Research into Traffic Models for the Economic Evaluation of Private Sector Toll Roads and Tunnel Proposals in New South Wales

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Abstract:

Government policy in New South Wales has shifted in recent years to allow a greater private-sector participation in the construction and operation of toll roads and tunnels. Examples of proposals include the Sydney Harbour Tunnel (due for completion in 1992), The Bulahdelah Tollway, the F2 and F4 toll roads in metropolitan Sydney, and the Queanbeyan-South Coast tollway. Unisearch Ltd - the University of New South Wales Research and Development company - has given independent advice to both the private and public sectors and to community-based groups on all of the examples mentioned above.

The objective of the paper is to describe the "research and development" aspects of the traffic models used to estimate future traffic assignments to the proposed facilities. Two case studies are included: a model for the temporal distribution of traffic demands over the Sydney Harbour Bridge and tunnel proposal; and a logit model for traffic assignment to a proposed tollway between Queanbeyan and the South Coast. The relationship between toll revenue and construction and operational costs is of crucial importance in determining financial viability.

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Introduction

In addressing the Forum theme of "transport research - do researchers know what the users want?" this paper does not report on a scientifically-based investigation of the question, nor does it distill the contents and themes of papers published in the Forum Proceedings, as undertaken by Black and Rimmer (1985). Instead, the paper is prepared from the perspective of researchers working in the area of research and development for clearly-defined clients (users). The function of this applied research fits conveniently into Scrafton's (1977) schema: to enable the development of transport technology and operational practices (technical and scientific research) to provide the necessary information for governments and politicians to allow them to formulate policies and make decisions objectively (policy research).

Although main roads in Australia traditionally have been constructed by state governments, in New South Wales, in recent years, the policy has shifted to accommodate, and then encourage, private-sector participation in the construction and operation of road facilities. Attracting private funds will allow the Authority to accelerate the construction of major road projects. Total funds available from both Commonwealth and State Government sources are inadequate to upgrade all major road corridors (Loveday and Morris, 1988). The $400 million Sydney Harbour Tunnel, due for completion in 1992, is an example where the state government has allowed the construction of a road facility funded by a private consortium. Furthermore, the Roads and Traffic Authority, New South Wales, has called for expressions of interest for privately-funded toll roads: the Bulahdelah Tollway, on the Pacific Highway, about 250 km north of Sydney; the F4 toll road in the north western sector of Sydney ; the F5 between Moorebank and Beverley Hills in south west Sydney; and the F2 toll road on the western fringe of Sydney.

Both public and private sectors have invited the Department of Transport Engineering at the University of New South Wales to assist in the economic and financial evaluations of a number of facilities. Working through the University's Rsearch and Development company, Unisearch Ltd, several assessments have been completed. The clients required advice on traffic matters, in general, and the financial viability of any proposal, in particular, to assist in making decisions. Despite clear objectives on the scope of investigations into the economic evaluation of toll roads and tunnels, research was necessary to develop appropriate traffic models. Users of such research are interested in the experience of the real world, as well as the predictions from mathematical models. An extensive list of publications on toll roads was therefore reviewed. The topics reported were: government regulations; the regulatory process; descriptions of toll roads and associated facilities; descriptions of financing arrangements; and traffic flow surveys. However, little elaboration on any traffic estimation models was reported, despite both over - and under - estimates on U.S. tollways (Beesley, 1963, p 36), with the possible exception of three papers. Burpee (1953) stressed the need for methods that would allow traffic flow projections to be made, and recognised contributing factors, but mathematical relationships were neither mentioned nor developed. Wuestfeld and Regan (1981) considered 16 toll facilities with the demand reported for toll increases in the range of 10-50 per cent, giving elasticity values ranging from -0.1 to -0.3, without distinguishing between arc and point eleasiticities. Hendrickson and McNeil (1984) developed mathematical models to aid the design of toll levels for each category of vehicles according to the notion of cost-based pricing. Relative toll levels were determined according to the incremental cost associated with the facility standards required for each category of vehicles but projected levels of traffic were assumed to be known.

One reason for the lack of published material on traffic forecasting methodology is its confidential nature. Unless forced into the public arena through the Environmental Impact Statement processes or Public Inquiries, much of the analytical work remains hidden from the researcher. This was confirmed by a request refused to allow access to the traffic forecasting methodologies employed on submissions to build and operate tollroads in New South Wales that would allow a comparative study to be made (Brewer, 1989). The purpose of this paper is to present the structure of two traffic models - one for an urban tunnel proposal; the other for a rural tollway. First, we review some previous research.

Previous Australian research

In Australia, the most relevant work is the computer-based model (MOFAT) developed by the former Commonwealth Bureau of Roads to ascertain the financial feasibility of tollways (Atkins, *et al*, 1975). However, the model measures financial feasibility, given forecasts likely demand conditions. Direct experience on the demand for toll facilities proved to be limited in the literature, with the possible exception of the Sydney-Wollongong tollway, the West Gate Bridge in Melbourne and the Gateway Bridge in Brisbane. Carlisle (1990) provides a brief outline of toll roads in Australia which could act as a starting point for some in-depth, historical, case studies.

The 22.9 km, four-lane road between Waterfall Gully (south of Sydney) and Bulli pass (near Wollongong) was opened to traffic on July 24, 1975, at a cost of $30.9 million - or $1.35 million per kilometre, including the upgrading of approach roads, in 1975 prices. The tolls were $0.40 for private cars and $1.60 for commercial vehicles (trucks). The existing road section on the Princes Highway that was "by passed" by this new facility was 26.5 km long - a saving in distance of 3.6 km. There appears to be considerable divergence in opinion on how much travel time was saved on the new road: Clark (1977) indicates that realistic estimates of time savings range from 4 minutes in the off-peak periods to half an hour, when demand is high and vehicles are virtually bumper to bumper.

Clark (1977) made an attempt to calculate the average motorist's willingness to pay for the new facility, and conducted surveys in Wollongong, both before, and one year after, the tollway opened. The forty cents toll (1975 prices) was felt by many respondents to be expensive, but the expectation was that the new road would be so much better, and, hence, individuals and business were prepared to pay 77 cents and 64 cents, respectively. However, once the road was opened, individuals were willing to pay in 1975 prices, on average, considerably less - 51 cents - although the business community valued the facility only slightly less (59 cents) than before (64 cents). In current prices, private travellers would be willing to pay about $2.50 for a toll on 23 km route.

Traffic volumes for both-directions, on the existing road (Princes Highway) and on the new tollway during the first 45 weeks of tollway operation indicated, typically, that from 65 to 75 per cent of traffic used the tollway. (On Christmas Day, the proportion rose to 80 per cent.) Clark's statistical analysis found that the number of vehicles on the tollway did not increase over the first ten months, that the traffic on the Princes Highway did not drop, and that there was no relationship between the time that the tollway had been operating and the proportion of traffic that it had attracted (Clark, 1977). In 1987, the tollway carried about 80 per cent of the total traffic.

Since the West Gate Bridge in Melbourne was completed the volume of traffic has been considerably less than that predicted by Pak Poy and Associates, in 1968 - typically in the order of 25 per cent lower. In August, 1982, increase in tolls resulted in a noticeable decline in traffic (Thompson and Vincent, 1988). The price elasticity of demand was estimated to be approximately - 0.3 (Symons, *et al.*, 1984). When the toll was removed on the bridge on November 29, 1985, there was an increase of approximately 43 per cent in total traffic using the bridge (commercial vehicles increased by 77 per cent). These figures represent a direct result of the toll removal once seasonal effects are taken into account.

The Brisbane Gateway Bridge, and its immediate approach roads, were opened to traffic on January 11, 1986. Traffic grew rapidly from 15,000 vehicles per day, early in 1986, to 23,000 vehicles per day a year later. Its success is founded on there being no satisfactory competing route, other than one passing through the inner city of Brisbane and crossing at the Storey Bridge, which is 14 km longer. The length of the tollway is 42 km and the travel time is almost half of the 66 minutes taken on the old road (Davidson, 1987). This offers substantial savings to freight traffic and is influencing the location of industrial activity (Grigg, 1987).

Economic analysis of cross harbour transport

Accuracy of the economic evaluation of toll roads depends on successful forecasting of the level of traffic using the transport facility. These traffic forecasts need to be referenced to the level of tolls, which make information on elasticity vital. In the *Sydney Harbour Tunnel Environmental Impact Statement*, the consultants estimated that an increase in the toll on the Sydney Harbour Bridge from 20 cents to $1 in 1987 would reduce two-way annual traffic by 2.5 per cent in the first year of the higher toll. This reduction is expected to be sustained in subsequent years as a result of the toll (on the bridge and tunnel) being indexed to retain its real value (Cameron McNamara, 1986a, p. 42). Figure 1 shows the methodology developed for the economic evaluation of the Sydney Harbour Tunnel project and other alternative cross-harbour transport proposals by Unisearch Ltd. The four lane, 2.4 km long tunnel, now under construction, is, conceptually, a parallel facility to the existing bridge, which has 8 road lanes and two train tracks connecting the north and south banks of Port Jackson and the Parramatta River (the Sydney harbour). The investment and operating costs will be recovered by the toll levied on traffic crossing the harbour using either the (existing) bridge or the tunnel (when opened in late 1992), over a 35 year-period commencing on May, 1987. The topmost cell in Figure 1 refers to traffic projections related to Average Annual Daily

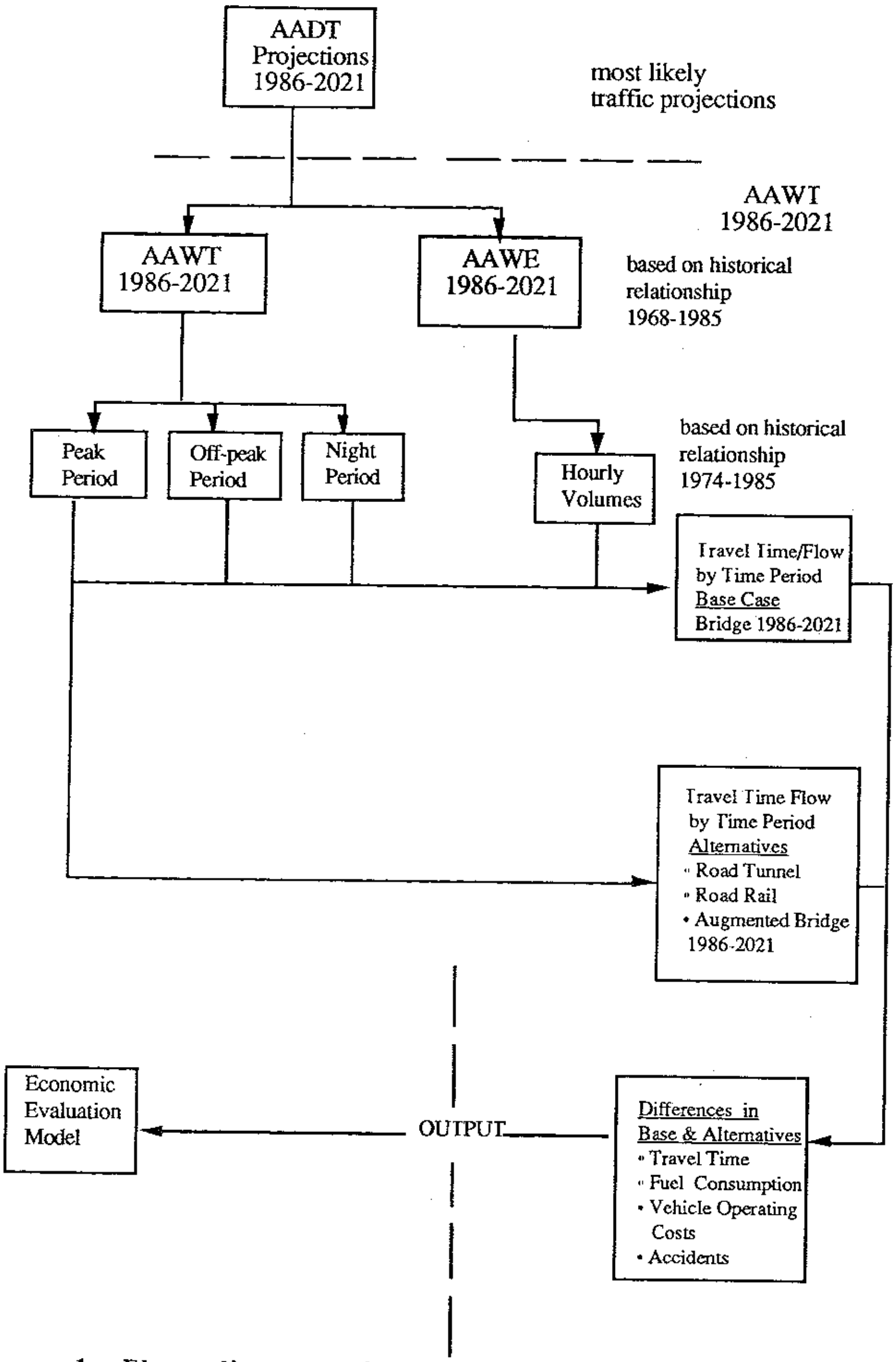

Figure 1. Flow diagram of traffic forecasting methodology and economic evaluation model for Sydney cross-harbour transport

Traffic (AADT) given by the New South Wales, Department of Main roads in *Traffic Volumes and Supplementary Data*. The following traffic projections for the Sydney Harbour Bridge, based on past traffic trends, are:

$$\text{Max Growth } \hat{Y}_{max} = 178372 + 3358x$$

$$\text{Min Growth } \hat{Y}_{min} = \frac{200000}{1 + 0.14e^{-0.09x}}$$

where

$\hat{Y}_{max}$ = estimate of AADT at maximum growth rate;
$\hat{Y}_{min}$ = estimate of AADT at minimum growth rate; and
x = number of years from the base year 1985.

Note that in these two formulae the maximum growth implies a constant annual increment of some 3360 AADT each year, whereas the minimum growth is based on a daily upper "saturation level" of 200,000 vehicles for AADT. These AADT estimates form an upper and lower bound to the traffic estimates used in the tunnel EIS.

Gutteridge, Haskins and Davey (1986) - the traffic consultants to the Sydney Harbour Tunnel: Transfield-Kumagai Joint Venture - approached traffic projections from a growth in southbound traffic on the Sydney Harbour Bridge for Average Annual Weekday Traffic (AAWT). The shape of the mathematical function is a logistic curve based on "a strongly linear historic trend and a long term growth constraint, based on a maximum Service Volume, creating a mathematical asymptote for the growth curve" (Gutteridge, Haskins and Davey, 1986). Traffic projections for Average Annual Weekday Traffic (AAWT) up to 2021 are illustrated by Cameron McNamara (1986a, Fig 4.6, p 47). These include "high", "most likely" and "low" projections. The "most likely" traffic projection assumed great importance in the final appraisal of the project because it formed the basis of the guaranteed revenue stream for the developers that was "underwritten" by government

An independent review of the traffic forecasts and social cost-benefit evaluation was sought by the NSW Department of Environment and Planning from Unisearch Ltd (1987a). In contrast to the traffic forecasting by the consultants the approach was to take given projections of AADT (as above) and then partition them into average annual weekday traffic (AAWT) and Average Annual Weekend Traffic (AAWE). Based on time series data of traffic volumes on the Sydney Harbour Bridge from 1968 to 1985, regression analysis leads to the following relationship:

$$\hat{Y}_{WE} = 4650 + 0.766Y \qquad (r^2 = 0.99)$$

where

$\hat{Y}_{WE}$ = estimate of average annual weekend traffic (AAWE); and
Y = average annual daily traffic (AADT).

Average Annual Daily Traffic (AADT) equals five-sevenths of Average Annual Weekday Traffic (AAWT) plus two sevenths of Average Annual Weekend Traffic (AAWE). By rearranging, and ignoring public holidays:

AAWT = 7/5(AADT - 2/7AAWE).

For the calculation of the costs and operational benefits associated with the tunnel proposal, three time periods for each weekday are defined:

Peak periods -	7 to 10 am and 4 to 7 pm;
off-peak periods -	10 am to 4 pm and 7 to 11 pm; and
night period -	11 pm to 7 am.

As travel times are flow dependent it was necessary to estimate typical hourly traffic flows for these three time periods over the life of the project (for evaluation purposes taken to be up to 2021). Based on historical data, regression analyses of the temporal distribution of traffic, as a function of Average Annual Weekday Traffic, leads to the following equations:

$$\widehat{Y}_p = 6.593 Y_{WT}^{0.78} \quad (r^2 = 0.99)$$

$$\widehat{Y}_{op} = 0.070 Y_{WT}^{1.16} \quad (r^2 = 1.00)$$

where

$\widehat{Y}_p$ = estimate of peak period traffic volumes;
$\widehat{Y}_{op}$ = estimate of off-peak period traffic volumes; and
Y_{WT} = estimate of average weekday traffic volumes.

To ensure the temporal distribution of traffic is properly constrained by the total average daily traffic figure, the estimate of the night period traffic volumes $\widehat{Y}_n$ becomes:

$$\widehat{Y}_n = \widehat{Y}_{WT} - \widehat{Y}_p - \widehat{Y}_{op}.$$

All the above dependent variables (traffic estimates) are explained by time, and hence the very high correlation coefficients.

Traffic assignment to a network requires the rate of demand to be established. The hourly traffic flows for the three time periods give the demand rate and the impact of projected traffic volumes on travel time were estimated using Davidson's (1966) travel time/traffic flow relationship. Thus, travel times at different times of the day are computed firstly for the bridge only situation and then for the bridge with tunnel alternative.

The bridge-only base case and the tunnel alternative can be compared in the form of four different measures: travel time saving (using monetary values of time); fuel consumption; vehicle operating costs; and accident savings. As mentioned before, the travel time differences were based on Davidson's model. Differences in fuel consumption were computed using the model reported by Bowyer *et al.*, (1984, 1985). Differences in vehicle operating costs were computed using published data from New South Wales Road Freight Transport Industry Council, (1986) for trucks and Royal Auto (July, 1986) for motor vehicles. Accident costs, which average at 1 cent per vehicle kilometre, were based directly on Department of Main Roads data (Cameron McNamara, 1986b), and were applied to the distance saving of 800 metres via the tunnel made by 33 per cent of weekday and weekend traffic.

These basic evaluation parameters were used both by the tunnel proponents and by Unisearch Ltd. and are values used by the Roads and Traffic Authority. The Joint Venture consultants undertook an economic evaluation of the "limited clearance" tunnel proposal and estimated the benefit-cost ratios as ranging from 1.9 to 0.8 depending on the discount rate adopted - 4 per cent per annum to 10 per cent per annum (Cameron McNamara, 1986a, Table 6.1, p. 64). The independent economic evaluation by Unisearch Ltd (1987a) applied the traffic model described above to represent the temporal traffic flows over the bridge and tunnel. A micro-computer model was developed to facilitate sensitivity analyses for variations in costs and benefits and in the values of the economic evaluation parameters. This approach gave lower benefit cost ratios than those derived by the consultants to the Joint Venturers, for the same range of discount values because of the different traffic assignment model.

An additional advantage of the Unisearch Ltd approach was that it allowed a ready comparison of other cross harbour transport proposals, such as an augmented Sydney Harbour Bridge and a cross harbour rail tunnel (Unisearch, 1987b). The augmented bridge gave the highest benefit-cost ratio, primarily because of its relatively low capital cost of $44 million. A rail tunnel, together with the extra two traffic lanes on the Sydney Harbour Bridge (replacing the existing rail tracks), gave a benefit cost ratio very similar to that of a road tunnel. The same methodology could be applied to an evaluation of a recent proposal by a consortium led by Transfield to link Sydney Kingsford Smith airport with St Leonards by a railway under the harbour (Sydney Morning Herald, 20 May, 1991).

Route choice modelling

A route choice model has been developed to forecast the level of traffic and hence the revenue from proposed toll road projects. Figure 2 shows the main steps of the methodology adopted in this forecasting procedure. The model takes into account the physical characteristics such as route length and operating speed of the existing road as well as the proposed toll road. Global parameters such as fuel consumption rates and monetary value of travel time are also required to estimate the cost of the journey using a particular alternative.

A binary logit model was applied to split the total traffic volume in a given corridor between the toll road and the non-toll road. Ben Akiva and Lerman (1979) show the applicability of logit formulation for choice modelling purposes. The formula for a binary choice logit model for route assignment is:

$$P(t) = \frac{1}{1 + \exp(\alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3)}$$

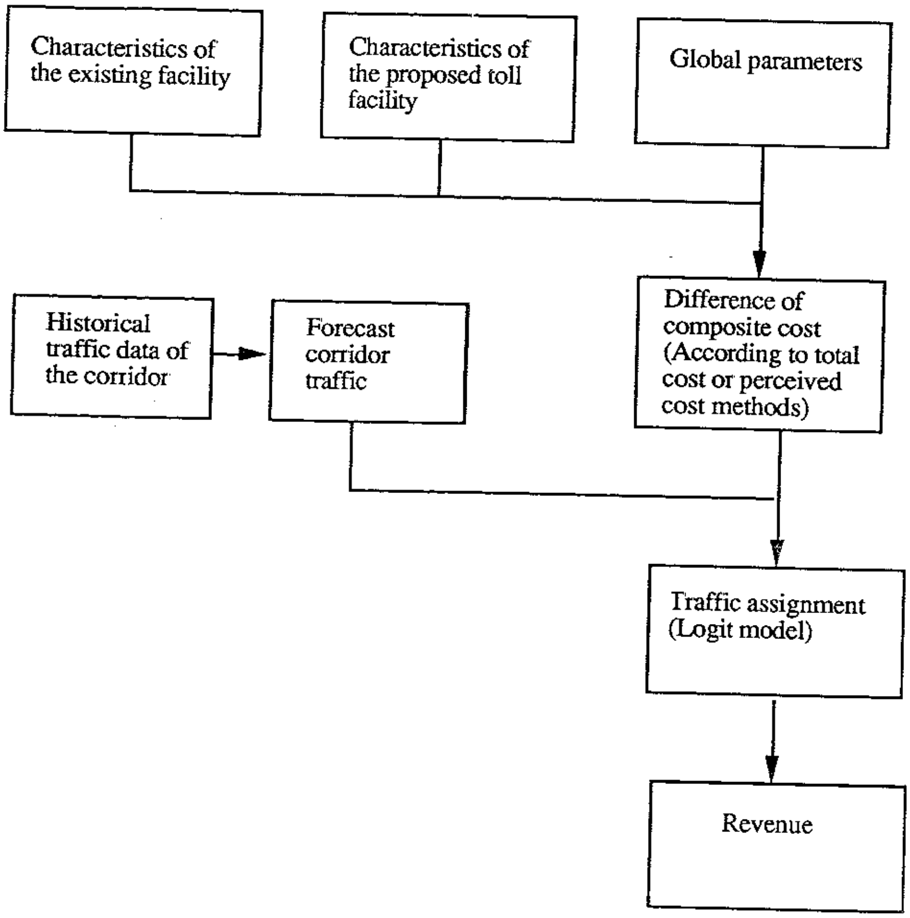

Figure 2. Components of the route choice model

where

P(t)	= probability of using the tollway;
x_1	= differences in route distances;
x_2	= differences in route travel times;
x_3	= differences in operating costs including toll;
α	= constant term; and
$\beta_1, \beta_2, \beta_3$	= coefficients.

However, due to paucity of data it is not possible to estimate all the coefficients in the above formula. Therefore the following simplified form of the logit model is adopted for the traffic assignment.

$$P(t) = \frac{1}{1 + \exp(\beta x)}$$

where x = difference in composite cost.

Composite cost includes the monetary value of travel time and other travel cost components due to vehicle operating costs and toll. It should be noted that α is not included in the simplified equation because it is assumed that when the composite costs of the two alternatives are equal, the probability of using a particular alternative becomes 50 per cent. Effects of driving comfort, level of accident exposure and scenic value of a particular alternative are ignored in the analysis due to quantification difficulties. The model was calibrated using the data obtained from Sydney-Wollongong Tollway in 1987.

The above logit model was applied, for example, in traffic estimation and financial appraisal of a proposal for a tollway from Queanbeyan to the South Coast of New South Wales. This particular application was part of the research and development of a consultancy project undertaken by Unisearch Ltd. for a private-sector consortium. The essential features of the existing situation are described as follows. The distance from Canberra to Moruya (on the South Coast) via the Araluen Valley is 162 km. The Araluen Valley road is about 7 metres wide and of gravel construction. It is a very steep mountain road with many tight curves and is presently not a feasible route for Canberra - South Coast traffic. For instance, field studies showed that driving from Moruya to Araluen on a Saturday morning in April (Autumn), only three cars and two motorcycles were observed. On the other hand, Canberra to Moruya, via the Kings Highway (Main Road 51) and Batemans Bay, is 152 km. From Braidwood to Batemans Bay the distance is 61 km, with a winding section of road through Clyde Mountain. During the weekdays, the traffic flow is light between Bungendore (25 km to the east of Queanbeyan) and Batemans Bay, because two thirds of traffic to and from Queanbeyan leaves Main Road 51 at Bungendore, with destinations to and from Goulburn, located to the north.

Over a twenty-year period from 1967 to 1988, traffic counts by the New South Wales Department of Main Roads (1986a, b), show that the number of vehicles using the Kings Highway has increased from about 1000 vehicles per day to about 3000 vehicles per day. However, the average traffic counts conceal both the seasonal, and weekend, characteristics of traffic. This general level of traffic activity noted above was confirmed by a survey undertaken by the local government authority, Tallaganda Shire Council in December, 1987.

A number of different toll road configurations have been analysed. Table 1 shows the route lengths of the existing road and two toll road alignments considered in the analysis. One of the proposed alignments is about 5 km longer than the other alignment over the total distance of the corridor. In the context of the wider land-use/transport system, we observe that the toll road concept is a sound one. It is consistent with current New South Wales Government policy on roads. An alternative, free, road would be available to motorists, irrespective of any toll road alignment finally adopted. A toll road between Queanbeyan and Moruya would give genuine route distance saving to motorists (who currently use Kings Highway to gain access to and from the coast) from Goulburn, Canberra, and parts of country New South Wales. The alignment would also make travel from Melbourne via Canberra to the South Coast almost as short as the currently favoured route via the Princes Highway (782 km compared with 742 km). Distance savings to road users represent genuine resource savings in fuel consumption and vehicle operating costs.

Table 1 Comparison of route length of the existing road and the proposed toll road alternative.

Toll road alignment		Route length in km		
From	To	Existing road	Alignment 1	Alignment 2
Queanbeyan	Batemans Bay	140	142	147
Queanbeyan	Moruya	167	115	120
Queanbeyan	Braidwood	90	61	64
Braidwood	Moruya	61	88	93
Braidwood	Batemans Bay	88	61	69

The micro-computer-based traffic forecasting model that was developed allows a variety of assumptions about toll road characteristics to be analysed - length, tolls charged, whether tolls are indexed or unindexed, or whether drivers decide on their route choice because of total, or perceived, costs. Toll charged, value of travel time, and fuel consumption costs are taken into account in the analysis based on perceived costs. In addition, vehicle operating cost (which includes depreciation and tyre wear) is included in the total costs based method. The level of traffic obtained from the total costs method is generally less than that obtained from the perceived costs method because of increased operating cost for toll road users. The results of this analysis, using a logit model to take into account behavioural response of travellers for the two toll road alignments, have been presented elsewhere (Unisearch Ltd, 1989).

A brief summary of this analysis makes the following points. Based on the historical growth of traffic on the Kings Highway, and traffic projection by trend extrapolation into the future, it can be shown that a toll road is not financially viable (given its construction, operation and maintenance costs). This is summarised in Figure 3 for the corridor between Queanbeyan and Batemans Bay and in Figure 4 for the corridor between Queanbeyan and Moruya. The graphs show the relative traffic levels for long and short alignments, for perceived and total costs, and for four toll levels ($5 for cars, $10 for trucks; $10 for cars, $20 for trucks; $20 for cars, $30 for trucks; and $30 for cars, $50 for trucks in terms of 1989 dollars). In conclusion, the level of traffic on these toll road alignments, considering the historical growth of traffic alone, is insufficient to justify investment.

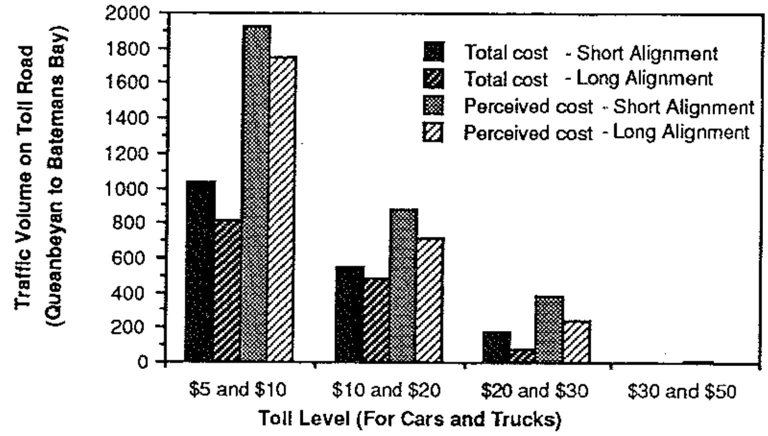

Figure 3. Traffic Estimates for Different Toll Levels - Corridor Between Queanbeyan and Batemans Bay (South Coast)

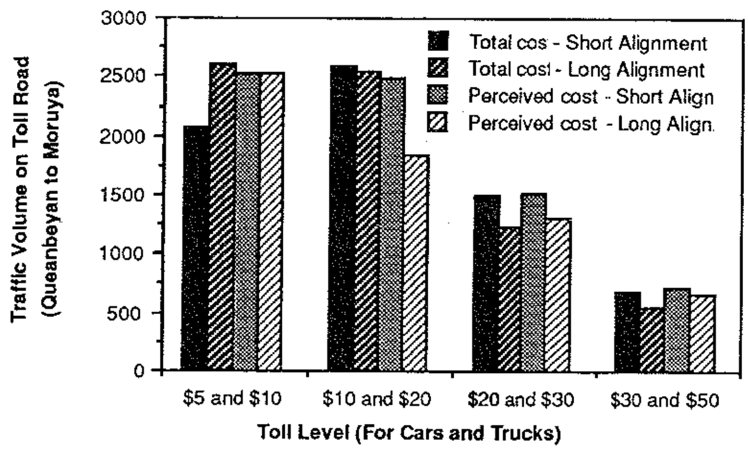

Figure 4. Traffic estimates for different toll levels - corridor between Queanbeyan and Moruya (South Coast)

However, trend extrapolation can be a misleading technique for long-term traffic forecasting, especially when there is substantial change in the land-use context. Therefore, the second stage of the analysis took a different approach. We asked the question: what level of traffic would be required to give a return on investment assuming construction costs and maintenance costs of the toll road were known? This is referred to as the break-even traffic analysis. The results are summarised in Figure 5. The graphs show the traffic volume required over a period of 30 years to make the proposal financially viable (8 percent return on investment) for three toll levels ($5-car, $10-trucks; $10-cars, $20-trucks; and $20 cars, $30-trucks). Assuming a toll level of $10 for cars, the traffic levels required initially would be in the order of 14000 vehicles per day.

The significance of identifying the level of traffic required for a break-even revenue is to determine the difference between traffic forecasts based on historical trends, and the traffic required to justify, on economic grounds, investment in new roads. This traffic "shortfall" represents the amount of annual traffic that would have to be "generated" or "induced" by new land-use developments. In the context of the Queanbeyan - South Coast toll road proposal, these developments relate primarily to tourism and the attraction of the coast both for retired people (from Canberra) and for holiday home investment. Also considered was the relationship between the Very Fast Train (VFT) proposal linking Sydney, Canberra, and Melbourne and its influence on

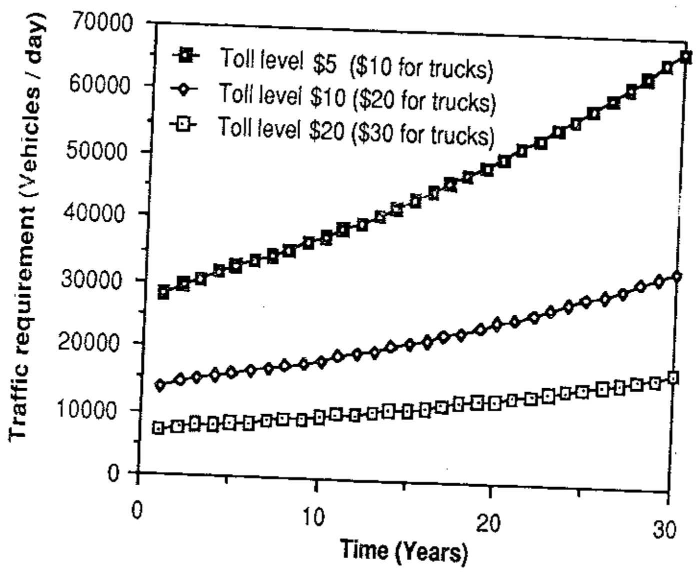

Figure 5. Average annual daily traffic over a 30-year period required to financially justify a toll toad from Queanbeyan to Batemans Bay

tourist traffic, especially the role of the tollway as a "feeder service" to this new railway. The traffic results of these scenarios are beyond the scope of this paper, but nevertheless they formed an important part of traffic forecasting methodology that was developed for the client. It is also fair to say that the link between tourist development and travel is an area deserving of much research.

The traffic forecasting model developed for the analysis of the toll road from Queanbeyan to the South Coast uses a fixed operating speed for a given alternative in the computation of the travel time. In reality, the operating speed is a function of the level of traffic intensity, which is defined as a fraction obtained from dividing the traffic flow by the capacity of the facility. Materu (1991) has demonstrated an iterative method to account for the secondary effects of the amount of assigned traffic on operating speed. The travel time-flow relationships proposed by Davidson (1966) is applied to estimate the operating speed when the assigned traffic flow is available. Convergence is usually assured within 30 iterations. Materu (1991) applied the modified forecasting model to investigate the sensitivity of the results to the calibration parameter β in the logit model. Considering a 10 km toll road and a 12 km alternative road it is shown that the assignment results are not sensitive to the value of β, in the range of applicability of β, at a nominal level of toll. When \$2 toll level is adopted, the share of traffic on the toll road varied from 48 per cent to 43 per cent in a linear manner for a change in the calibration parameter β from -0.1 to -0.5. With a \$3 toll level though, the corresponding share of traffic on the toll road varied from 46 per cent to 36 per cent.

Discussion and conclusions

The methodology of traffic forecasting for the economic evaluation and financial appraisal of transport facilities has been described using two case studies. The first case study, the \$400 million Sydney Harbour Tunnel project, required the development of a methodology that took standard AADT traffic projections and separated them into weekday and weekend traffic and then into traffic by three periods of the day. This traffic estimation procedure provided the necessary input to the application of Davidson's travel time/flow model to transform the traffic projections into level of service measures, such as travel time and fuel consumption. Standard economic evaluations (benefit cost ratio, internal rate of return, and net present value) were performed based on the predicted variations of the economic evaluation parameters under a number of alternative transport improvement strategies. A flexible micro-computer program allowed sensitivity analyses to be readily undertaken.

The second case study of a proposed toll road project in rural New South Wales was introduced to demonstrate the application of the logit model to account for the manner in which road users weigh the costs and benefits in choosing between alternative routes. The logit model was applied to estimate the potential traffic share on a toll facility, compared to the total traffic volume of the corridor, given assumptions about route lengths, speeds and toll charges. This particular case study was also used to demonstrate the break-even traffic analysis developed to estimate the annual level of traffic required over the project life-time to attract private investment.

This paper has explained the research and development into traffic models that underpin consultancy advice to government and to the private sector by the University of New South Wales R & D Company, Unisearch Ltd. Although economic evaluation has become standard practice in road project appraisal there are nevertheless technical issues in the quantification of benefits (and also of environmental costs that have not been addressed in this paper). Quantification of benefits requires accurate traffic estimation because the level of facility use will be an important factor in total user benefits and in the financial viability of any project financed on a user-pays principle. In Australia, as direct experience with tollways is limited, and our search through the literature failed to discover any suitable methodology (probably because of the commercial-in-confidence nature of recent work) it was necessary for the authors to develop traffic models. These have been explained in technical detail in this paper, which is presented to stimulate discussion about the methodology to improve the accuracy of traffic modelling and forecasting exercises.

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