

Some contracts give revenue guarantees to operators, underwritten by government. However, China’s 2002 State Council directive scrapped such revenue guarantees overriding contract provisions, leading to New World Development divesting from 13 toll roads and bridges (Chan, 2003).

As price inflation accelerates the ability to increase tolls commensurately becomes more critical: whereas when price inflation decreases the impacts of delays or resistance to toll increases may be less than assessed during *ex ante* project appraisal, during price inflation increases the impacts of delayed or reduced toll increases will increase.

Whilst non-toll revenues may be generated (e.g. service stations, advertising), Streeter et al (2004) note their contribution is usually dwarfed by toll revenues.

4.2.6 Ramp-Up

Bain and Wilkins (2002) define ramp-up as information lag for users unfamiliar with a new highway and general reluctance to pay tolls (see Richardson (2004) for experimental evidence). Streeter and McManus (1999) reckon on 3-5 years’ ramp-up and note this is often underestimated in traffic forecasts.

Bain and Wilkins (2002) note ramp-up experience tends to cluster to extremes: either of limited duration (even exceeding forecast traffic levels) or lagging for a long duration, maybe never “catching up”, particularly for projects with a high Traffic Risk Index (see Appendix 2).

4.2.7 Operating Costs

Many models also apply distance-based monetary Vehicle Operating Costs (VOC) reflecting fuel, maintenance, depreciation, etc with a cost advantage for smoother expressways. Whilst economic values can be derived, accurate behavioural values can be elusive. Where there are larger VOC savings from an expressway *ceteris paribus* there is more scope for higher tolls. However, there is an issue as to who pays these costs (driver or employer).

4.2.8 Toll Leakage

Some vehicles use a facility without paying, either legitimately (e.g. certain government or military vehicles) or illegitimately. There may be theft by toll-collectors and fraud by administrators. Forsgren et al (1999) note toll leakage can be as high as 20% of revenues. Sometimes computerised toll collection and auditing can restrain losses, but on lower volume routes the cost of such measures might outweigh savings. If price inflation outstrips wages, there may be increased risk of malfeasance.

4.2.9 Induced Traffic

When a new highway significantly reduces transport costs or relieves congestion, it may result in additional (induced) traffic. And such traffic induction may correlate to increased economic growth. Indeed, Corbett et al (2006, p.A2-99) report substantial, rapid induction on Cambodia’s roads following rehabilitation. On green-field sites, it may also over time enable expanded development, generating further traffic demand. However, Willumsen and Russell

(1998) note the difficulty of reliably forecasting such effects; Bain and Polakovic (2005) report the prevalence of significant errors in induced traffic forecasts.

4.2.10 Economic Effects

Economic risks feed through many elements of traffic forecasts:

- Overall travel demand (e.g. car ownership and usage, freight volumes, extent of traffic induction)
- Willingness-to-pay tolls and tollways (affordability; ramp-up extent and duration)
- Toll leakage (incentive for malfeasance)
- Over-investment increasing likelihood of competing routes being built/ upgraded

Economic cycles can affect decision-making, both in terms of evaluation assumptions adopted (often projections based on adaptive expectations) and the number of schemes being considered at any time. When expectations are high more projects are evaluated, so proportionally more projects are likely to founder on downturn (and be blamed on transport forecasts). This may create cynicism regarding tollway investments extending into the early economic recovery, resulting in under-investment in some areas, thence over-investment as returns on operating (and newly opened) highways exceed expectations, thus creating a new “error of optimism” (Pigou, 1920).

Luu (2006) and Gomez and Jomo (1999) cite governments in Vietnam and Malaysia potentially over-expanding transport infrastructure development.

4.3 Construction, Operations and Maintenance

Construction cost overruns and delay (deferred/ lost revenue) may imperil initial debt repayments. Rigby (1999) notes using engineering, procurement and construction (EPC) contractors’ reputations to proxy technical risk is both commonplace and erroneous: construction risks are often inadequately assessed. Based on UK experience, Flyvbjerg and COWI (2004) recommend highway construction cost estimates be uplifted 15% if a 50% chance of overrun/ delay is acceptable, or by 32% if 20% chance acceptable.

Ruster (1996) notes construction cost overruns, delays and defects can be largely mitigated by liquidated damages, performance bonds, warranties, contingency funds and insurance. As revenue losses are rarely disputed during delay/ overrun arbitrations, the focus of the research remains on demand-side risks. However, when the contractor is the concessionaire, such risks should be analysed. Similarly, operations and maintenance (O&M) risks should also be considered.

4.4 Summary of Key Issues

Key issues, whose importance may vary between countries and projects (with some risks correlated), which may be summarised under the following headings:

- **Macro-Economic Risks:** including institutional, sovereign and broad economic risks.
- **Market Risks:** primarily concerning scheme attractiveness and riskiness.
- **Forecasting Risks:** pertaining to uncertainty and transport modelling practice.

Stakeholder attitudes to many of these risks (and the utility of evaluation criteria) were tested by questionnaire surveys, in terms of how often such risks are considered, whether they are deemed important and in the case of certain economic parameters, whether they are expected to increase or decrease in the near- to medium-term. Many risks were tested quantitatively by risk simulation modelling. The factors and proposed testing methods are

indicated in Table 3. Certain risks were beyond the remit of the research (e.g. bidding strategy) or not readily testable by either questionnaire or risk simulation.

Addressing the hypothesis, excepting the use of interest rates in financial analysis, little literature emphasised any importance of either price inflation or interest rates on tollways. They are therefore included in the key risks to be considered in both the questionnaire surveys and risk simulation.

Table 3: Summary of Key Risks and Issues

Risk Type	For Testing By	
	Questionnaire	Risk Simulation
Macro-Economic Risks		
Country's political and legal systems	✓	
Exchange risks: exchange rate and cash repatriation	✓	
Interest rates	✓	✓
Price inflation	✓	✓
Economic growth and business cycles	✓	✓
Income (in)equality	✓	
Tolling culture	✓	
Corruption	✓	
Market Risks		
Road's social/ economic benefits	✓	
Construction time/ threat of over-run	✓	✓
Construction cost/ threat of over-run	✓	✓
Operation & maintenance costs	✓	✓
Contractual foundations	✓	
Threat of competing routes	✓	✓
Ramp-up: size and length	✓	✓
Toll affordability	✓	✓
Enforceability of toll increases	✓	✓
Minimum income guarantees	✓	
Toll leakage	✓	✓
Truckers using free routes, pocketing boss's toll money		
<i>Guanxi</i> (importance of business relationships)	✓	
Connecting roads: access/ egress	✓	✓
Forecasting Risks		
Frequency of Over- and Under-Forecasting	✓	✓
Ramp up: length & size	✓	✓
Toll affordability	✓	✓
Sensitivity of traffic levels to GDP growth	✓	✓
Overall sensitivity of project traffic to tolls		✓
Sensitivity of trucks/ large vehicles to tolls	✓	✓
Toll sensitivity to changes in income		✓
Data availability/ quality for model calibration	✓	
Data availability/ quality for forecasting	✓	
Reliability of transport modelling process	✓	
Induced traffic		
Forecasters pressured by clients to adjust numbers	✓	
Treatment of connecting and competing routes		✓
Evaluation Criteria		
Use of financial metrics, e.g. NPV, Financial IRR	✓	
Project's social cost/ benefit and which metrics used	✓	
Do counterparties mitigate or add to project risk?	✓	

5. Questionnaire Survey

5.1 Purpose

In order to test both literature and environmental analyses, a questionnaire survey was undertaken to test practitioners' experience and perceptions regarding:

- Their scope of project experience;
- Relative weightings of difference macro- and micro-level project risks;
- Data availability and quality;
- Accuracy of forecasts and which metrics are employed to test risk;
- Market outlook in the nine Study Area countries; and,
- Expectations for economic parameters.

The questionnaire was designed to afford a relatively broad sample of opinion; various advisory professions were sampled. Respondents were also asked to state the extent of their working experience, the proportion of this spent in relevant fields and their geographic experience. Questions covered economic, legal, engineering and connectivity risks, as well as (for those with modelling experience) an investigation into the reliability of transport demand forecasts, attempting to identify where practitioners feel their art is weakest.

Given the relative obscurity of business cycle theory even amongst economists, only one question relates directly to the use of business cycles, though others test expectations regarding price inflation and other economic variables. In order to prevent comparison with especially turbulent periods, expectation comparisons were between the previous 5 and next 10 years.

Sampling was done via the author's personal contacts, extracting contact details from literature reviewed, using a number of internet-based newsgroups ("yahooglegroups"), plus review of professional databases. As suggested by "sub-tribalism" (Morris, 1971), the best response rate was from those known to the author and those in the same primary field (transport planning), so the sample skewed towards transport planners/ economists. Such people also accounted for most of the optional (text) responses on broader issues. Given that some questions were designed specifically for transport planners this was not considered a problem (those without such experience being screened out of such questions, though not the rest of the survey).

5.2 Design and Execution

The internet-based www.surveymonkey.com was employed, allowing easy questionnaire dissemination and automatic result collation.

Piloting occurred in September 2006, followed shortly thereafter by the main survey (into October 2006).

Approximately 40 respondents started the survey but dropped-out after just a few questions. These responses were excluded from the analysis. In a number of cases, respondents did not give answers to each question, but nonetheless gave answers to many questions. Under such circumstances a "not sure" response was assumed for omitted answers. And when evaluating answers, such "not sure" responses were typically excluded, such that analysis would concentrate on stated opinions only. A total of 162 responses were considered as valid for analysis (though due to "not sure" and omitted answers, this number was often lower for specific questions), summarised by type of respondent in Figure 6 and years of experience in Figure 7.

Figure 6: Respondents by Experience Type

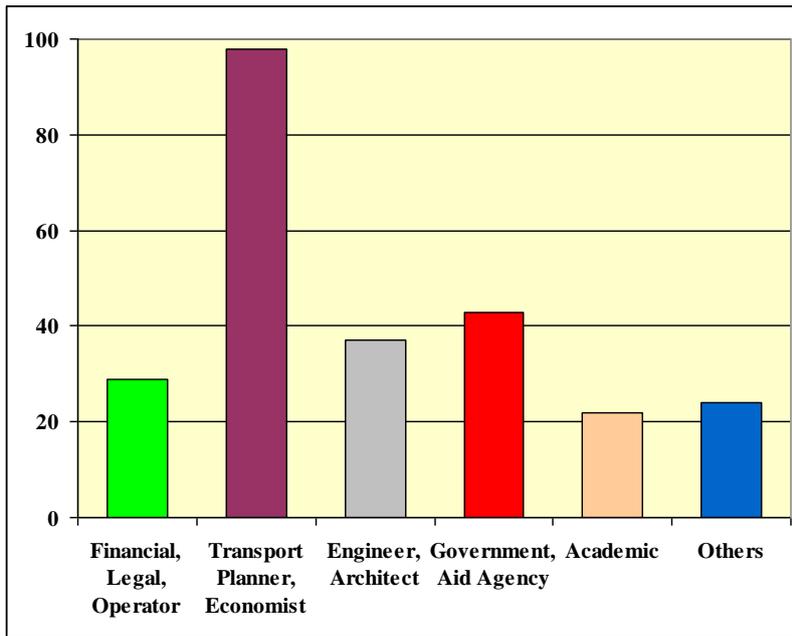
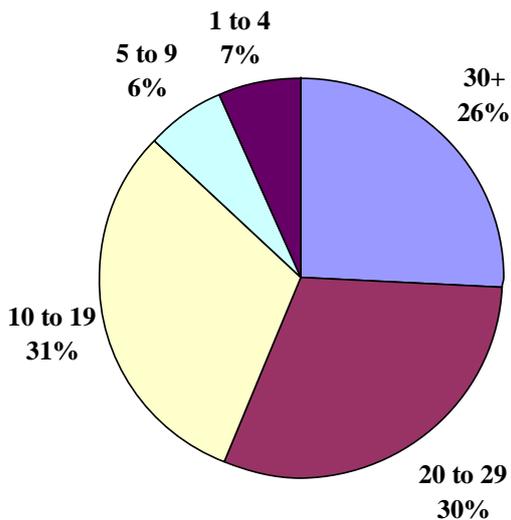


Figure 7: Working Experience of Respondents



5.3 Key Findings

Findings are shown in Appendix 3.

There is perceived primacy of legal and political factors on viability; though once modelling commences, economic factors predominate. Business cycles, toll familiarity and income inequality are deemed slightly unimportant.

Data quality and availability is deemed better in developed economies, as expected. There is no strong preference between four-stage, assignment and spreadsheet models. Rather each model should be tailored for specific conditions. Four-stage models are perceived as fairly reliable, but also as opaque.

Whilst under-forecasting appears relatively rare, over-forecasting happens much more often. There is some acknowledgement of transport planners adjusting forecasts to meet clients' expectations. There appears a fundamental misunderstanding of the purposes of equity- and

debt-side forecasts; this based on only weak acceptance of differences between forecasts for either side (as the author suspected a priori).

NPV is the most often-used evaluation criterion, followed by FIRR, then economic metrics. Counterparty risks and risk correlation versus other projects are used more rarely.

Country categorisation in Section 2.2 is broadly supported, but with Indonesia seen as less advanced than posited there. On average, Malaysia is seen as steady-to-maturing; Thailand and China as developing-to-steady; Philippines, Indonesia and Vietnam as nascent-to-developing; and Cambodia, Myanmar and Laos as sub-nascent. However, those with Indonesia experience rate the country as developing-to-steady; and those with local experience regard Cambodia and Myanmar as nascent.

There is a reasonable acceptance of symptoms of a K-Wave upswing, in terms of increasing price inflation (especially fuel prices), interest rates and to a lesser extent, economic growth. Tolling acceptability is predicted to increase. However, respondents did not deem the impacts of rising interest rates and price inflation to be significant.

6. Risk Simulation Model

6.1 Model Definition

A simple notional highway network model was developed. Using Excel/ Visual Basic, a simple incremental assignment model was developed for application to this, which was integrated with a financial model. Variables as set out in Appendix 4 were parameterised based on distributions of values, for testing through Monte Carlo risk simulation. This enabled quantitative estimation of the relative importance of different risks, both to test the specific hypothesis and to test whether questionnaire respondents might have underrated such risks.

In reality, each toll road project has specific locational and institutional risks. These were deliberately excluded by use of the simplified, notional case study; the aim being to concentrate on the relative importance of broad risks irrespective of particular locational context.

Three economic simulation scenarios are defined as follows:

- “Conventional Case” of interest rates and price inflation similar to recent values;
- “Respondents’ Case” based on questionnaire results with increased fuel prices and some increase in general price inflation and interest rates; and,
- “Kondratieff Case” assuming an upswing with more substantial increases in price inflation, interest rates and also increased economic growth.

The case study network comprised six zones and eight links, including the fictional tolled highway. Both the total number of trips and road capacities were included amongst the simulation variables; all of which are shown in Appendix 4, together with network topology. 27 parameters were common for all three Cases (Conventional, Respondents’ and Kondratieff). A further 6 parameters had values specified for each Case differently, though for each Monte Carlo iteration, the values were inter-related.

10,000 iterations of Monte Carlo simulation were employed, using the following methodology:

- Defining random parameters
- Applying parameters to derive values for each quarter over a 30-year period, covering construction and operation (120 periods considered)
- Traffic assignment for each quarter (but for initial quarters, prior to completion of the expressway, traffic is set to zero) and generation of resultant quarterly financials,

including servicing of debt (interest and/or principal as appropriate and any requirements for short-term financing to cover shortfalls)

- Financial analysis across the project duration: summarised using FIRR, payback period and NPV (at a range of interest rates). Any run with FIRR≤0% or payback period >120 quarters was deemed to constitute financial failure

6.2 Results of Forecasting Model

Table 4 sets out results of an initial run for each scenario based upon modal values for each parameter (i.e. without Monte Carlo risk simulation). This suggests that despite delayed Payback (due to higher price inflation and interest rates) the Kondratieff case may give superior returns than the Conventional case, but that the Respondents' case would yield the best returns; perhaps indicating more optimism amongst practitioners (transport planners being the largest respondent group).

Table 4: Comparison of Initial Runs (without Monte Carlo Risk Simulation)

	Case		
	Conventional	Respondents'	Kondratieff
FIRR	16.83%	17.88%	16.95%
Payback Period (years)	10.728	10.676	12.090
NPV (at 16%)	\$17,910,017	\$45,944,246	\$27,524,725

Table 5 sets out summary results of the 10,000 simulation runs for each case, with cumulative probability distributions of FIRR, payback and NPV (at 16%) shown in Figures 8, 9, and 10. Comparing Table 5 against Table 4, mean FIRR's are greater, yet payback periods are longer except in the Kondratieff case (though this excludes 13 instances where there is no payback within 30 years).

Table 5: Summary Results from Simulation Runs

Metric	Statistic	Case		
		Conventional	Respondents'	Kondratieff
FIRR	Mean	17.20%	17.99%	17.62%
	Minimum*	0.01%	0.49%	0.11%
	Maximum	28.75%	29.26%	30.14%
	Standard Deviation	3.74%	3.77%	4.11%
Payback Period (years)†	Mean	10.83	10.85	11.60
	Minimum	6.44	6.31	6.53
	Maximum	29.98	29.23	29.66
	Standard Deviation	2.32	2.41	2.73
NPV at 16% (\$ million)	Mean	\$28.1	\$46.4	-\$37.7
	Minimum	-\$377.8	-\$936.0	-\$5,600.3
	Maximum	\$296.6	\$357.3	\$465.0
	Standard Deviation	\$80.3	\$96.3	\$308.9
Financial Failure	# of Cases	55	114	1250
	% of Cases	0.6%	1.1%	12.5%

Note: * FIRR's were not calculable once beneath 0%; hence 0% minimum value in all cases.

† Excludes 13 instances under Kondratieff case where no payback obtained.

Figure 8: Cumulative Probability Distribution of FIRR (excluding FIRR<0%)

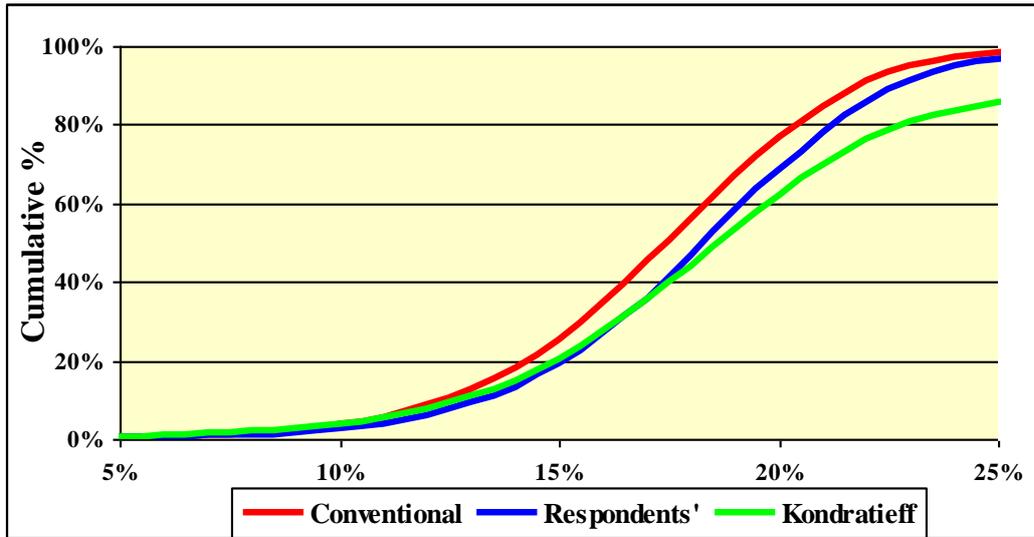


Figure 9: Cumulative Probability Distribution of Payback Period (years)

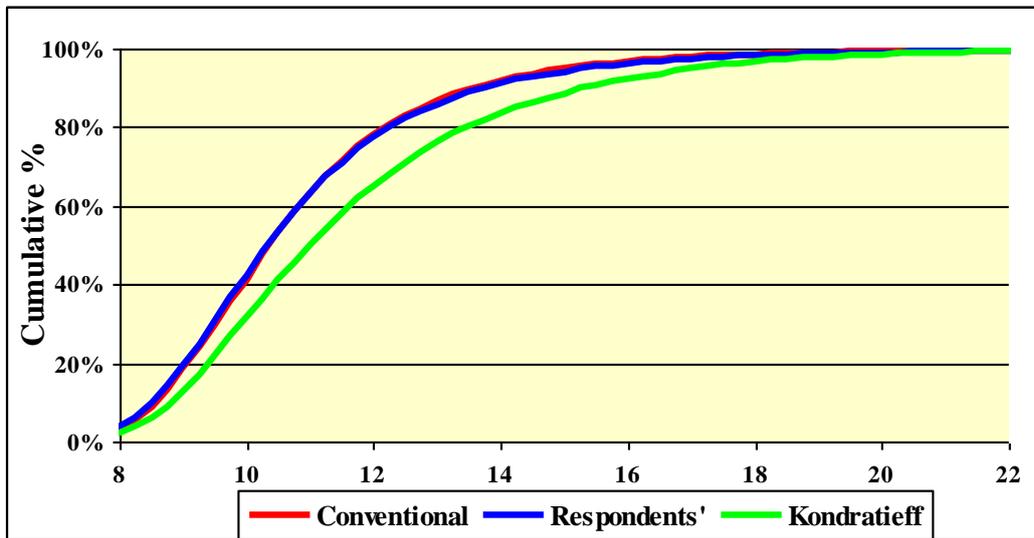
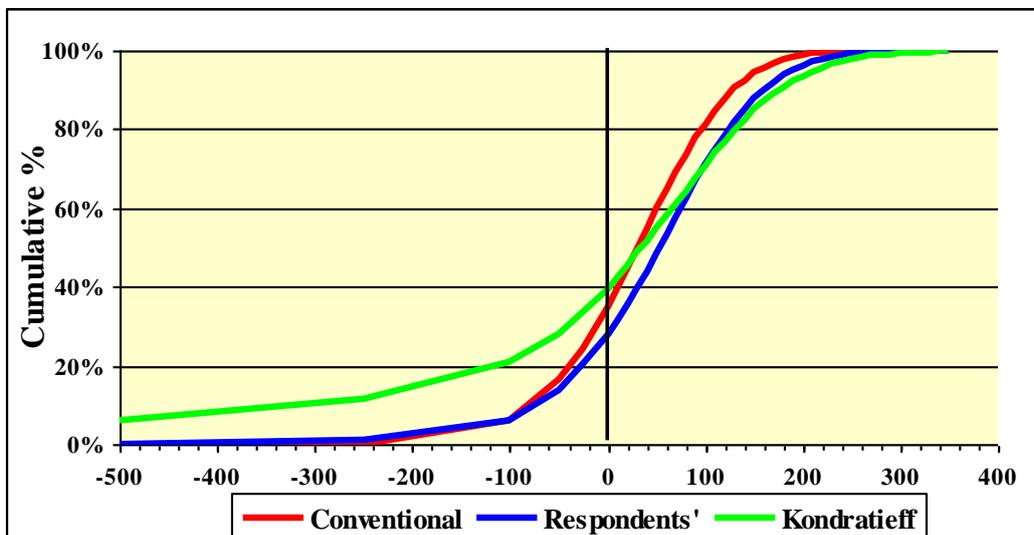


Figure 10: Cumulative Probability Distribution of NPV at 16% (\$m)



For both FIRR and payback, the general pattern of Respondents' Case being the most optimistic and the Conventional Case the most pessimistic holds. At a 16% discount rate, Respondents' Case NPV is similar to the "base" run, but mean NPV is substantially higher in the Conventional Case, though still less than in the Respondents' Case.

However, mean Kondratieff NPV is actually negative, despite mean FIRR of 17.62%; Figure 10 shows that average NPV is lowered due to a significant number of large negative NPV's. In all cases, Kondratieff standard deviations are the greatest and Conventional standard deviations the smallest. Furthermore, 12.5% of Kondratieff runs resulted in "failure" (i.e. negative FIRR or no payback); substantially greater than 1.1% of Respondents' runs and 0.6% of Conventional runs.

This suggests immediately that notwithstanding its superior mean values, the Respondents' case is riskier than the Conventional case; however, the Kondratieff case is substantially riskier still.

6.3 Analysis of Individual Risks

Analysis of the impact of different simulation variables showed some variables have a large but poorly correlated effect on FIRR, whilst others have a smaller but better correlated effect. Importance was therefore assessed as follows:

- The range (maximum less minimum) is calculated
- The range is multiplied by the linear regression equation's coefficient to determine the impact on FIRR; an absolute value is taken
- The impact is multiplied by the linear regression equation's R^2 to weight impact by strength-of-relationship

The simulation variables were then grouped by category, so as to determine the relative importance of such risk categories, thus avoiding distortions due to the number of variables tested within each category. The categories were then ranked for each of the three cases, as shown in Table 6. The Case Study appears to give very low importance to the Value of Time, but this might be a consequence of the nature of network modelled.

Table 6: Rankings of Risk Categories' Importance by Case

Risk Group	Conventional		Respondents'		Kondratieff	
	Impact*R ²	Ranking	Impact*R ²	Ranking	Impact*R ²	Ranking
Road Capacities	0.30%	11	0.53%	10	1.35%	9
Construction Cost & Duration	5.68%	4	6.40%	4	8.75%	5
All O&M Costs	0.59%	9	1.02%	8	1.98%	8
Value of Time & Its Income Elasticity	0.00%	13	0.03%	13	0.05%	13
Vehicle Operating Costs	0.30%	10	0.19%	11	0.27%	12
Demand (Initial & Income Elasticity)	12.13%	1	12.69%	2	16.05%	2
Toll Revenue Leakage	0.95%	8	0.94%	9	1.20%	10
Ramp-Up: Amplitude & Duration	2.14%	6	2.30%	7	3.66%	7
Logit Model Parameters	0.09%	12	0.12%	12	0.32%	11
Toll Escalation Rate and Frequency	1.73%	7	2.56%	6	4.69%	6
GDP Growth	10.84%	2	12.62%	3	15.01%	3
Price Inflation	5.12%	5	5.91%	5	11.67%	4
Interest Rates	8.78%	3	15.73%	1	47.38%	1

What is more critical in the context of this research is the change in impacts and rankings between cases. Excepting Vehicle Operating Costs and Toll Leakage (the latter in the Respondents' case), all parameters increase their impact on FIRR between Conventional and Respondents' and Respondents' and Kondratieff cases, indicating increased forecast risk volatility overall.

Interest rates increase markedly in importance in both Respondents' and Kondratieff cases; this may be slightly overstated as initial interest rates feed into interest rates on any extra (subsequent) borrowings. However, in the Kondratieff case both sets of interest rates would individually outrank all other categories; illustrating the exponential increase in their impact as they rise, thus signifying that interest rates increase markedly in importance in times of high (or increasing) interest rates.

Demand ranks as most important in the Conventional case and remains second only to interest rates in the other cases, followed by GDP growth (which itself permeates many other parameters as explained in Section 4.2.10). Price inflation and construction costs/ duration are 4th and 5th most important (precise ranking case-dependent). The importance of toll escalation rates and frequency of increases also increases in the Respondents' and especially the Kondratieff case, as might be expected: with price inflation increasing, the impact of delayed or incomplete adjustments increases. Indeed the impact of price inflation does not appear simple. General price inflation accounts for most price impact, but is positively correlated with outturn performance; likely because it decreases the real value of initial debt and is abated to an extent by toll increases, so downside risks associated with increased price inflation are statistically associated more strongly with toll escalation-associated variables.

Such inter-relationships between simulation system variables often occur; isolation of individual variables' impacts is not always possible (Pindyck and Rubinfeld, 1981). With regards the Hypothesis, this suggests the impacts of increasing price inflation and interest rates on various project risk elements are not always wholly linear; rather, more complex system-wide interactions are possible.

7. Discussion of Key Findings and Conclusions

7.1 Interest Rates and Price Inflation

Whilst interest rates do not feature greatly in transport planning literature, they are very important in project finance: with investment risk increasing substantially as interest rates escalate; this corroborated by the risk simulation modelling. Price inflation can affect both construction and operating/ maintenance costs, as well as the impacts of delayed toll escalation or toll increases at under the rate of price inflation. Neither price inflation nor interest rates were seen as especially important in project risk analysis by most questionnaire respondents. Furthermore, there was little literature found in transport planning on the importance of these parameters (Kilsby (2006a, 2006b) being a rare exception.)

However, economic growth was recognised as very important to project performance (ranked by survey respondents behind only political and legal systems). Economic growth feeds through many aspects of market and forecasting risks (both discussed below). Survey respondents expected increasing price inflation and interest rates (and especially fuel prices), yet their importance was not rated that highly.

The simulation model adopted three economic scenarios. The first ("Conventional Case") assumed similar trends to those experienced in recent years; the second ("Respondents' Case") incorporated respondents' expectations of higher fuel prices and slightly higher interest rates and economic growth; the third case ("Kondratieff Case") was based on an upswing in the K-Wave (Kondratieff, 1926), resulting in markedly higher general price inflation and interest rates, as well as higher economic growth. Based on FIRR, the

Respondents' Case generally gave the most optimistic returns, with mean Kondratieff Case returns also higher than those from the Conventional Case. However, 12.5% of Kondratieff Case runs resulted in project failure (i.e. no payback and/or negative FIRR), versus 0.6% in the Conventional Case and 1.1% in the Respondents' Case.

Given that economic growth correlates positively with FIRR, the impacts of increased price inflation and interest rates, where these outstrip economic growth would appear to have a significant negative impact on project performance. Furthermore, the apparent volatility of the Kondratieff Case would tend to support Faber's (2002) assertion regarding the riskiness of the K-Wave Upswing (higher mean returns, but with an inherent danger of short-term reversals which can lead to bankruptcy).

7.2 Evaluation of Hypothesis and its Implications

In addition to general forecast uncertainty, the following risks should be highlighted (based on Conventional Case risk simulations):

- Base demand (i.e. whether there is sufficient traffic congestion to drive demand);
- Economic growth (which is likely to be volatile);
- Interest rates (for financing);
- Construction costs and duration; and,
- Price inflation.

The specific hypothesis is *"There is a significant change in the nature and extent of project finance risks for private stakeholders in East Asian toll roads during a period of increasing price inflation and interest rates."* Practitioners generally held that both price inflation and interest rates would increase to an extent, though were less certain as to the significance of such increases. The risk simulations showed both were strongly correlated with project FIRR. Assuming that projects are substantially debt-financed, then increasing interest rates would markedly affect outturn performance. Meanwhile, price inflation will affect construction and operating and maintenance costs, as well as increasing the impact of delayed toll increases (and increases beneath price inflation rates). Risk simulation showed that rising price inflation and especially interest rates are likely to substantially increase their importance relative to other project-level risks. However, should fixed-rate debt be available (e.g. bonds) then risk can be offset (rising price inflation decreasing the real debt burden) and subsequent increases in interest rates are less important (so long as re-financing is not necessary).

Furthermore, increasing price inflation and interest rates could be associated with accelerating economic growth; though the K-Wave posits this, acceptance of the K-Wave is not necessarily required to accept the linkage between economic growth, price inflation and interest rates. And economic growth is strongly positively correlated with project performance, permeating most aspects of demand forecasting and potentially mitigating some of the impacts of rising interest rates.

In conclusion, rising price inflation and interest rates do appear likely to change the nature and extent of project finance risks for private stakeholders in toll roads.

And furthermore, the potential implications of this appear to have been underestimated.

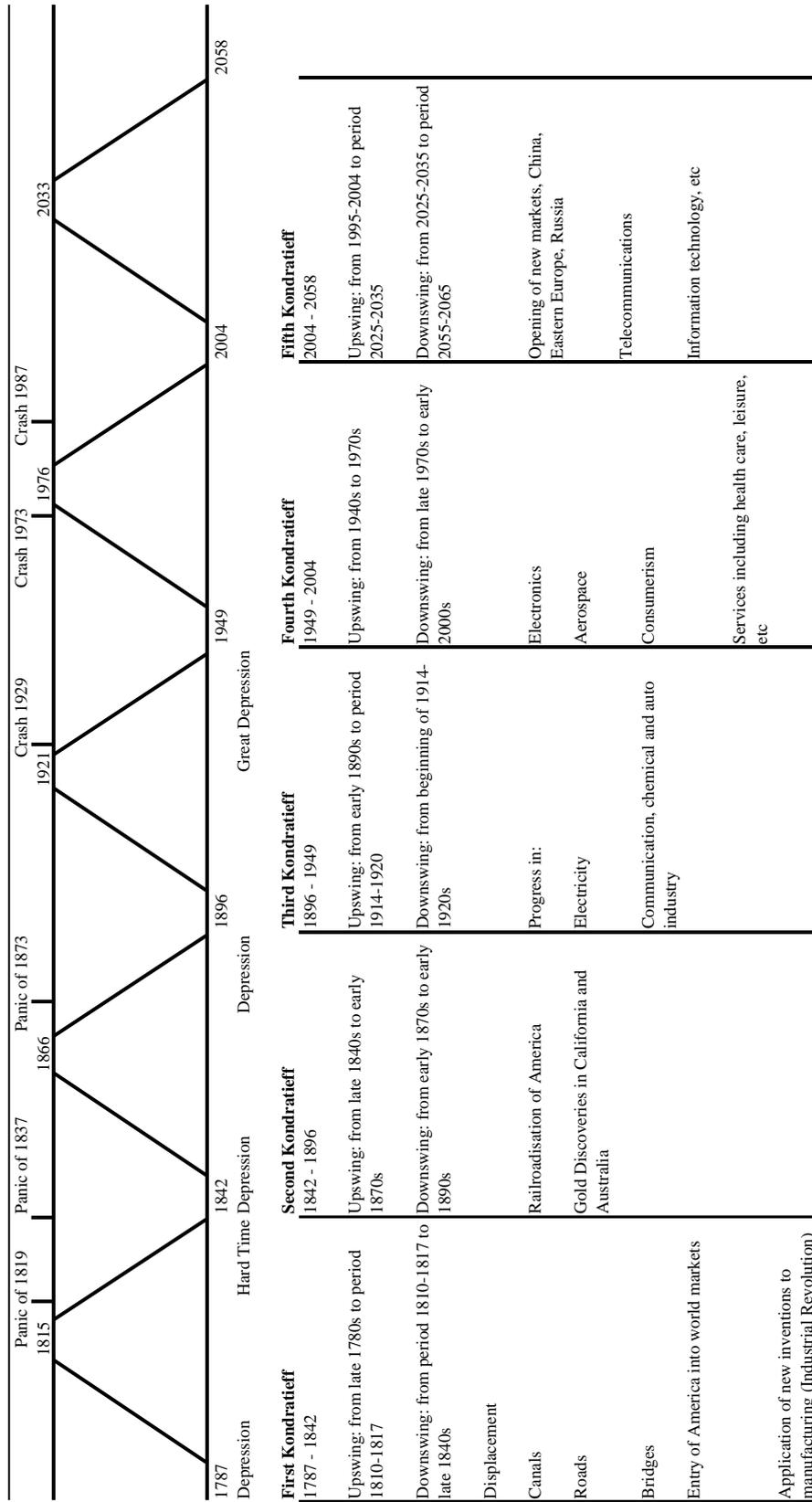
Acknowledgements

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Within transport planning and associated professions, there are simply too many people to thank individually. I believe I have learnt something from almost everyone I have worked with. Whilst undertaking the research over a couple of years, I have picked the brains of many colleagues and clients, past and present; and due to frequent commercial sensitivity, many comments and discussions have been on an anonymous basis. Many also acted as disseminators of my questionnaire and as “sounding boards” to discuss ideas and informally corroborate “ball park” figures used in the Monte Carlo risk simulations.

Appendix 1 – Kondratieff Waves Since 1787

(from Faber, 2002)



Appendix 2 – Traffic Risk Index (Bain and Wilkins, 2002)

Project Attributes	Low	High
Tolling Regime	Shadow tolls	User-paid tolls
Tolling Culture	Toll roads well established; data on actual use available	No toll roads in country; uncertainty over acceptance
Tariff Escalation	Flexible rate setting/ escalation formula; no government approval required	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 early 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 (including tolling points and 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” (congested access/ egress routes)	
“Active” competition protections (e.g. traffic calming, truck bans)	Autonomous authorities can do what they want	
Surveys/ data collection	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?)
Users: private	Existing zone framework (widely used)	Develop zone framework from scratch
	Clear market segment(s)	Unclear market segments
	Few, key origins and destinations	Multiple origins and destinations
	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?
Users: commercial	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
	Fleet operator pays toll	Owner-driver pays toll
Micro-economics	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
Traffic growth	Strong, stable, diversified local economy	Weak/ transitional 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

Appendix 3 – Results of Questionnaire Survey

Table A3.1: Aggregated Respondent Experience Categories

Group	Components	Number
Financial, Legal, Operator	Expressway Developer/ Operator/ Equity Investor Lawyer/ Attorney/ Solicitor Private Sector Lender Investment Banker Ratings Agency Accountant/ Valuer Insurer	29
Transport Planner/ Economist	Transport Planning Consultant Economist	98
Engineer/ Architect	Civil/ Structural/ Pavement/ Highway Engineer/ Architect	37
Government/ Aid Agency	Government Aid Agency	43
Academic	Academic	22
Other	Other	24

Table A3.2: Respondents' Mean Years' Experience in Various Fields

Project Type	Average Years per Respondent	Sample's Total Years' Experience
Transport infrastructure projects	10.66	1,642
All infrastructure projects (transport & non-transport)	13.13	2,022
Projects in developing economies	7.26	1,119
Tolled highway projects (urban and/or rural, anywhere)	2.57	396
Rural or inter-urban tolled highway projects	1.70	262
Rural/ inter-urban tolled highways in developing economies	1.12	173

Figure A3.1: Respondents' Global Experience

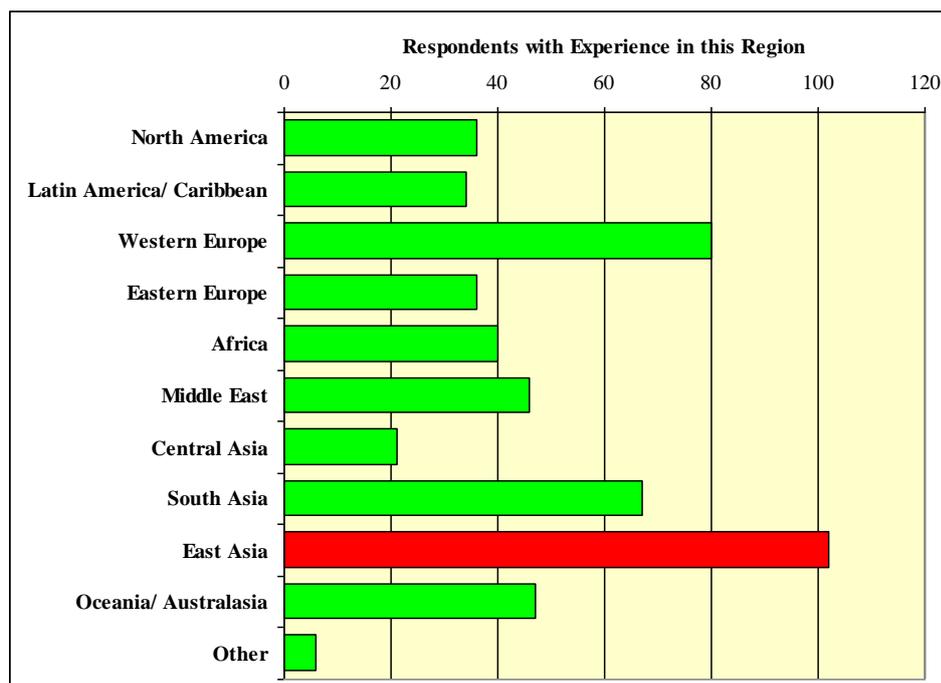


Table A3.3: Rankings of Macro-Level Risks by Respondent Category

	All	Financial, Legal, Operators	Transport Planner, Economist	Engineer, Architect	Government, Aid Agency	Academic	Other
Political System	1	1	1	1	1	1	1
Legal System	2	2	2	2	2	2	3
Economic Growth	3	5	3	6	3	5	2
Corruption	4	3	5	3	4	4	4
Repatriating Profits	5	4	4	5	5	3	6
Currency Risks	6	6	7	4	8	7	5
Price Inflation	7	8	7	8	5	9	6
Interest Rates	8	6	6	7	7	6	9
Business Cycles	9	9	9	9	11	10	8
Toll Familiarity	10	10	10	10	9	8	10
Income (ln)Equality	11	11	11	11	10	11	11

Table A3.4: Rankings of Project-Level Risks by Respondent Category

	All	Financial, Legal, Operators	Transport Planner, Economist	Engineer, Architect	Government, Aid Agency	Academic	Other
Legal/ contractual foundations	1	2	1	1	3	5	5
Construction cost	2	3	4	2	2	2	2
Competing routes	3	3	2	2	8	1	8
Toll increase enforceability	4	1	3	5	4	3	8
Social/ economic benefits	5	14	7	4	1	10	5
Construction time	6	7	5	7	6	4	1
Concession length	7	11	6	11	5	5	4
Operating & maintenance costs	8	12	11	9	7	13	3
Toll affordability (large vehicles)	9	7	9	12	12	12	11
Connecting routes	10	7	8	14	9	5	13
Toll affordability (other vehicles)	11	5	10	10	13	8	14
Guanxi	12	13	13	8	10	9	10
Minimum income guarantees	13	6	12	12	11	14	7
Toll leakage	14	10	14	6	14	11	12
Ramp up	15	15	15	15	15	15	15

Figure A3.2: Attitudes to Transport Model Types

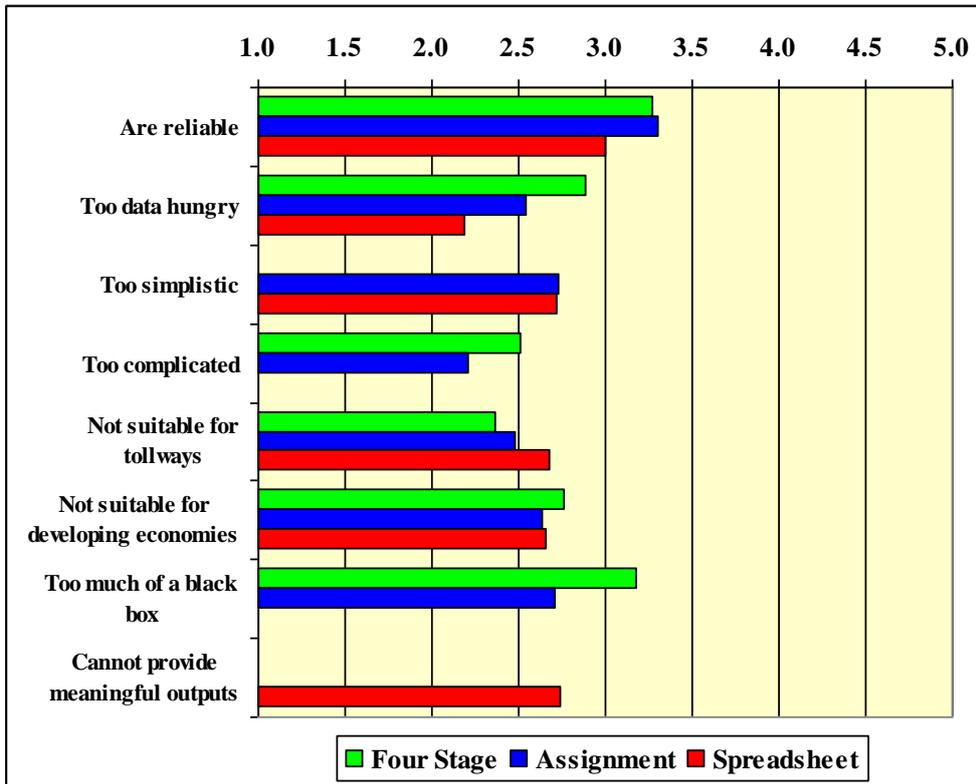


Figure A3.3: Perceptions of Forecast Performance

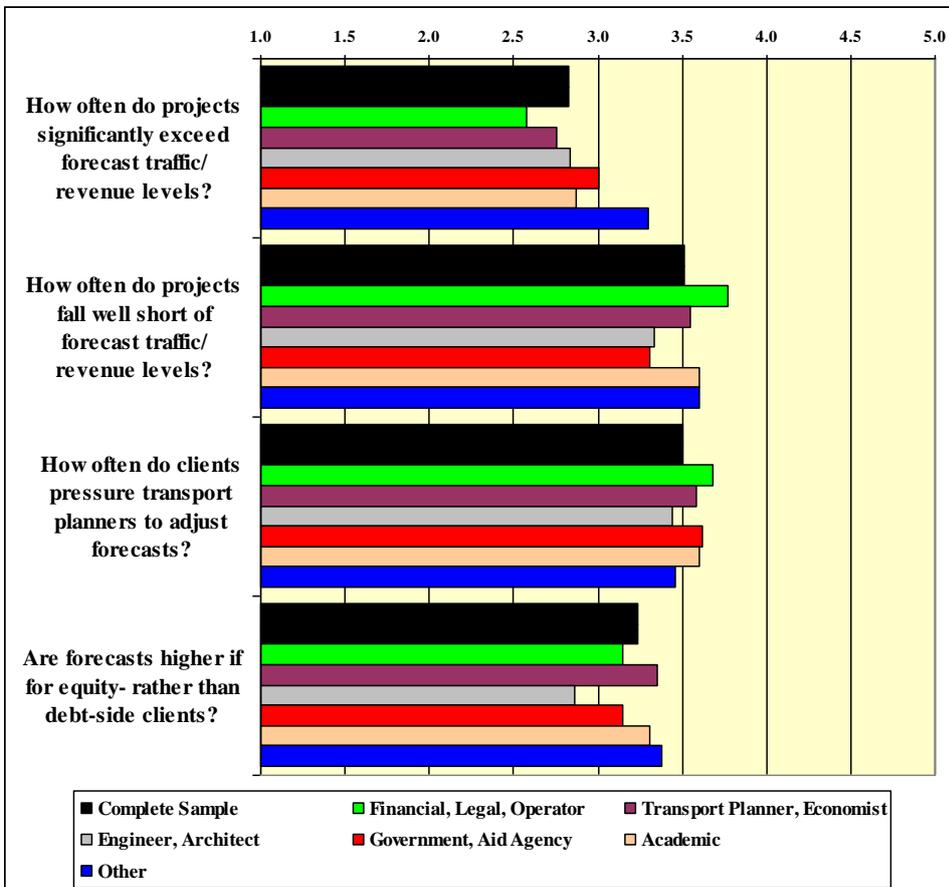


Figure A3.4: Perceived Tollway Opportunities by Country

(mean value and standard deviation)

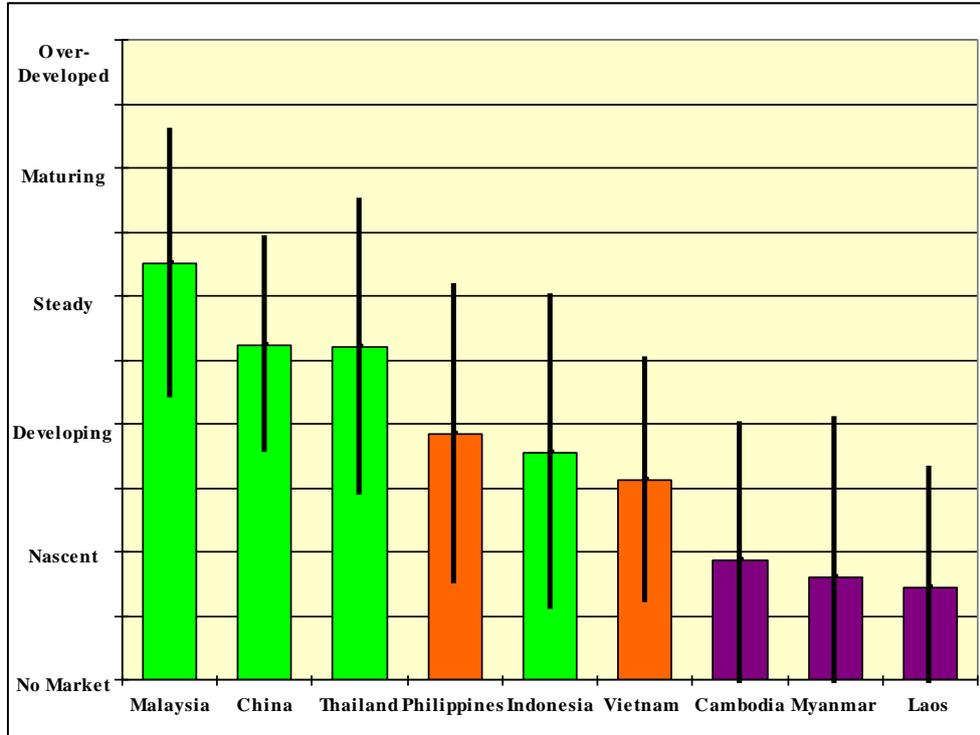
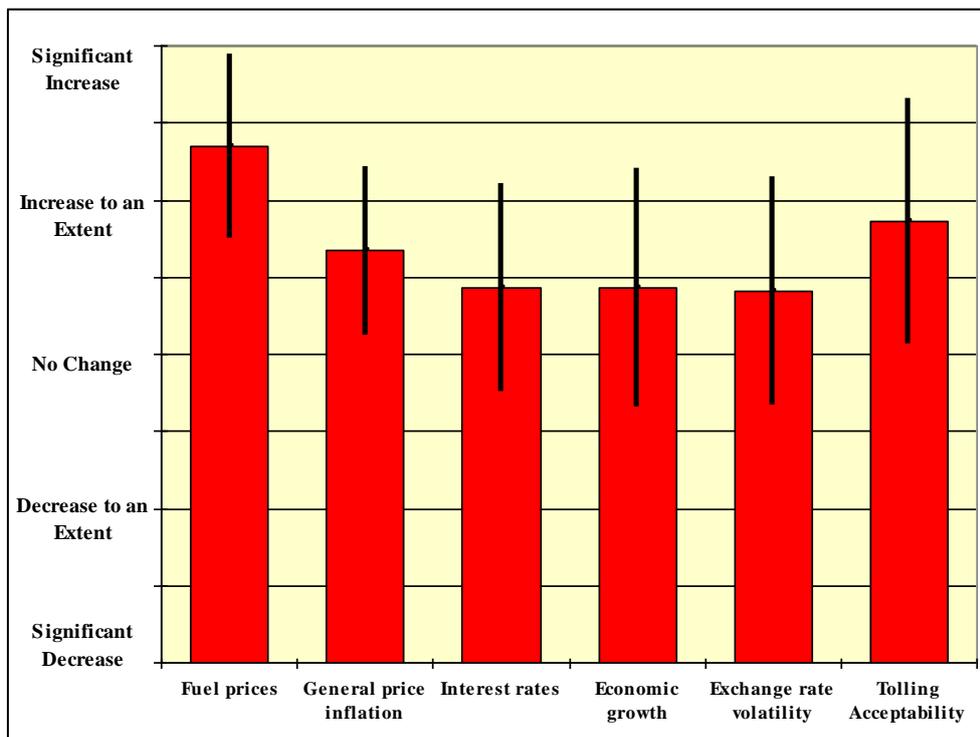


Figure A3.5: Economic Expectations

(mean value and standard deviation)



Appendix 4 - Definition of Simulation Model Parameters

Figure A4.1: Network Topology

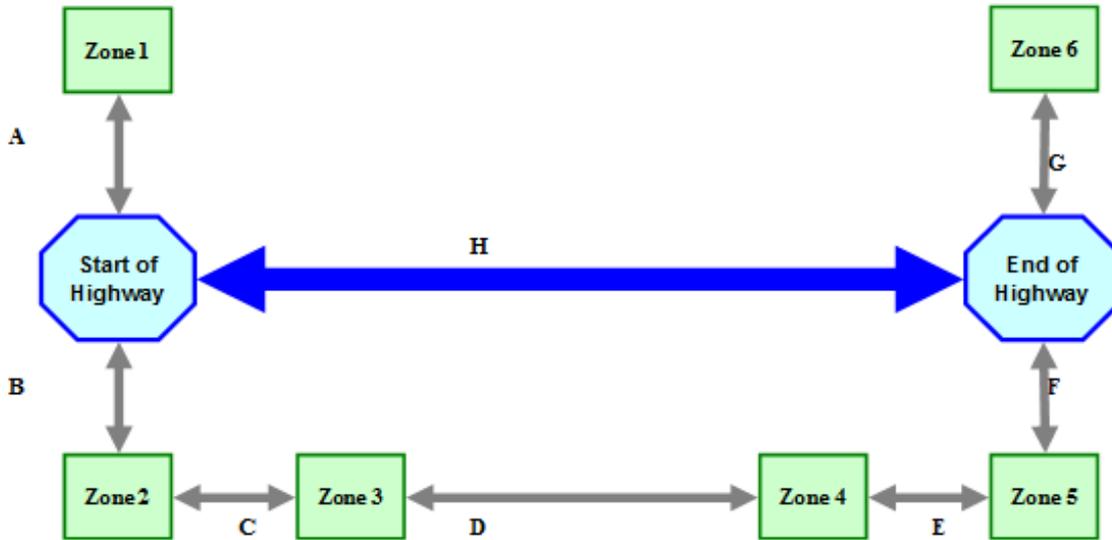


Table A4.1: Link Characteristics

Road Section ("Link")	Length (km)	Road Standard	Lanes per Direction	Freeflow Speed (kph)	
				Small Vehicles	Large Vehicles
A	10	Local Road	3	70	60
B	3	Local Road	4	70	60
C	15	Local Road	3	70	60
D	25	Local Road	3	70	60
E	10	Local Road	2	70	60
F	2	Local Road	4	70	60
G	10	Local Road	3	70	60
H	40	Tollway	2	120	100

Table A4.2: Trip Distribution

		To Zone						Total
		1	2	3	4	5	6	
From Zone	1		3%	2%	4%	4%	5%	18%
	2	3%		5%	3%	3%	3%	17%
	3	2%	5%		5%	3%	3%	18%
	4	4%	3%	5%		3%	2%	17%
	5	4%	3%	3%	3%		2%	15%
	6	5%	3%	3%	2%	2%		15%
	Total	18%	17%	18%	17%	15%	15%	100%

Figure A4.1: Speed-Flow Curves by Link Type and Vehicle Type

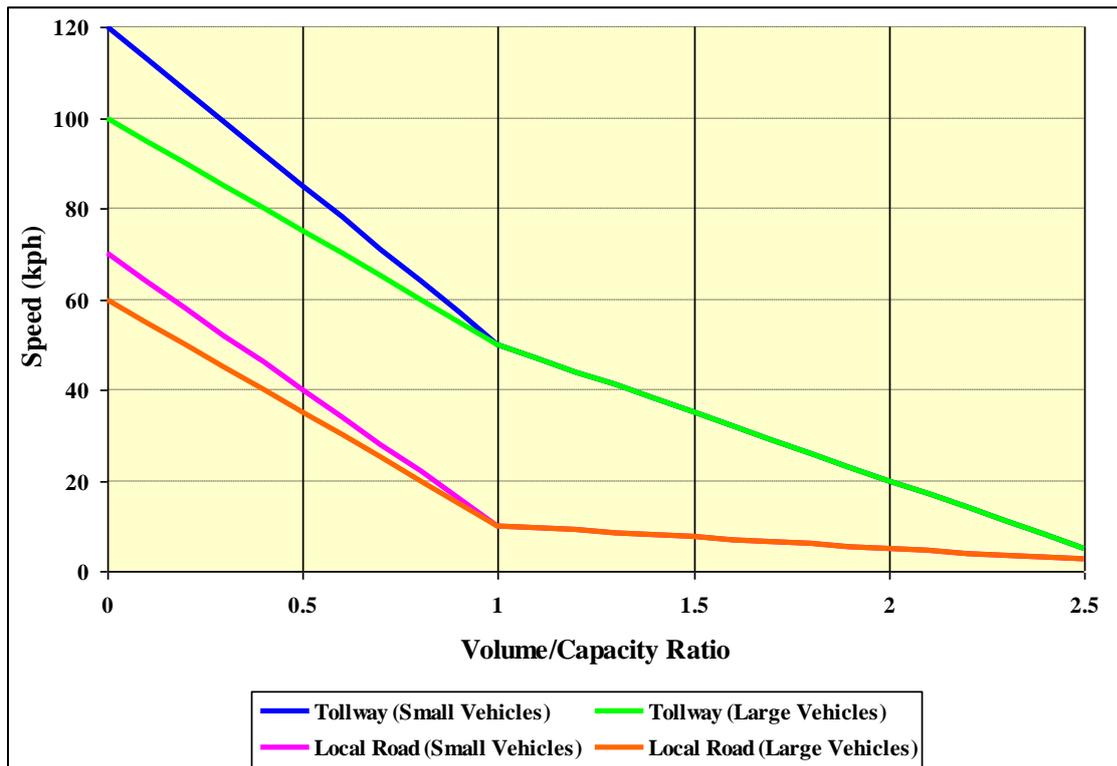


Table A4.3: Parameter Value Distributions by Economic Scenario (1 of 4)

Case	Variable	Modal Value	Chance of Smaller Value	Standard Deviation (Low Values)	Minimum Value	Standard Deviation (High Values)	Maximum Value	Source/ Justification
Conventional Respondents' Kondratieff	Expressway Capacity/ Lane (pcu's per day)	20,000	50%	2,000	20,000	2,000	28,000	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Local Road Capacity/ Lane (pcu's per day)	10,000	50%	1,000	8,000	1,000	12,000	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Construction Cost (\$)*	\$185.32m	25%	5%	90%	15%	30%	\$4,633,000 per km * 40 km; cost overrun more likely than underrun
Conventional Respondents' Kondratieff	Construction Duration (in Quarters)	10	20%	1	8	2	14	time overrun more likely than underrun specified in whole quarters (i.e. integers)
Conventional Respondents' Kondratieff	Operations & Maintenance Fixed Costs (% of Construction Cost)	2%	50%	0.50%	0.10%	1%	4%	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Operations & Maintenance Variable Costs (% of Revenues)	3%	50%	1%	1%	1%	5%	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Base Value of Time for Small Vehicles (\$/hour)	\$4	50%	\$1	\$2	\$1	\$6	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Base Value of Time for Large Vehicles (\$/hour)	\$3	50%	\$1	\$1	\$1	\$5	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Income Elasticity of Value of Time (Small Vehicles)	0.5	50%	0.15	0.2	0.15	0.8	
Conventional Respondents' Kondratieff	Income Elasticity of Value of Time (Large Vehicles)	0.5	50%	0.15	0.2	0.15	0.8	

Table A4.3: Parameter Value Distributions by Economic Scenario (2 of 4)

Case	Variable	Modal Value	Chance of Smaller Value	Standard Deviation (Low Values)	Minimum Value	Standard Deviation (High Values)	Maximum Value	Source/ Justification
Conventional Respondents' Kondratieff	Base Small Vehicle Operating Costs on Expressways (\$/km)	\$0.06	50%	\$0.015	\$0.03	\$0.015	\$0.09	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Base Large Vehicle Operating Costs on Expressways (\$/km)	\$0.10	50%	\$0.025	\$0.05	\$0.025	\$0.15	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Small Vehicle Local Road Operating Cost (relative to expressway)	1.5	50%	0.25	1.0	0.15	2.0	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Large Vehicle Local Road Operating Cost (relative to expressway)	2.0	50%	0.25	1.5	0.25	2.5	From other studies (corroborated by other transport planners)
Conventional Respondents' Kondratieff	Factor for Base Small Vehicle Demand Matrix	100%	50%	15%	70%	15%	130%	arbitrary to reflect possible error range in initial surveys on a "real world" project
Conventional Respondents' Kondratieff	Factor for Base Large Vehicle Demand Matrix	100%	50%	15%	70%	15%	130%	arbitrary to reflect possible error range in initial surveys on a "real world" project
Conventional Respondents' Kondratieff	Income Elasticity of Small Vehicle Traffic	1.25	50%	0.20	0.85	0.20	1.65	
Conventional Respondents' Kondratieff	Income Elasticity of Large Vehicle Traffic	1.10	50%	0.20	0.70	0.20	1.50	(smaller value to allow for larger trucks and coaches and increased efficiency)
Conventional Respondents' Kondratieff	Toll Revenue Leakage (%)	10%	50%	2.50%	5%	5%	20%	From other studies (corroborated by other transport planners)

Table A4.3: Parameter Value Distributions by Economic Scenario (3 of 4)

Case	Variable	Modal Value	Chance of Smaller Value	Standard Deviation (Low Values)	Minimum Value	Standard Deviation (High Values)	Maximum Value	Source/ Justification
Conventional Respondents' Kondratieff	Initial Amplitude of Ramp-Up (% traffic decrease)	40%	50%	10%	20%	20%	80%	
Conventional Respondents' Kondratieff	Ramp-Up Duration (in Quarters)	8	40%	2	4	5	20	
Conventional Respondents' Kondratieff	Small Vehicles' Tolling Penalty (minutes)	10	50%	5	0	5	20	corroborated by other transport planners)
Conventional Respondents' Kondratieff	Large Vehicles' Tolling Penalty (minutes)	15	50%	5	5	5	25	corroborated by other transport planners)
Conventional Respondents' Kondratieff	Small Vehicle Routing Sensitivity "Lambda" for Logit-Sub-Model	0.05	50%	0.0125	0.25	0.0125	0.75	arbitrary value
Conventional Respondents' Kondratieff	Large Vehicle Routing Sensitivity "Lambda" for Logit-Sub-Model	0.05	50%	0.0125	0.25	0.0125	0.75	arbitrary value
Conventional Respondents' Kondratieff	Toll Escalation Rate (% of Retail Price Index Inflation)	90%	50%	15%	60%	5%	100%	
Conventional Respondents' Kondratieff	Quarters Between Toll Increases	12	40%	2	8	4	20	

Table A4.3: Parameter Value Distributions by Economic Scenario (4 of 4)

Case	Variable	Modal Value	Chance of Smaller Value	Standard Deviation (Low Values)	Minimum Value	Standard Deviation (High Values)	Maximum Value	Source/ Justification
Conventional Respondents' Kondratieff	GDP Growth (% p.a.)	6%	50%	2%	2%	2%	10%	base for other cases also
Conventional Respondents' Kondratieff		+1%	50%	0.5%	+0%	0.5%	+2%	in addition to Conventional value
Conventional Respondents' Kondratieff		+1%	50%	0.5%	+0%	0.5%	+2.5%	in addition to Respondents value
Conventional Respondents' Kondratieff	Vehicle Operating Cost Price Inflation (% p.a.)	2.5%	50%	1%	0.5%	1%	4.5%	base for other cases also
Conventional Respondents' Kondratieff		+2.5%	50%	1.5%	+0%	1.5%	+5.5%	in addition to Conventional value
Conventional Respondents' Kondratieff		+0%	n/a	n/a	n/a	n/a	n/a	same as Respondents value
Conventional Respondents' Kondratieff	Construction, Operations & Maintenance Cost Inflation (% p.a.)	2.5%	50%	1%	0.5%	1%	4.5%	base for other cases also
Conventional Respondents' Kondratieff		+0.75%	50%	0.25%	+0.25%	0.25%	+1.25%	in addition to Conventional value
Conventional Respondents' Kondratieff		+1.0%	50%	0.50%	+0%	0.50%	+2.5%	in addition to Respondents value
Conventional Respondents' Kondratieff	General Price Inflation (% p.a.)	2.5%	50%	1%	0.5%	1%	4.5%	base for other cases also
Conventional Respondents' Kondratieff		+0.75%	50%	0.25%	+0.25%	0.25%	+1.25%	in addition to Conventional value
Conventional Respondents' Kondratieff		+1.0%	50%	0.50%	+0%	0.50%	+2.5%	in addition to Respondents value
Conventional Respondents' Kondratieff	Interest Rates for Initial Debt (% p.a.) based on construction costs	5%	50%	1%	3%	1%	7%	base for other cases also
Conventional Respondents' Kondratieff		+1%	50%	0.50%	+0%	0.50%	+2%	in addition to Conventional value
Conventional Respondents' Kondratieff		+2%	50%	1%	+0%	1%	+4%	in addition to Respondents value
Conventional Respondents' Kondratieff	Interest Rates for Extra Debt (% p.a.) for subsequent cash shortfalls	+2%	50%	1%	+0%	1%	+4%	in addition to initial debt rate
Conventional Respondents' Kondratieff		+2%	50%	1%	+0%	1%	+4%	in addition to initial debt rate
Conventional Respondents' Kondratieff		+2%	50%	1%	+0%	1%	+4%	in addition to initial debt rate

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