ON ECONOMIC EVALUATION OF PRIVATE - PUBLIC SECTOR TRANSPORT PROJECTS

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ABSTRACT: *Although private and public involvement in transport projects has a long history, the economic and political climate has placed new emphasis on private - public sector partnerships as public funding diminishes. After reviewing briefly the history of private sector involvement in roads in New South Wales and the system of highway financing through tolls, two major private sector initiatives are described. They are the Sydney-Newcastle toll road proposal of the early 1960s and the Sydney Harbour Tunnel (1986 onwards). Both projects are discussed not only in terms of their economic evaluation but in their conceptual validity and functional utility. The paper concludes by making several points on the economic evaluation of private - public sector transport projects.*

> "I heard a very warm debate between two professors, about the most commodious and effectual ways and means of raising money without grieving the subject. The first affirmed, the justest method would be to lay certain tax upon vices and folly....."
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> (Jonathon Swift, 1726, "A Voyage to Balnibarbi" in *Gulliver's Travels*, pp 113-114).

Introduction

The notion of private and public involvement in transport project has a long historical tradition - turnpikes, toll roads and bridges date back some hundreds of years. A brief history of private sector involvement with roads in New South Wales is given later. If one considers transport in the broader context of its place in the full land-use and transport system then private and public interests are always involved. Sometimes, the transport investment is public and the benefits accrue either to the transport users, the land holders served by it, or the public generally, or all three in combination. In such circumstances the investment may either be liquidated through some form of taxation - either, by tolls as direct user charges or by a betterment tax. In other instances, the investment in transport is private, and it is serviced by direct user charges and, or, rents. As public funding for transport diminishes, the economic and political climate in the USA, Britain and Australia has placed new emphasis on public-private sector partnerships and the privatisation of public services. Rush (1988) provides a recent bibliography as a guide to sources of information on private sector alternatives for transport; and OECD (1987) discusses toll financing and private sector involvement in roads.

The range of options for public and private sector involvement is widespread and it is not surprising that recourse is made to some form of economic analysis for their evaluation and rationalization. The methodology involved had its origin in the well known accountancy-based investment analysis with the inclusion of the time value of money. With origins in the work of Dupuis (1844) the methodology was much applied in the 19th century rail building booms to attract investors. 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 in use in public (and mixed public/private) enterprises many difficulties arise. Benefits and disbenefits need to be subjectively quantified by perceived "value" coefficients and the discount rate arbitrarily defined. Whilst economic indices thus derived have value for comparing alternative 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 project or projects. In fact, economic analyses can be misleading. This is particularly true in the urban context where there is a high degree of interaction between modes and with land-use infrastructure.

In what follows an attempt will be made to elucidate some of the problems and difficulties by reviewing in some detail two major projects with which the authors have been closely associated. One relates to a proposal to build a privately-financed toll road between the great city of Sydney and the industrial city of Newcastle some 160 km to its north. The other is the recently proposed Sydney Harbour Tunnel Road Project to parallel in close proximity the Sydney Harbour Bridge to link the Warringah Expressway

in North Sydney with the Domain Tunnel under the Botanical Gardens in the south Before describing the salient features of these case studies, the historical scene is set for private sector involvement in roads in New South Wales.

Historical Background

There are two relevant aspects: the system of highway financing through tolls; and private sector involvement in roads. In the seventieth 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 first turnpike in New South Wales was the floating pontoon bridge over South Creek on the road between Hawkesbury and Parramatta in 1802. The rates of toll were fourpence for a foot passenger, one shilling and sixpence for a cart or carriage, and two shillings for a horse. More on the history of turnpikes in early New South Wales can be found in Main Roads, (June, 1951, pp. 107-111).

This first turnpike also appears to be the first example of a "public sector - private sector" partnership in New South Wales. The deal was that the government would provide £15 and six man-months of labour and Andrew Thompson, an early settler and constable, would collect the tolls for fourteen years. On this surety he constructed the floating pontoon bridge. (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).

Other examples of public and private sector cooperation are provided in The Roadmakers (Department of Main Roads, 1976). For example, in 1805 road committees were established to raise voluntary contributions from citizens for road repair and maintenance. In 1840, the Parish Roads Acts, land owners were entitled to set up organisations to determine local road needs and fix and collect tolls. The government abolished tolls on all roads in 1877. The establishment of the Main Roads Board (later Department of Main Roads) in 1925 put the responsibility for administering, financing, constructing (we are ignoring here contracting to the private sector construction companies) and maintaining roads firmly in the public sector. In New South Wales, the challenge came in the late 1950s.

The Sydney Newcastle Toll Road Project

In the nineteen fifties, the main road link between Sydney and Newcastle was a two lane section of the Pacific Highway. This road between Sydney and Newcastle was brought into a condition capable of carrying motor vehicles and proclaimed in May, 1929, under the name of the Great Northern Highway (Upton, 1932). Previously, no direct connection existed other than the circuitous routes through Parramatta, Pitt Town, Wiseman's Ferry branching through Wollombi and Maitland (264 km long) or through Gosford, Wyong and Swansea (248 km long). It had an appallingly poor safety record - 167 crashes per 100 million vehicle-kilometres of travel. A syndicate, C A S (Turnpikes) Ltd,headed by John Tate, an ex-Senator of the Commonwealth and the first Chairman of the Cumberland County Council, lobbied the government in 1958 with a proposal to construct an access-controlled toll road on a completely new alignment through the Gosford Woy-Woy basin to Newcastle. Apart from avoiding mountainous terrain of the existing road it reduced the length of the Sydney-Newcastle road connection by no less than some 50 kilometres in the total 160 km taken by the Pacific Highway. To foreshadow an important consideration to be raised later on in this paper it should be stressed here that there was virtually no road alternative to the then existing Pacific Highway route in the Sydney-Newcastle corridor.

By the turn of the decade (1960s) the NSW State Government had embraced the idea in principle and called for proposals from interested parties and syndicates. The Department of Main Roads, New South Wales issued a prospectus and specification which included basic traffic data obtained from a roadside interview survey at the Hawkesbury River Bridge. Two proposals were submitted: one from the Tait Syndicate, supported by the UK Laing Group - the contractors for the London to Birmingham Motorway; the other from a locally-based construction group. One of the authors, supported by his staff and graduate students, undertook the economic evaluation for the Tait proposal (Blunden, 1960). Some details of the results of these studies are given in Appendix I. It is sufficient to mention here that the analyses, which was conservatively based, indicated that as a toll project it would have been financially viable, and, as an addition to the road capacity of this important corridor, it was also conceptually and economically sound.

The key to its economic and financial viability was clearly linked to the huge distance savings of the proposed route, particularly between Sydney and the Gosford Woy-Woy basin with its rapidly growing population. Having in mind the high standard geometrics of the road, and the spread of traffic pattern, the time savings would have been proportionately greater. And, notwithstanding the fact that the proposed road called for a major bridge across the Hawkesbury from West-Head to Patonga, the construction cost was low because of the easy terrain along the coastal verge from Patonga northwards. As a result, the proposed toll could be fixed at well below half of the tangible direct benefits to the user.

That the Tait proposal was not proceeded with remains one of the great mysteries of political decision making in New South Wales. However, the public support for some such new road was so overwhelming (as evidenced by contemporary press clippings) that the government had little option but to propose an alternative. It seems clear that no meaningful comparative economic analysis was undertaken, or, if it had been, it was ignored in the cause of political expediency. But with or without such analysis the relative merit of the two proposals can be demonstrated on conceptual grounds. The route chosen had been long established as the new route of the Pacific Highway north from Sydney. Its ultimate destination was Brisbane and beyond and it seemed sensible to by-pass the Gosford Woy-Woy basin, even Newcastle, especially as the by-passing of Gosford avoided the construction of the expensive Mooney Mooney Creek Bridge.

The first section between Berowra and Mt White (5.8 miles) and was opened in 1965 as the "Sydney/Newcastle Toll Road" at a cost of approximately £600,000 per mile ($750,000 per kilometre), including bridges and interchanges. This route was inland from the coastal verge and traversed rugged sandstone terrain. To construct a road of freeway standard in such county was a prodigeous, and costly, road-building exercise (an estimated $6 million per kilometre in current prices based on the DMR. Road Cost Index). When, two decades later, the road was extended northwards as the F3 Freeway with Commonwealth Bicentennial Road funding, the original route was changed to incorporate the Mooney-Mooney Creek Bridge and to improve the access to the Gosford Woy-Woy basin. The F3 Freeway between Calga and Somersby cost $5.3 million per kilometre for 15 km, including the $14.6 million, 480 m long, twin bridges over Mooney Mooney Creek (Opened on 14 December, 1986), and earned the Department of Main Roads a 1988 Institution of Engineers Australia National Engineering Excellence Award in the Public Works category. By Easter, 1988, the freeway had extended to Freeman's interchange, some 30 km short of Newcastle.

The Sydney Harbour Tunnel

If contrast is sought when presenting two major examples of joint public/private transport proposals it would be difficult to cite a more appropriate second example than the Sydney Harbour Tunnel project. Apart from the radically different land-use context, the major

difference lies in the fact that the Sydney/Newcastle project offered a solution to a problem with great potential benefits whereas the Harbour Tunnel could at best only realise marginal economic results at $408 million for a 2.4 km link. This judgement on its limited effectiveness is due primarily to the unique role of major road traffic bottle-necks in urban areas.

To understand this one must distinguish clearly between the *total* demand and the *rate* of demand. It is only the latter that can be equated to the capacity of the transport facility. To illustrate this key concept let us consider the existing Sydney Harbour Bridge. It has a road traffic capacity of some 15000 veh/hour. Now if the *total* demand was merely 500 vehicles seeking to cross it between, say 8.00am and 8.01 there would be a prima facie case for duplicating it because 500 vehicles in a minute represents a demand *rate* of 30,000 veh/hour. What happens, of course, is that the hapless 500 spread themselves out over say two minutes. This process of the temporal distribution of traffic (see Alfa et al, 1984, for a theoretical model of this process) goes on until the busy period stretches out to some tolerable upper limit, say two hours.

Whilst this is happening, public transport alternatives (if any) become relatively more attractive and adjustments take place to vehicular traffic demands. Bottle-neck constraints result in land-use changes. In the Sydney case, this has been in no small measure responsible for North Sydney becoming a commercial centre with as much office space as the city of Adelaide, and the North Shore a metropolis the size of Brisbane or Perth (Similar trends are discernible on Auckland's north shore and to the south of the isthmus). The extension of busy periods, the appeal of different modes, and the merit (or otherwise) of land-use changes may well be seen as "penalties" or disbenefits by some and by others as benefits. The important point, however, is to recognise them and to account for them in economic terms, not substitute for them the high cost of congestion that would result from arguing that the status quo should be preserved.

With these points as background we can discuss more meaningfully the tunnel project. For the purposes of this discussion the essential characteristics of the tunnel may be summarised below.

(a) It has four lanes (two each way) which are not reversible.

(b Its length is 2.4 km, portal to portal; it takes off from the capacious Warringah Expressway adjacent to the North Sydney CBD and emerges on the south side of the Harbour at the entrance to the Domain Tunnel of the Eastern Distributor.

(c) For all practical purposes, its functional role is one of augmenting the existing 8 road lanes on the main deck of the Harbour Bridge - no additional facilities are proposed for feeding the tunnel other than the already long-planned Gore Hill Freeway and the extension of the Eastern Distributor to Moore Park. The Tunnel proponents argue that is provides a CBD by-pass.

(d) The investment and operating costs are to be recouped with a CPI indexed toll, already set in May, 1987, at $1.00 per vehicle, levied on all traffic crossing the harbour, on the existing bridge and, later, on the bridge plus the tunnel over a period of 35 years.

(e) The present total daily traffic is some 190,000 vehicles with about 80,000 seeking to cross during the morning and evening busy periods. Future traffic is crudely estimated by extrapolating historical average daily traffic trends (and arbitrary factoring of the diurnal variation to obtain peak demands) and is expected to reach some 250000 veh/day by the end of the second decade of the next century.

(f) A feature of the financial agreement is that this estimated traffic growth pattern be guarantied by the government for the repayment period. (This notwithstanding that by 2020 we may be carrying out much more of our commercial and professional business via electronic highways.)

(g) The before and after capacity situation (both ways) is

- before - 18000 passengers/hour by car
  40000 passengers/hour by train
- after - 27000 passengers/hour by car
  40000 passengers/hour by train.

These are idealised upper limit figures as they do not take account of directional split characteristics. However, as the tunnel lanes are not reversible the alternate road capacity "after" is not likely to exceed 25000 passengers per hour; the vehicle occupancy rate is assumed to remain constant (but it is of interest to note that the same capacity increase as that provided by tunnel could be achieved by increasing average vehicle occupancy from 1.25 to 1.8)

(h) The tunnel scheme was negotiated privately between the Transfield-Kumagai consortium and the Government of New South Wales; no substantive alternative schemes were compared in carrying out the economic and environmental evaluations, as part of the Environmental Assessment Act, prepared by the developers. (The consultants responsible for undertaking the EIS argued at a meeting of the Institution of Engineers Australia, Sydney Division in March 1988 that it was not in their terms of reference under the wording of the Act to analyse alternatives.)

In the light of the above considerations the tunnel project can be broadly evaluated in terms of: (a) its economic merit; and (b) its conceptual and functional adequacy as a major transport innovation to the complex land-use/transport infrastructures of a great city. In view of the title of this paper the discussion will be focussed on the former, but it is important to establish that from the point of view of long-term planning the latter considerations may well be dominant, especially if the economics are marginal. We return to this latter point in the last section where we suggest several important lessons

Table 1 lists the main events surrounding the Sydney Harbour Tunnel assessment and decision making. When the Environmental Impact Statement was exhibited for the nine weeks from 19, December, 1986, it attracted a total of 463 individual submissions plus four petitions. Exclusive of the petitions, 65 per cent objected to the proposal, 9 per cent supported the proposal, and 27 per cent made comments, including offering alternative proposals. A review of these submissions, plus independent expert advice, are contained in a report by the Department of Environment and Planning (1987) - a Director's examination under the Environmental Planning and Assessment Act. The four significant issues raised were: the alternative proposals that should require evaluation; the regional planning implications of the tunnel; traffic matters, including the accuracy of traffic projections; and economic and financial matters. The final determination on the tunnel was made by the Department of Main Roads (1987), who considered that the more realistic figure for the benefit-cost ratio was 1.5. This was achieved by placing a token residual (salvage) value on the tunnel after 30 years and revising the monetary value of travellers' time upwards by an extra 70 per cent. The decision to go-ahead with the tunnel construction was made in April, 1987.

Table 1: The Sydney Harbour Tunnel - Chronology of Main Events

Date	Event
March, 1986	Premier of NSW, Mr Wran, announces that a tunnel would be built linking the Warringah Expressway with the Western Distributor pending the favourable results of a feasibility study by the joint venturers Transfield-Kumagai.
June, 1986	Scope of investigations broadened to include other alignments.
December, 1986-February, 1987	Public exhibition of Sydney Harbour Tunnel Environmental Impact Statement
April 1987	Determination by the Commissioner for Main Roads (DMR, 1987).
April 27, 1987	Premier of NSW, Mr Unsworth, announces go-ahead for the tunnel.
May 12-14, 1987	Second reading of Sydney Harbour Tunnel (Private Joint Venture) Bill, State Roads (Sydney Harbour Tunnel) Amendment Bill and Miscellaneous Acts (Sydney Harbour Tunnel) Repeal and Amendment Bill
May 31,1987	Toll increases from 20 cents to $1 on bridge
April 1, 1988	Newly elected Liberal-Coalition Government announce stopping work on tunnel, pending legal advice on the legislation and contract
May, 1988	Government decision to proceed with tunnel.

The economic analysis was of a very rudimentary kind. It employed the benefit/cost ratio method, where the discount rate was arbitrarily taken at 4, 7 and 10 percent, even though the project was to be financed directly by the user (which would suggest that the discount rate should have been more directly related to the market rate of interest). The calculation of the benefits was confined to those arising from traffic operation on a limited section of a major network serving the cross harbour demand. The benefits quantified were travel time, vehicle operating cost savings, and accident reductions. The first benefit overwhelmed the others by an order of magnitude and was quantified by a perceived monetary value of private time - the value of which was arbitrary and controversial. Leaving aside the many philosophical and practical difficulties in choosing such a value, the more fundamental difficulty arises in respect of the method of calculating the time savings (if any).

No rational travel time/flow formula was used (compare the methodology of Unisearch Ltd, 1987a, for the NSW Department of Environment and Planning). Instead recourse was made to the American Highway Capacity Manual service volume concept which is

based on a subjective definition of levels of service. Furthermore, no account was taken of the self adjustment of the Y-value (traffic intensity) that occurs in bottle-neck situations. Certainly, some time savings will occur on the "shoulders" of the peak but these are relatively minor. Time savings of limited magnitude may well be realised if the section analysed, the bridge plus tunnel, ceased to be the bottle-neck section. But if this were the case, the bottle-neck would occur elsewhere and these possibilities were not considered in detail.

The proposed scheme does not, in any way, reduce significantly the distance, nor the length of the time, between north and south. This contrasts dramatically with the Tait proposal for the Sydney-Newcastle toll road. When over the road distance is saved the whole of the unit vehicle operating cost, not just its marginal changes, is also saved. In addition, proportionate reductions in travel time occur.

However, in spite of the many artificialities implicit in the EIS approach, the benefit/cost ratio barely reaches unity at a 7% discount rate. Two other alternative cross-harbour schemes that were suggested, in outline, in response to the public exhibition of the tunnel environmental impact statement have been subsequently examined by one of the authors (Unisearch Ltd, 1987b). One is predicated on removing the rail tracks from the existing bridge and pulling them under the water in a tunnel linking Wynyard Station with St Leonards Station; the other is a version of the"Nippon Clippon" principle by augmenting the Sydney Harbour Bridge by two additional vehicular traffic lanes. Both give better benefit/cost ratios than the tunnel. The merit of this independent study is that the overall economic assessment is comparative which avoids some of the objections of the arbitrariness in quantifying in travel time parameters and other methodological weaknesses.

But none of the studies really addressed the question as to whether or not there is a real need for increased cross harbour capacity in this already heavily loaded corridor. This brings one to the point of addressing the problem in a more fundamental and conceptual way. As Roland McKean has observed in this admirable treatise on Efficiency in Government Through Systems Analysis the most thorough methodology will not yield the "best" answer if the best alternative has not been included: "sound models and criteria will not result in picking out good policies if only poor ones are considered" (McKean, 1958, p. 97). It follows that much preliminary exploration and systems analysis must be undertaken before advancing particular projects for economic or financial appraisal, and this irrespective of whether the proposal comes from the private or public sectors.

In context , the coastal toll road to Newcastle was clearly of obvious merit. The Harbour Tunnel, on the other hand, is in conflict with many established constraints. First and foremost, it is not compatible with the government's own centres policy for Sydney. Second, as part of the inner area road network that provides limited connections across the Harbour and Parramatta River barrier, consideration should be given to the location of an additional crossing roadway between any two others to make a significant reduction in average length of trips between northern and southern origin and destination pairs. Third, its value as a by-pass of the city, which is claimed to be its major role, is compromised by the fact that it not only runs close to the "heart" of the centres it by-passes but has liberal access to them. Fourth, it has no potential for encouraging wealth producing land-use developments along it or above it, for these areas are already well developed. By contrast, a railway going to the Warringah Peninsular would give public transport parity with the rest of the metropolis, and would provide much incentive for development on the Peninsular and at many points along the Military Road corridor, connecting North Sydney with the Peninsula. A public transport alternative, such as the Abigroup rail tunnel/road proposal, would be more compatible with providing increased access to the CBD where parking difficulties already act as

powerful constraints on modal choice, and would give opportunities for land-use enhancements on the lower North Shore.

Concluding Remarks

From the foregoing examples and discussion it is clear that joint public/private enterprise in transport projects can conceive major undertakings. That one was stillborn and the other may yet be a monster teaches us some important lessons. In both cases the economic analysis seems to have been superfluous. In each, the decision taken was at variance with the result of the economic assessment and one can surmise that political expediency was the dominant consideration.

(1) It is clear that the role of economic analysis is but an aid to the decision-maker, not that of a substitute for conceptual validity and functional utility. In the face of uncertainty about outcomes, careful analysis can assist, but not supplant, the exercise of judgement as to which policy is best. In the two examples discussed, the criteria were confused as not recognising that the Sydney-Newcastle toll road provided for a free-flowing facility with very tangible benefits,whereas the Sydney Harbour Tunnel presents a major bottle-neck situation where neither distance savings, and, for that matter, time savings, are likely to be realised.

(2) Ingenuity in the designing, redesigning, and seeking (if necessary by invitation) alternative courses of action is of great importance. The devising of the alternative policies to be compared cannot be undertaken perfunctorily. When the Premier of New South Wales, Mr Unsworth, dismissed the Unisearch evaluation of cross harbour alternatives as "not adding anything new" (The Sydney Morning Herald, March, 1988) he was failing to recognise the significance of McKean's maxim that sound models and criteria will not result in picking out good policies if only poor ones are considered.

(3) Uncertainty is all pervasive with private-public sector proposals, including uncertainties due to imperfect data and techniques of estimation (since it is not cost effective to put unlimited resources into the preparation of estimates), and so possible results of a course of action should emerge as a frequency distribution, not as a single outcome. When a spokesperson for the former NSW Minister for Public Works and Roads, Mr Brereton, described the less favourable report on the tunnel by the Department of Environment and Planning, New South Wales as "economic voodoo" (The Sydney Morning Herald, 30 March, 1987) there was a failure to grasp the point that uncertainty in the values of the evaluation parameters (traffic estimates, monetary value of time, discount rates, etc) lead to a divergence in the benefit-cost ratio. Any project with economic merit should be robust with respect to the numerical results obtained by sensitivity analyses (one way of coping with "uncertainty").

(4) Intangibles are characterised by not being readily translated into the common denominator that is being used by the analyst. Although they are likely to mar the neatness of any analysis, they should not be ignored: quantitative information about these intangibles in terms of other than the common denominator may be helpful to decision-makers.

(5) When the private sector is paying it will demand a greater say in the transport planning process. Business organisations can assist government agencies and transport suppliers in a number of tasks, particularly those relating to transport to, or from, or within, the central business district (Rimmer and Black, 1987, pp. 427-428). They

include: clarifying or identifying problems and offering potential solutions; assisting the public sector with decision making; playing a direct role in implementation; financial support; and monitoring the transport process. Clearly, co-operative public-private sector partnerships already exist in central business districts in Australia (for example, the TNT Darling Harbour link monorail in Sydney).

(6) The matter of environmental harmony is of utmost importance in any joint private sector-public sector proposal when financial return may be placed above broadly-based community norms and interests. For instance, in extoling the advantages of toll road projects in the USA, Wuestefeld (1988, p.11) suggests that they do not always have to comply with federal statutes, standards and regulations, and there is usually no need to go through a review process by federal and state agencies.

(7) Finally, it is important not to confound the economic merit of a proposal with the financial viability, particularly with schemes involving the private motor car where the "addictive appeal" of the car and the paranoid of its users with traffic congestion may well have all the hallmarks, to borrow from Jonathon Swift's observation, of "vice and folly".

Notwithstanding the difficulties and pitfalls of applying economic analysis to large scale, complex projects in the private and public sectors, the two case studies reviewed here show that, providing the traffic analyses are well conceived to reflect the conceptual and functional characteristics of the alternatives, the economic tests do give the right points for the decision makers.

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References

Blunden, W. R. (1960) "Consolidated Report on Studies and Evaluations Carried Out by the School of Traffic Engineering on the Proposed Sydney - Newcastle Toll Road", December.

Cameron McNamara (1986) Sydney Harbour Tunnel: Environmental Impact Statement prepared for Transfield-Kumagai Joint Venture by Cameron McNamara Consultants, November.

Department of Environment and Planning (1987) Proposed Sydney Harbour Tunnel: Environmental Impact Assessment (Sydney: Department of Environment and Planning, New South Wales).

Department of Main Roads (1976) The Roadmakers: A History of Main Roads in New South Wales (Sydney: Department of Main Roads).

Department of Main Roads (1987) Sydney Harbour Tunnel: Report on Environmental Impact Assessment Pursuant to Clause 64 of the Environmental Planning and Assessment Regulation 1980 (Sydney:|Department of Main Roads, New South Wales), April.

McKean, R. N. (1958) Efficiency in Government Through Systems Analysis-with Emphasis on Water Resources Development (New York: John Wiley and Sons)

OECD (1987) Toll Financing and Private Sector Involvement in Road Infrastructure Development (Paris: Organisation for Economic Cooperation and Development).

Rush, A.G. (1988) Private Sector Alternatives for Transportation: An Annotated Bibliography (Monticello, Illinois: Vance Bibliographies - Public Administration Series).

Unisearch Ltd (1987a) "The Proposed Sydney Harbour Tunnel: Some Comments on Vehicular Traffic Projections and Their Implications for Economic Evaluation", A report prepared on behalf of Unisearch Ltd by J A Black and G H Kim for the Department of Environment and Planning, New South Wales (Kensington, NSW: Unisearch Ltd), February.

Unisearch Ltd (1987b) "Cross Harbour Transport Study - An Appraisal of the Sydney Harbour Tunnel and Some Alterations - Phase I", A report prepared on behalf of Unisearch Ltd by J A Black for Save Our Sydney Group (Kensington, NSW: Unisearch Ltd), December.

Upton, T. H. (1932) "The Establishment of direct road communication between Sydney and Newcastle", Journal of the Institution of Engineers, Australia, Vol. 4, nos. 5, 6 and 7 (reproduced by the Department of Main Roads, New South Wales).

Wuestefeld, N. H. (1988) "Toll roads", Transportation Quarterly, Vol. 42, pp. 5-22.

Appendix I: Summary of Economic Evaluation - Parameters for the Sydney - Newcastle Tollroad

Parameter	Value
Construction costs	29 million pounds (to Gosford - 4 lanes) -equivalent to about $500 million in current prices
Monetary value of time	192 pence per vehicle-hour
Road User Cost	Average road user cost by speed, road type and vehicle class-from 9 pence per vehicle mile (car, 2% grade) to 60 pence per vehicle mile (heavy truck, 8% grade)
Tolls	Cars $1\frac{1}{2}$ pence per mile plus 2 shillings at Hawkesbury Bridge; trucks 3 pence per mile plus 4 shillings at Hawkesbury Bridge
Traffic Estimation	Unconstrained gravity model using populations of centres and travel time
Revenue	4.7 million pounds per annum average over 20 years operation

(Source: Blunden, 1960)

Appendix II: Summary of Economic Evaluation-Parameters for the Sydney Harbour Tunnel

Parameter	Value
Construction costs (limited clearance tunnel)	$395 million
Annual operating/maintenance cost	$7.9 million
Weighted monetary value of time	$6.00 per peak hour (1992-1999) $7.70 per hour (1993 onwards)
Vehicle operating cost	$0.16 per veh/km
Vehicle occupancy	1.4 persons/vehicle
Vehicle accident costs	$0.01 per veh/km
Fuel savings	$0.55 per litre
Traffic estimation ("most likely") for bridge and tunnel	$Y = \frac{13500}{1 + 10^{(-0.644+0.028X)}}$ where, Y = average annual weekday traffic southbound X = number of years (base 1975)
Benefit cost ratios	1.9 at 4% p.a. discount 1.2 at 7% p.a. discount 0.8 at 10% p.a. discount

(Source: Cameron McNamara, 1986)