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Traffic risk in the Australian toll road sector

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TRAFFIC RISK IN THE AUSTRALIAN TOLL ROAD SECTOR

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ABSTRACT

The article seeks to provide an answer to question about the role of the state in infrastructure planning and delivery and why have Australian state governments been keen to embrace the PPP model of procurement for roads, bridges and tunnels. A contemporary issue is the accuracy of the traffic forecasts on toll roads procured by governments with the PPP model. The "traffic forecasters" in Australia are identified and the broad order of magnitude are the accuracies of their forecasts on projected traffic for toll facilities compared with the actual opening traffic are analysed. Performance is poor (on average, traffic is over-estimated by 100 per cent) when benchmarked against international experience in road traffic forecasting. Explanations for this poor forecasting performance are offered. Finally, the conclusions synthesise the main messages about toll road traffic risks.

INTRODUCTION

A public private partnership (PPP) for economic or social infrastructure describes a government service or private business venture which is funded through a partnership of one or more private sector companies. It is a flexible arrangement and its structure will vary according to the type of service (such as a toll road) and, importantly, the allocation of risk amongst participants. The range of options for public and private sector involvement in infrastructure is widespread and it is not surprising that recourse is made to some form of economic analysis for their evaluation. The methodology involved had its origin in the well-known accountancy-based investment analysis with the inclusion of the monetary value of time. With origins in the work of Dupuis in 1844, the methodology was frequently applied to persuade investors during the 19th century railway-building booms. In the commercial context, benefit/cost ratios, present worth, and rates of return are meaningful because the benefits are measured in real dollars and cents and are commensurate with the investment dollar. Furthermore, the discount rate could be directly equated to the market rate of interest.

However, when these financial investment tools are adapted for use in public (and mixed public/private) enterprises many difficulties arise. Whilst economic indices thus derived have value for comparing alternative infrastructure projects, or project series that would permit a "best" utilisation of an arbitrarily given budget, they have little value in measuring the inherent economic merit of a particular infrastructure project. Such limitations of cost-benefit analysis will be debated in the context of the recent high-speed rail study in Australia. Accompanying the release of the second-stage report on the East Coast High Speed Rail (AECOM et al, 2013) came the additional, inevitable criticism of the patronage forecasts that underpin the user benefits that might offset the estimate A$114 billion dollars for an operational railway line connecting Melbourne, Canberra, Sydney and Brisbane (Swan, 2013). These concerns over the underestimation of the costs (Cantarelli, et al 2012) and the overestimation of the benefits of major infrastructure projects are known in the international literature as "optimism bias" (Flyvbjerg et al, 2005) and "strategic misrepresentation" (Flyvbjerg, 2006).

Substantial errors in toll road traffic forecasting in Australia is a contemporary issue given the private-sector involvement in financing and operating this asset class (Victorian Auditor, General 2011). Media headlines include: "Toll Road Forecasters' Flights of Fancy" (Pascoe, 2013); "Traffic Forecaster Sued for $700 Million – Landmark Case" (*The Sydney Morning Herald*, 14 April, 2011); and "Paved with (Fool's) Gold" (Saulwick 2013, p.2). The scope of this article is deliberately restricted to toll roads in Australia, and the risk associated with the traffic demand forecasts from the perspective of governments, the private sector and the community (road users). Traditionally, governments in Australia have provided road infrastructure and errors in traffic forecasting were largely unreported because the main

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impact on the road authority was getting building priorities in the wrong order. With public-sector private-sector partnerships in the road sector a wider range of stakeholders are exposed to the inaccuracies of the forecasting methodologies.

The article seeks to provide evidence of the following questions:

What is the role of the state in infrastructure planning and delivery and why have Australian state governments been keen to embrace the PPP model of procurement for roads, bridges and tunnels?

- In the management of risk what should the role of governments be in proper project planning?
- Who are the "traffic forecasters" in Australia and what broad order of magnitude are the accuracies of their forecasts on projected traffic on toll facilities compared with the actual opening traffic?
- How does this benchmark against international experience in road traffic forecasting and what might explain poor forecasting performance?

Finally, the conclusions synthesise the main messages about toll road traffic risks.

ROLE OF GOVERNMENTS

The question as to who builds and maintains public infrastructure can be answered only by examining the role of the state, and this has changed over time, and inevitably the role will transform in the future. For instance, in the seventeenth century, the word "turnpike" was applied in Britain to the pivoted or hinged bar or pole used to close a road until a toll had been paid, and later gave its name to a system of road financing by means of tolls. The history of turnpikes in New South Wales can be found in *Main Roads* (June 1951 pp 107-111). The first turnpike in New South Wales was the floating pontoon bridge over South Creek on the road between Hawkesbury and Parramatta in 1802. It also appears to be the first example of a "public sector - private sector" partnership in New South Wales (Black and Blunden, 1988, p 777) in that the deal involved the colonial government providing £15 and six man-months of labour, and Andrew Thompson, an early settler and constable, constructing the bridge and collecting the tolls for fourteen years. (In 1813, a log bridge was erected, which, in turn, was replaced in 1830, 1848 and 1880, with tolls being collected on all these bridges until 1887.)

In vast agricultural countries such as the USA and Australia, governments established main road authorities in the 1920s primarily to get the farmers out of the mud. Although the private-sector involvement with roads, bridges and tunnels is obviously not a recent phenomenon in many countries of the world (Lay, 1992, pp 99-120), it is a little-known fact that, in Australia, the New South Wales Government experience in assessing private-sector involvement in the financing, construction, and operation of toll roads extends for over 50 years. In 1924, the Main Roads Board (later the NSW Department of Main Roads and now the NSW Roads and Maritime Services) was established with its main task to construct a coastal road (now the Pacific Highway) between Sydney and Newcastle. However, the geometric design standards of the day – with a two-lane undivided highway that had 200 curves of tight radius in the difficult sandstone terrain between Cowan and Gosford alone (Dobinson, 1964) – were inadequate in the 1950s with rapidly increasing motorisation.

A challenge to the state in providing road infrastructure first came in 1960. The NSW Department of Main Roads (Department of Main Roads, New South Wales 1960) invited offers (closing 30 September, 1960) from those interested in financing, constructing and operating a toll road of expressway standards between the metropolitan areas of Sydney and Newcastle. The Government received four proposals – two from CAS (Turnpikes) Ltd – a consortium of British and Australian interests – and two from Project Development Corporation – a Sydney-based construction company. In 1962, the Premier of New South Wales announced the government had resolved not to accept either company's proposals (Brewer and Black 1992 p 5) thereby stamping the authority of state in road-building matters: the NSW Government constructed the Sydney-Newcastle Toll Road along a different, yet somewhat parallel, route.

The monopoly by governments in Australia in the road sector of the economy was finally broken in the 1980 and the 1990s, first by state government political manoeuvring against Commonwealth government policy, then by micro economic reform and competition policy. The first private-sector involvement in Australia came with the Gateway Bridge in Brisbane, the Logan and Sunshine Toll Roads in Queensland and the Sydney Harbour Tunnel in Sydney, New South Wales. The latter was an unsolicited proposal in 1986 from Transfield/Kumagai Gumi to build the Sydney Harbour Tunnel (using immersed tube technology applied in the Second Harbour Crossing in Hong Kong as the intellectual property argument to explain why the government did not tender for a harbour crossing) as a BOOT scheme (Build Own Operate Transfer). It was described as public sector-private sector partnership (PPP) but the New South Wales Auditor General had a differing view in that it was a means of the NSW Government circumventing Australian Loan Council restrictions on state borrowing for capital works (the "global limits approach" introduced in 1985 to enhance the Federal Government's control over the Loan Council – see, Russell and Grewal, 1997, pp 595-596).

In those formative years of private-sector participation in infrastructure in Australia, there was one additional influence that encouraged private-sector participation in infrastructure: micro economic reform, and the introduction of a National Competition Policy. All levels of government in Australia had expressed a commitment to the implementation of competitive neutrality principles (*Competition Principles Agreement, 1995*). In June, 1996, the Federal Government released its Competitive Neutrality Policy Statement. Competitive neutrality requires that government business activities do not have a net competitive advantage over their private-sector competitors merely as a result of their public ownership. Competitive neutrality is related to, and plays a role in, the Federal Department of Finance and Administration, *The Performance Improvement Cycle and Competitive Tendering and Contracting* (http:// www.treasury.gov.au). In today's competitive environment, it is the public sector comparator for infrastructure projects, and value for money, that are key procedural requirements that determine whether governments will procure infrastructure through a PPP model.

Governments in Australia responded by publishing guidelines for the private sector's involvement with infrastructure. The objectives and principles of the New South Wales Government's policy on BOT arrangements was provided in the *Public Authorities (Financial Arrangement) Act, 1987*, which gave the NSW Treasurer the responsibility to approve government agencies the authority to enter into joint financing arrangements with the private sector. This was met with considerable enthusiasm by the private sector, including to provide and operate toll facilities in the road network (Australian Federation of Construction Contractors, (1993, p 22). The New South Wales Public Accounts Committee recommendation of 1993 was that the Treasurer should develop clear guidelines that outlined various forms of acceptable co-operation with the private sector, and the broad risks that government would consider acceptable to assume.

All state governments and Infrastructure Australia have developed such guidelines (Australian Trade Commission, 2011, p 36 for the website addresses). In New South Wales, guidelines have been in existence since 1989 and updated guidelines were issued in December 2006. *Partnerships Victoria* is about creating long-term service contracts between the Government and private businesses to deliver public infrastructure and related services. The Partnerships Victoria approach achieves value for money by stimulating innovation through competitive bidding, by appropriate transfer of risk and by facilitating whole of life cost considerations. The policy focuses on whole-of-life costing and full consideration of project risks and optimal risk allocation between the public and private sectors. There is a clear approach to value for money assessment and the public interest is protected by a formal public interest test and the retention of "core" public services. The Partnerships Victoria website assists project proponents, investors, bidders, citizens and government departments and agencies by providing guidance materials, information on projects and details of contacts in departments. Queensland's PPP Policy reflects the growing international evidence that PPPs can represent a viable alternative for efficiently and effectively delivering quality infrastructure solutions to support the community. *Western Australia Partnerships for Growth*, Western Australia has for some time now actively engaged the private sector in the provision of economic infrastructure and ancillary services. However, this engagement occurred for the most part in the absence of a formal policy position until December 2012 when 'Partnerships for Growth' was released as the Policies and Guidelines for Public Private Partnerships in Western Australia.

GOVERNMENTS AND PROPER PROJECT PLANNING

Who builds, operates and maintains transport infrastructure is a matter of political philosophy. Given the prevailing policy position in Australia today the important principle is that of risk and risk allocation, where the respective parties bear the risk that they can best manage (OECD, 1987). A clear responsibility of governments is in the area of strategic land use and transport planning (Black, 1994). Associated with this is that governments must invest in high quality spatial information on land use and socioeconomic factors and allocate resources to developing credible forecasting tools. Whilst *Census of Population and Housing* is invaluable data, travel and traffic surveys are needed to build the necessary tools such as the strategic travel models used in the larger cities (Department of Infrastructure and Transport, 2011).

When undertaking strategic planning the government establishes the business case for any transport infrastructure concept. The government's primary roles are, in a preliminary way, to establish: first, the conceptual validity of the proposal in the context of alternative options and government policies; and, secondly, to estimate its economic worth to society. In simple outline, this assessment considers what it will cost to build and maintain the infrastructure over its defined lifetime and what are the user benefits to the traffic that will use the proposed means of transport. Cost benefit analysis is a guide for decision makers as to whether the proposal meets various investment criteria such as Cost Benefit Return (CBR), Net Present Value (NPV) and Internal Rate of Return (IRR) (Jones, 1977). Later work will firm up the project design and undertake more detailed analyses of economic, social and environmental impacts consistent with government guidelines on ecologically sustainable development (ESD). Following the business case, the government formulates the procurement strategy that will determine whether the project will be procured through a PPP model.

Continuous improvements can be expected in government strategic planning. For example, in the UK, despite the creation of the Major Projects Authority (MPA) within the Cabinet Office, and an enhanced remit for Infrastructure UK (within HM Treasury) in 2010, there is still insufficient attention given prior to the initiation of projects to identifying options and risks; consistent failure to put in place project leaders with the right skills, experience and incentives; and inadequate scrutiny of the most complex and expensive projects at the centre of government (Lord Browne of Madingley, 2013, p 1). The process used in government for managing the set-up of new projects is called the 'starting gate process,' but much can be learnt from the private sector which identifies options for delivering a major project at the outset, prior to committing any spend, and creates strategies for managing risk. Recognising the complex mix of issues involved, initiation in the private sector is not treated as a single stage but an accumulation of stages relating to:

- the conception of the idea;
- development of options;
- the choice of the preferred option and its full design;
- the preparation of a financial case; and
- the proposition for project leadership, including incentives (Lord Browne of Madingley, 2013, p 6).

TRAFFIC FORECASTERS

In establishing the business case for toll roads governments require traffic forecasts to establish user benefits (economic evaluation) and revenue for different toll regimes (financial evaluation). If infrastructure is intended as a PPP project, bidding consortia will conduct their own traffic studies. Who are these traffic forecasters that appear in the contemporary issues surrounding the accuracy of toll road traffic forecasts and what are the methods (mathematical models generally referred to as the 4-step model) that they apply?

The application of models by analogy from the physical sciences to traffic forecasting can be traced back to the work of the German railway engineers of the 19th Century (Black and Salter, 1975) and were applied by Danish urban traffic planners in the immediate post Second World War period. The models used today have their developmental antecedents in the urban land use and transport studies of the mid 1950s conducted in the USA, most famously the Chicago Area Transportation Study. Consulting engineers refined the models for widespread application in the United States and exported the technology to other countries, including Australia, where De Leuw Cather undertook the Canberra Area Transportation Study for the National Capital Development Commission in 1961 (Black, 1981, Chapter 6). By the mid-1970s all Australia capital cities and larger towns had completed these studies, some by US consultants; others by the emerging Australian engineering consulting industry (Black, 1975). The important point to note that the application of such models was to determine the relative merits of *alternative* land use and transport plans based on the same set of input assumptions and to recommend to governments the preferred course of action.

The propagation of errors in the 4 step modelling sequence and the sources of uncertainty in this planning process, and how best to manage the reality associated with the inaccuracies of the model was recognised a long time ago (Black and Kuranami, 1980), although, surprisingly, the first Australian government report on the limitations in the use of models is quite recent (Department of Infrastructure and Transport, 2011). Furthermore, vast sums of money have been spent, especially in the USA, on research and development into improved traffic modeling reported each year at the Transportation Research Board Conference in Washington, DC and today there are computer based platforms for the models used throughout the world. The consulting industry has a global reach with the dominance of large companies who can assemble teams with considerable experience and work with local partners. With such a pedigree it is surprising that there has been so much controversy surrounding the inaccuracies of traffic forecasting on toll roads in Australia.

TRAFFIC RISK

The accuracy of traffic forecasts is of considerable interest to practitioners in the toll road sector, and one of the greatest risks to investors. The Cross City Tunnel in Sydney (see, Phibbs, 2008?) did great damage to the toll industry. Because the toll was relatively high per kilometer when the tunnel opened in June, 2005, the actual traffic was one third of that forecast. Soon, the Tunnel Company made a decision to provide 5 weeks toll free ($4.5 million lost in revenue). When the toll ($3.60) was re-introduced on 1st December there was an immediate 44% drop in traffic (from 22, 136 to 12, 406 midnight to midday on 30 November and 1 December).

Traffic forecasting has become a major issue in Australia as noted by Ferguson (2009):

> *"Some of the less successful public-private partnerships over the past few years include RiverCity Motorways, which is building Brisbane's North-South bypass tunnel and is trading at an 85 per cent discount to its $1 issue price. Others include Lane Cove Tunnel tollway, which missed traffic forecasts and forced its backers to write off the value of the asset in their books. Sydney's Cross City Tunnel was another disaster and ConnectEast Group, the owner of Melbourne's EastLink toll road, has failed to meet traffic forecasts and recently went to investors to raise money to help cover its debts. But none has caused as much of a fracas as BrisConnections. It was a white elephant from the get-go. Established to build and operate a 6.7km toll road between inner Brisbane and the airport, it raised $1.2 billion by offering units priced at $1 upfront, with two further instalments of $1 each payable over the next 18 months. Within months, the first instalment tanked to 0.001c a share."*

The performance of traffic models to predict the opening volume of traffic on Australian toll roads can be assessed from the data in Table 1. Of the eight tolled roads and tunnels in this sample of Australian toll facilities all recorded traffic flows were substantially less

TABLE 1.

Comparison of Daily Traffic Forecasts and Actual Traffic on Australian Toll Roads and Tunnels

TOLL FACILITY	OPENING VOLUME (DAILY FORECAST)	OPENING VOLUME (DAILY ACTUAL)	RATIO ACTUAL / FORECAST
M2, Sydney	72,000	40,000	0.56
M7, Sydney Orbital	196,500	94,808	0.48
Cross City Tunnel, Sydney	85,000	27,000	0.32
Lane Cove Tunnel, Sydney	104,786*	44,420	0.42
East Link, Melbourne	259,000	149,000	0.58
Eastern Distributor, Sydney	33,000	27,000	0.82
Brisbane Airport Tunnel Link	135, 000	47,000	0.35
Clem7 Riverside Motorway, Brisbane	60, 000	26,711**	0.45
	945 286	455 939	0.48

- * - EIS Forecast (2006) compared to ADT main tunnel for first 10 months of opening
- ** December 2012 after tunnel opened in 2010 and tolls were introduced

(Sources: calculated from data in:
http://www.smh.com.au/articles/2006/03/01/1141191732148.html?from=rss;
http://www.smh.com.au/articles/2006/03/01/1141191732148.html?from=rss;
http://www.theaustralian.news.com.au/business/story/0,,24704301-23634,00.html;
http://www.smh.com.au/articles/2006/03/01/1141191732148.html?from=rss;
Pasco, 2013)

than forecast flows on opening of the facility. The mean ratio of actual to forecast traffic is 0.48. For these toll roads and tunnels, almost one million motorists per day were forecast, but the actual traffic counted was about 456, 000 vehicles per day.

Obviously, traffic performance needs to be tracked over a longer period. Ramp-up is the initial period following the opening of any toll road where drivers adjust their travel patterns and habits to take account of the new road. Experience in Australia is that this period is about 15 months from opening the facility. Initially, traffic is expected to be 72 percent of "steady state" traffic estimates, according to industry experts. As the usage of the road filters into people's driving patterns and as marketing of the toll road ramps up, there tends to be a rapid increase in usage initially, tapering to a steady state growth rate. The rolling 12-month mean daily traffic on Australian toll roads from 2006 to 2011 illustrates this growth in traffic (http://chartingtransport.files.wordpress.com/2010/04/aus-toll-road-traffic-growth-4.png. Accessed 17 April 2013).

It is interesting to note that the traffic performance of the Sydney Harbour Tunnel, Sydney's first tolled facility that opened in 1992 has tracked along the "most likely" forecast scenario prepared by the consultants to the consortium based on an extrapolation of historical daily traffic trends modified by an upper bound (the traffic carrying capacity of the bridge and tunnel traffic lanes combined). Proprietary data on actual traffic and traffic forecasts were analysed by Arioka and Black (2006), and, 18 years after opening, the actual daily traffic on the bridge and tunnel combined was 250,000 in 2010 (with approximately 90,000 vehicles using the tunnel), only marginally below the "most likely" traffic scenario. The New South Wales Government accepted all of the traffic risk with the guaranteed revenue stream passed by legislation, whereby the government would compensate the Sydney Harbor Tunnel Company for any revenue shortfall below the "most likely" traffic forecast. The Sydney Harbor Tunnel was arranged as a BOT (Build Operate and Transfer) scheme (Neilson, 1992). When there was no way to reduce the gap of 5 cents for the toll, the negotiation with government was deadlocked (Perry and Dobinson, 1988; Dobinson, 1992). The counter measure that resolved this issue was a CPI bond where the interest rate is linked to consumer price index in conjunction with the toll revenue that is also linked to the Consumer Price Index (CPI).

Apart from the apparent success of the Sydney Harbor Tunnel how does the poor traffic forecasting performance in Australia compare with international best practice. Given the enormous amount of research and development money invested over the decades in traffic model theory and traffic forecasting software it somewhat surprising there is very little cross sectional data in the public realm that would permit a comparison of toll road traffic forecasts with out turn figures (Bain, 2009). The published studies appear to be limited to Morgan (1997), Bain (2009), research by Standard and Poor's (Bain and Wilkins, 2002; Bain and Plantagie, 2003 2004; and Bain and Polakovic 2005), research by Flyvbjerg *et al,* 2005, by Premius *et al,* 2008 and by Cantarelli *et al,* 2012).

In Bain's study of 104 privately funded toll roads, bridges and tunnels throughout the world, traffic forecasting performance as measured by the actual traffic for a specific year divided by the forecast traffic (at financial closure) ranged from 0.14 to 1.51 with a mean of 0.77 and a standard deviation of 0.26. Actual traffic was found to be within a considerable range - between 86% below forecast to 51% above forecast and the mean traffic was 23% below the mean forecast (Bain, 2009, p 472). Similar results were obtained when stratifying traffic into light vehicles (predominately private motor vehicles) and trucks.

Flyvbjerg *et al,* (2005) compared forecasts for international public (un-tolled) roads. Bain adjusted the Flyvbjerg distribution into ratios and noted it had two striking features (Bain, 2009, p 477): it resembled a

TABLE 2.

Performance of Four Different Traffic Models to Forecast Traffic on a Toll Road, 2005 Base Case

FORECAST PERIOD (FROM PROJECT OPENING) IN YEARS	DIFFERENCE BETWEEN THE HIGHEST AND THE LOWEST BASE-CASE FORECAST (%)
5	26
10	66
15	106
20	130
25	164
30	204
35	255

(Source: Bain, 2009, Table 3 p 480)

normal distribution, but with an extended right hand tail. The mean of the bell shaped portion of the distribution was located near 1.0. Forecasts for toll free roads do not display the strong systematic tendency towards optimistic forecasts and bias noted above. Forecasts for toll free roads appear to have a more equal chance of over and under prediction, as one might expect from a forecast. The long right hand tail of the distribution of values for individual public roads represents actual traffic that exceeded its respective forecasts by some margin (over twice). An even more disturbing finding for those investors who are skeptical about traffic forecasts is that often a number of traffic forecasts are made by different parties for the same project road, with very little consistency among the results (Table 2). Bain (2009, Fig 9, p 479) illustrates this with four base case forecasts for a well-known toll road for the period 2005 - 2040, made by international traffic consultants within months of each other.

AUSTRALIAN PERFORMANCE WITH TRAFFIC FORECASTS

In comparison to international experience, the record of toll road traffic forecasting in Australia is a poor one. From the above discussion, it is clear that the issue of traffic demand forecasting plays a major role in toll road planning and assessment procedures. We have already noted that urban toll roads and tunnels in Australia have been driven on optimistic financial modelling techniques while supported by the overestimation of traffic forecasts. Whilst many traffic models are complex it must be recognised that "they are still radical simplifications of real urban systems" (Bureau of Transport and Communication Economics, 1996, p. iii). Infrastructure Australia (2011, Table 2, p 18) presented a full range of factors affecting the accuracy of traffic forecasts, but concluded: "a question remains as to which of them will apply to the Australian context" (p 20). There is a widely held view about the relevance of "optimism bias" in Australia. Construction consortia have often led the private sector proposals and can instruct their consultants to inflate traffic projections because they can exit the market after completion of construction, having made their profit. As noted by West (2009):

> *"It has become increasingly clear that the traffic projections for most toll roads have been built around the financial model, not vice versa as it should be. And that financial model was structured in such a way as to "upfront" or bring forward the project cashflows so the bankers and all their hangers-on could pocket billions of dollars in fees before even a cent was earned in tolls."*

Sturgess (2006) points out that the responsibility for building politically sustainable markets for toll roads does not just rest with government:

> *"Those of us in the private sector who need to convince our investors and analysts that this industry has a long-term future need to be concerned about these problems as well."*

He warns that the private sector might walk away from procurements that are focused too heavily on price and aggressive risk transfer, and which are unlikely to be sustainable over time. Ernst and Young (2007 p 6) have suggested a model for the next generation of urban transport projects. Politically acceptable toll levels will result in public sector "subsidies" or "contributions", and that Australia should consider: availability payments; safety payments; congestion payments; and shadow tolls.

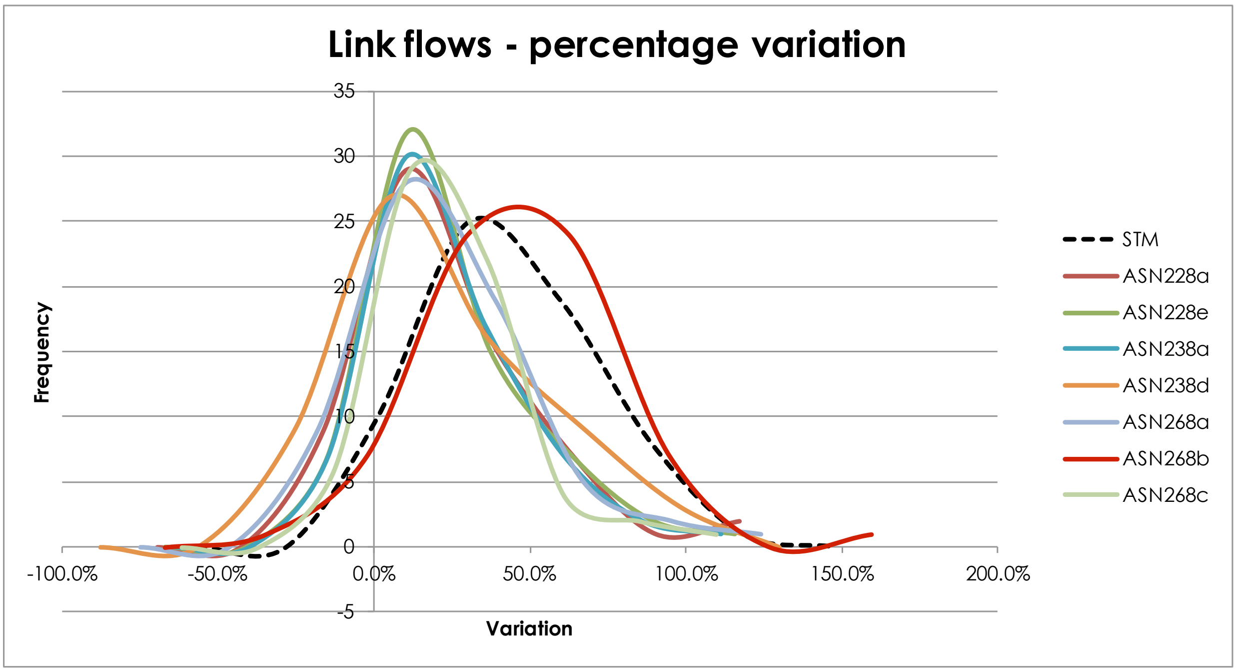
A GHD (2011) report to the Australian Government Department of Infrastructure and Transport investigated the causes of over optimistic patronage forecasts with the purpose of identifying potential remedies. Desktop research supported by interviews with stakeholders covering the spectrum of stakeholders in the road procurement process found:

- "PPP bidding processes for toll roads lead to selection of the most optimistic of optimistic forecasts:
- Government forecasts, erring on the high side to avoid under-estimating environmental impacts, may set a forecast 'floor';
- Traffic modellers in bid teams produce a 'low' forecast above this floor for debt lenders and a 'high' estimate of possible returns for those taking equity;
- Equity forecasts are submitted with bids and the highest forecast almost always wins." (GHD, 2011, p1).

There are various elements that could easy lead to miscalculation in the traffic forecast for toll roads. For example, short toll routes within an urban area are basically subject to a lower demand. The blog by the Intelligent Investor (www.intelligentinvestor.com.au) reports that:

FIGURE 1.

Variation of modelled results from counts from Sydney Strategic Model and from Models Developed by Norley (Source: Norley, personal communication. Figure 37 of draft thesis)



> *"Toll roads don't seem to work so well where the distances are short. Sydney's Cross City Tunnel (2.1km) and the Lane Cove Tunnel (3.6km) are built on the same time value of money models but both have been abject failures – traffic has been less than half of what was forecast and equity investors won't get a cent of their investment back. It looks like people don't value time after all. They value distance. Or perhaps they use distance as a proxy for time."*

On the other hand, the same report highlights that:

> *"Once you adjust for the inherent optimism required to win a bid, these models seem to work reasonably well for roads that cover long distances. Melbourne's CityLink (22km), Sydney's M2 (21km), M4 (40km) and M5 (32km) motorways and the Western Sydney Orbital (40km) have all been successful investments because the traffic projections have been close enough to accurate."*

Whilst the scope of this paper excludes detailed technical considerations of the various factors identified by Infrastructure Australia reference should be made briefly to research undertaken at the University of New South Wales during the past three decades. First, the sources of errors in the modelling approach to strategic land use and transport planning has long been recognised (Black and Kuranami, 1980) and suggestions as how best to handle this risk were proposed.

Secondly, the models rely on exogenous inputs such as future population distributions and these forecasts of socioeconomic activity are notoriously difficult to predict. The major data input for the above modelling process includes: zone definition, origin-destination surveys, land use and socioeconomic parameters, and operational characteristics of existing roads and transit networks. For example, Brewer and Black (1992) have undertaken a detailed evaluation of the performance of the traffic model (unconstrained gravity model with regional population distributions as inputs) applied in the unsuccessful private sector proposal for the Sydney-Newcastle toll road in 1960. By knowing the historical population data as inputs to the model in this *ex post*

analysis, *backcasting* revealed that the gravity model was sufficiently accurate for traffic forecasting (and revenue) purposes. However, the zonal population forecasts made in the 1960s were wildly inaccurate when compared with the actual populations that eventuated in this corridor between Sydney and Newcastle.

Thirdly, it appears that Australian consultants pay no notice of research and development undertaken into the assumptions underpinning, and the inaccuracies of traffic models. The outputs from these modelling processes simulate vehicles traffic volumes, speeds and travel times for given (planned) changes to land use and the transport network. Traffic modelling computer software conveniently provides such simulations (e.g. TRANSCAD, EMME/2) but it is sometimes expedient in practice to ignore alternative models. For example, Cheung and Black (2008) demonstrated that the intervening opportunities model calibrated against *Census of Population Journey to Work* data was a better model in representing the base year spatial pattern of commuting that the fully-constrained gravity model. More worrying from the perspective of accurate traffic forecasts was that the gravity model (with its one global parameter that calibrates the mean trip length) contains systematic geographical bias. In the case of journey to work data for Sydney this included a systematic over representation of traffic on some of the radial toll roads. Equally, the latest edition of *Transportation Planning and Technology* demonstrates convincingly that a genetic fuzzy rule based system provides more accurate results than conventional trip distribution models such as the gravity model (Kompil and Celik, 2013).

Finally, doctoral research by Kym Norley at UNSW includes building a road network and traffic model for Sydney and the results have been compared with the NSW Government Sydney Strategic Travel Model that has been widely adopted by traffic forecasters. These data are primarily sourced from the Roads and Traffic Authority (RTA) permanent counting stations, supplemented by the data provided by TransUrban, for the base-year of 2006. Figure 1 compares the percentage variation in model and survey link traffic flows. The Sydney Strategic Model is compared with seven road traffic models developed by Norley. The histograms show clearly that Norley's models are producing flow results that show a tighter relationship to actual counts than the Sydney Travel Model for the locations used. The Sydney Travel Model produces flow estimates that are on average 30% higher than actual counts. At a detailed road network level Norley's model produces good estimates of traffic flows on the lower M2 sections (east of Pennant Hills) with overestimates of flows on the Windsor Road to Pennant Hills section. However, this is a better result than the Sydney Travel Model (STM) that

Despite the research and development effort it is a fact that the traffic projections for the Sydney Harbor tunnel remain the most accurate over a 20-year period yet the method used by the consultants was a simple trend extrapolation.

CONCLUSIONS

Australia has a long experience in public private partnerships (PPP) in the road sector of the economy. The accuracy of traffic forecasts is of considerable interest to practitioners in the toll road sector, and one of the greatest risks to investors. Policy in Australia has evolved in the light of experience and collectively learning by both the public and the private sectors of the economy. One of the unresolved issues is that of the poor performance of traffic forecasts on the proposed toll roads and tunnels in urban Australia, an issue made more poignant following the global recession of 2008. The ratio of actual traffic on opening a toll road facility to that of the forecast traffic confirms the optimism bias that has been identified in the literature: the Australia roads and tunnels (Table 1) have ratios from 0.3 to 0.8 with a mean value of 0.5. In the Australian experience, it has become clear that the traffic projections for most toll roads have been built around the financial model, not vice versa as it should be (West, 2009). And that the financial model was structured in such a way as to ''upfront'' or bring forward the project cashflows so the bankers and and their consultants could pocket billions of dollars in fees before even a cent was earned in tolls.

Traffic consultants are encouraged to review their traffic forecasting methodologies and assumptions and should apply the type of model to apply should fit the context for the proposal. Each toll road proposal is subject to specific contextual criteria and requirements, and the type of traffic model to apply. This requires that certain types of modelling and traffic demand forecasting would apply for each type of toll road scenario and its characteristics:

- *Intercity roads:* generally long distances connecting cities with a collection fee for the savings in travel time;
- *Intra-city roads:* most common toll routes including long distances within a metropolitan region, connecting major suburbs;
- *Links:* bridges or tunnels that are usually short distances with a high demand due to physical barriers (water or city centres); and
- *Connecting routes:* includes short distance routes within major urban areas where capacity issues are experienced.

shows a 60% overestimate in this western section of the M2 tollway.

Is there any guidance on the best method for toll road appraisal? Unfortunately not as the report by Transportation Research Board on *Estimating Toll Road Demand and Revenue* (2006) concluded:

> *No state-of-the-art consensus exists among transportation researchers and practitioners regarding the best methods for achieving traffic and revenue forecasts. This mirrors the general application of models in transportation planning practice. Methods being used today can still be categorized primarily by incremental or synthetic analysis, both of which the transportation planning community has been using. The choice of analytical method varies, based on the method that is used to develop origin–destination trip tables for a given time period, trip purpose, and travel market segment.''*

Consequently, traffic demand forecasting for each type of toll roads should be subject to different parameters as part of their assessments. However, most toll road traffic forecasting in Australia have taken place on the basis of traffic diversion from alternative routes. On this basis, a number of elasticities are also calculated to test sensitivities of traffic demand on toll road based on number factors; mainly travel time savings, toll levels and the catchment area. Typically, the traffic demand forecasting for toll roads have relied on two main approaches: network traffic modelling; and travel choice modelling. Without resort to a careful understanding of the context, especially the route length of the facility, there are various elements that could easy lead to miscalculation in the traffic forecast for toll roads.

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