

TRANSPORT ECONOMICS IN AUSTRALIA --  
THEORY, PRACTICE, CONFUSION AND CHALLENGE

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**ABSTRACT**

*This paper addresses a widening gap in the application of transport economics in Australia. On the one hand there is a strong interest in economic evaluation and a growing need for sophistication to cope with issues of national concern. On the other hand advances made in the 1970's in transport economic theory have largely been ignored or misunderstood with the result that in many cases the technology in use in Australia is out-of-date or otherwise erroneous. There is also an acute shortage of skills.*

*The paper briefly exhibits the type of economic skills that will be necessary to properly evaluate the contribution of export roads and then reviews the theory which has emerged since the early 1970's, including personal travel, freight movement and industrial development issues, and discusses some confusion that has arisen and other reasons why this methodology has generally not been more widely adopted, despite it being highly relevant to emerging issues of road funding in Australia.*

## INTRODUCTION

This paper addresses a widening gap in the application of transport economics in Australia. On the one hand there is a strong interest in economic evaluation and a growing need for sophistication to cope with issues of national concern. On the other hand advances made in the 1970's in transport economic theory have largely been ignored or misunderstood with the result that in many cases the technology in use in Australia is out-of-date and almost irrelevant to the task.

The next section discusses the historical development of transport economic theory and practices so that the current division in interests is highlighted in this context. The following section briefly reviews the developments in transport economic theory that took place in the 1970's and discusses some of the reasons why these developments were not adopted despite their relevance to current needs.

## HISTORICAL DEVELOPMENT OF TRANSPORT ECONOMICS

### Traditional methods

In Australia during the 1960's the State Road Authorities (SRA) were basically interested in least-cost or cost-effective road building technology and seldom considered they needed to employ a qualified economist.

From the mid-60's, the Commonwealth Bureau of Roads was active in promoting economic rationale and, largely as a result of its influence, Australia emerged from 'sufficiency rating' technology and began to apply economic methods with models such as MERRI (see LACK 1968) or NAASRA (1982), which followed the American Association of State Highway Officials basic methodology, (See AASHO 1952) concentrating on the potential for road improvements to create vehicle operating costs (VOC), road maintenance costs and user time savings.

Research topics of the day were the components and values of VOC (see PELENSKY 1968), the economic value of user time, maintenance costs or algorithms for resolving project priorities within limited budget constraints.

### Influences for change

In the early 1970's new pressures arose for better theory and practice of economic assessment of transport projects. The situation started to change in urban areas after the urban freeway program began failing in the face of public protests in the late 1960's.

Socio-economic and equity issues became an essential part of EIS procedures developed in the early 1970's. In this context, economic rationale based on VOC, user time and maintenance cost savings was totally inadequate and it was clear that improved procedures were required.

Further, public transport deficits began to be accepted in the early 1970's instead of new freeways and this led to a keener interest by State and Federal Treasuries in road funding. Tied financial arrangements, previously enjoyed by the SRA's, became unravelled and road funding became tighter. Instead of just concentrating on road-based cost savings, the evaluation technology needed to reflect a wider concept of the economic impact of road developments.

In developing countries with interests in World Bank or other aid programs, highway economic evaluation techniques, which also relied on VOC and maintenance cost savings, were being applied, mainly in rural areas. But this methodology was also being seen to be less and less relevant to the economic development issues it was meant to address.

The technology bore little relationship to rural industry development despite the fact that the road projects were often framed within an integrated rural development aid package. They also bore almost no relationship to welfare motives and socio-economic objectives, such as assisting in education or health delivery, or the humanitarian basis on which most of these aid programmes were founded. Post-project evaluation usually found there was a stark contrast between the development impacts that took place during or after construction and the lack of quantitative forecasting of these impacts during the feasibility studies.

In addition, it was easy to point to serious anomalies that arose from such a limited evaluation perspective.

For instance, if, as happened during the 1970's, fuel prices increase dramatically, then this economic rationale based on VOC, user time and maintenance cost savings leads to the economic conclusion that more roads should be built, as fuel cost savings would be greater. Of course when fuel prices soared, traffic volumes dropped in many countries, so there was less need for road construction.

This approach also means that roads, say in Bangladesh, carrying large volumes of human-powered bicycle or bullock carts, have almost no economic significance and should not be improved to a standard where they can efficiently carry motor vehicles since VOC and maintenance costs are small and road improvements cannot create savings in them.

The method also should not be applied to a completely new road, since, if a road is to carry traffic, it adds VOC, accident, maintenance and user time costs, not save them.

### Changes during the 1970's

Under this critical pressure, the early 1970's saw a watershed of research and change in economic evaluation technology as practitioners tried to come to grips with the realities of these criticisms and anomalies.

The critics wished to see a more socio-economic approach, which better reflected the human and social development objectives of road improvements. In an early step towards this, road user time savings methodology was improved, for instance in NIMPAC, a road planning model and part of the NAASRA Data Bank System. A concept of 'consumer surplus' to evaluate induced traffic was included, which is discussed later in this paper. (Also see OVERSEAS DEVELOPMENT ADMINISTRATION 1972).

A more correct approach, which provided a coherent logic for the valuation of personal travel and its incorporation into transport economics, arrived in the early 1970's due to the work of authors such as McINTOSH AND QUARMBY (1970) and NEUBERGER (1971). Concepts such as 'perceived prices' and 'generalised cost' were introduced, which provided a link between transport economics and the more traditional mainstream of economic thought, embracing micro-economic pricing notions and welfare economic principles and provided an intellectual integrity to the techniques.

This approach, which is outlined later in this paper, was initially applied in urban areas, the first application in Australia being the SYDNEY AREA TRANSPORTATION STUDY (1972) and it is of interest to note that the Urban Freeway Study, simultaneously being conducted by the Commonwealth Bureau of Roads, used the older, traditional approach and provided quite different results for the same projects in Sydney.

The same principles, albeit with a conservative attitude to consumer surplus, also saw early application in Australia in rural development economics but in the field of tourism. See NAIRN (1973). It is used in rural road evaluation in developing countries (See NAIRN 1988), but the World Bank's HDMIII model, while providing a substantial advance in road maintenance thinking, has not yet adopted this economic methodology. (See WATANATADA 1985).

Another criticism, that the old methodology bore little relationship to rural industry or agricultural production, which obviously benefits from rural road projects, also was answered when another significant innovation was introduced

by World Bank, called the 'producer surplus' approach, which is briefly discussed later (see WORLD BANK 1976).

The mechanism under scrutiny was the degree to which transport improvements reduced freight costs thus effectively increasing farm-gate prices for agricultural products. These cost reductions lead to increased profitability and may lead to increased production. The value of the 'producer's surplus' is legitimately attributable to the transport improvement. This method required the analyst to become much more aware of transport pricing impacts and mechanisms and their effect on rural development. While the theory is quite different, there are similarities between this approach and the methods applied to beef road projects in Australia in the 1960's.

Yet another group of critics pointed out that, while savings in VOC due to improvements on a road link may be substantial for that link, the induced traffic creates additional VOC on other unimproved links in the network (some links may lose traffic by diversion and accrue VOC savings). The savings in VOC for the network as a whole may be substantially less than that for just the link being improved. The same comments apply to the savings in maintenance and accident costs. In practice this means that these benefit items in fact become smaller and are only a relatively small proportion of the total benefit stream. (See NAIRN 1988).

This growing recognition of network inter-relationships was a further influence for change in evaluation methods. It was again easily understood and accepted for urban projects but those working on rural projects were slower to accept it and it is still not implemented within NIMPAC or HDMIII.

#### Recent directions

Current SRA interest in transport economics is now mainly in road investment analysis and pavement management systems, in recognition of the high proportion of SRA's budgets devoted to maintenance activities. This interest has mainly had an engineering rather than an economic flavour resulting in emphasis on issues such as pavement life-cycle details rather than on development benefits.

Other bodies have emphasised improvements to roads in Australia which link to export industries, which reflects public concern for Australia's continued poor balance of payments performance, despite low exchange rates, and the strain this places for high interest rates necessary to attract continued overseas investment in Australia. The technology requirements for analysis of this policy can be assessed from the following discussion.

### Road improvements and export industries

A reduction in transport costs for exports increases the competitiveness of our export production and may lead to an increased volume of exports and increased export earnings. Where Australian goods compete in highly competitive export markets, such as sugar, or against goods which are highly substitutable, such as wheat, export price elasticities should be high and transport improvements may lead to quite high economic benefits for Australia.

Most Australian exports are in the primary production sector, and while this helps to identify their location, the industry is so spread it does not help identify particular roads for improvement. It is also not quite that simple as a major proportion of primary production is subject to domestic or world market restrictions (sugar), price or market stabilisation schemes (wheat or wool), domestic subsidies (dairy products) or regulatory measures (uranium or coal). These market mechanisms may distort or negate the price reduction effect offered by transport improvements.

In non-rural areas most roads are heavily trafficked and travel is ubiquitous, so it is difficult to relate the traffic on a particular road to a particular export source.

Furthermore, the same market-port road improvement that reduces export prices, typically reduces import prices too. This may lead to an increase in imports and a disbenefit to the Australian economy. The types of goods and commodities that Australia imports, such as motor vehicles, fabrics and garments or manufactured goods, are highly competitive against our domestic industry.

The project selection process must, therefore, be very carefully undertaken for this policy to be a success. As import-replacement is as important as export promotion to the balance-of-payments equation, it is worth a wry mention that digging up some port-market roads may assist import-replacement policies by increasing the price of imports.

### Current problems

This increasing emphasis on economic rationale and increased sophistication and comprehensiveness in the technology expected to be applied, is completely out-of-line with current road evaluation practice, as, in Australia, the economic methods normally being applied are largely not even reflecting the changes in technology that took place in the 1970's and there are still very few qualified experienced economists in the SRAs. In addition

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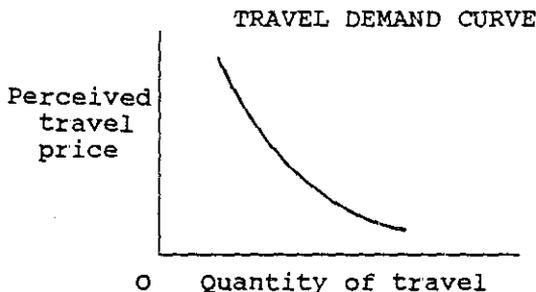
with these benefits. This section sets out an explanation of this theory.

Development infers an increase in the range and intensity of activities available to people, who choose to live where they do because the opportunities for economic and social participation is of greater intensity than in other areas. It is not possible to directly put a value on "participating in economic or social activities", however, if it were not worth at least the price paid for it, then people would not participate at all.

In general people do not wish to travel and it is seldom of value for its own sake, but, people do want to participate and, as different activities necessarily are separated from each other, travel is an inevitable consequence of this participation. Travel, therefore, has value because it enables people to take part in activities that are valued. It is valued at the travel price incurred in undertaking it and this value can quite legitimately be attributed to the transport system. Measurement of personal travel benefits is therefore a proxy for the enumeration of the peoples' participation in normal economic and social affairs.

If the price of any trip can be reduced, then people will be induced into taking part in more activities, because they have more time or because travel is cheaper. They will gain greater benefits, even if they travel more often in order to participate more. Therefore increased trip-making is an indicator of increased benefits. Many activities are virtually compulsory like going to work or school, but even for these activities, personal travel surveys show that people travel more frequently if the travel cost is lower.

The demand curve for travel, therefore, is much the same as any other demand curve as illustrated below:-



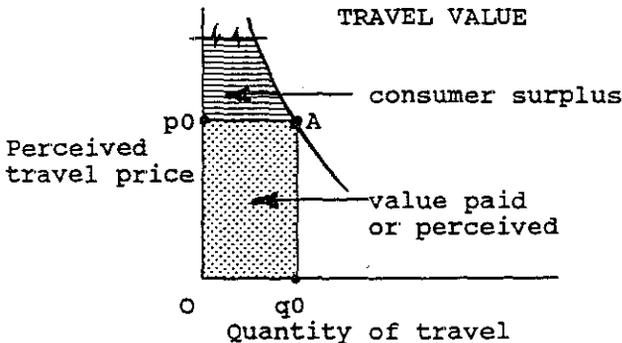
Not all travel is valued the same since not all people have to pay the same price for the same activity. Some people will travel long distances to see a football match 'away'

and sit next to a 'home' fan who is equally pleased to be there but only had to travel a short way. Thus some people have their participation 'on-the-cheap' and would have been prepared to pay more. To allow for this effect, consumer surplus is added to the travel price in valuing travel.

Travel price is not just the fare paid or the cost of petrol used for the trip, but, since people value their time, this must also be added to the travel price to value the trip. Further people are not very good at knowing the price of a trip. They often do not know accurately how long the trip took or how much petrol, oil and tyres were consumed or even the fare they paid. Perceptions of trip 'cost' may be quite different for travel in an air-conditioned car than standing in a crowded bus. In valuing personal travel it is necessary to use peoples' perceived travel cost, assessed from their actual travel habits, because their perceptions govern their travel demands.

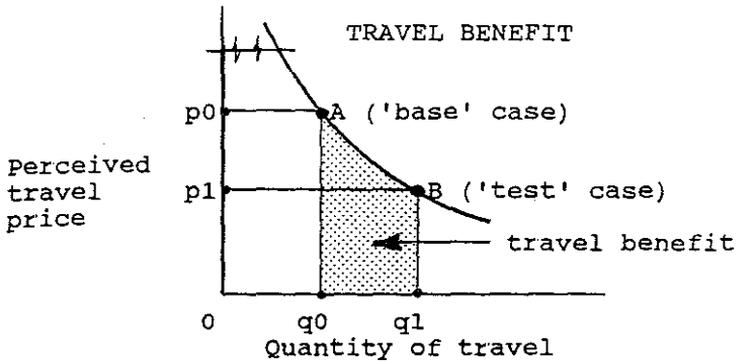
Conversely, only the perceived price of travel can be measured in travel surveys, not its actual cost. Travel demand curves based on travel surveys, are directly useful in measuring the value of travel.

In the 'base' case, travel is assumed to have reached equilibrium at the point A ( $p_0, q_0$ ) on the demand curve as shown in the diagram below. The value of travel is the price perceived to have been paid for it ( $p_0 * q_0$ ) plus the indeterminate value of consumer surplus.



If a transport improvement reduces travel prices and thereby induces more travel, then the equilibrium point shifts along the travel demand curve to the point B ( $p_1, q_1$ ) as depicted in the diagram below:-

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The initial value of travel is the rectangle  $0.p_0.A.q_0$  plus the consumer surplus wedge, and the new value of travel is the figure  $0.p_1.B.q_1$  plus the new consumer surplus wedge. The benefit, or change in value, is the area  $q_1.q_0.A.B$ . If the curve between A and B is taken as a straight line, then the travel benefit is calculated by the formula:-

$$\text{Travel benefit} = 1/2 * (q_1 - q_0) * (p_1 + p_0)$$

Although travel time and VOC are used in assessing the value of personal travel, the actual benefits associated with savings in travel time or VOCs themselves, due to a transport improvement, have not been taken into account twice in this procedure. There is no double-counting.

Personal travel benefits only appear if, as a result of project improvements, there is an increase in total travel. As this benefit can become a large, even dominant, source of project benefits, it is very important that the slope of the demand curve is accurately determined and that the resulting trip generation is credibly assessed.

The reason why people travel (trip purpose) is basically irrelevant in this theory, nor does it basically matter which travel mode is adopted, provided the correct generalised cost is computed, although the theory can be applied to an analysis of travel by mode or purpose.

### Comparison with the traditional method

The traditional method of simply computing savings in maintenance, accidents, VOC and user time costs, items(a)-(d) above, is clearly only a partial evaluation when compared with the methodology which includes the above personal travel benefits as illustrated in the following table, which reports the results of a recent road project feasibility study in Papua New Guinea:-

COMPARISON OF RESULTS OF DIFFERENT METHODS  
Mt. Hagen-Baiyer River-Ruti Road Feasibility Study  
Costs/benefits are Net Present Values @ 12% K'000

Cost/Benefit item'	Above	Traditional
<b>COSTS</b>		
Construction costs	K 11,004	K 11,004
<b>BENEFITS</b>		
Savings in maintenance	K 2,332	K 4,780
Savings in accidents	K -1	K 2
Savings in VOC and user's time	K 3,146	K 3,494
Personal travel	K 11,244	K n.a.
Freight movement	K 394	K n.a.
Agricultural production	K 184	K n.a.
<b>TOTAL BENEFITS</b>	<b>K 17,299</b>	<b>K 8,276</b>
<b>Benefit/Cost Ratio @ 12%</b>	<b>1.572</b>	<b>0.752</b>

Source: CARDNO & DAVIES (1988)

This example relates to a road which already carries a fair volume of traffic for much of its length and part of which is already sealed. It serves no strategic purpose other than serving its immediate catchment area and the induced travel was about 10 percent. Despite this the traditional method only reveals about half of the stream of benefits, and those it computes are overstated and distorted in importance. It must be concluded that the traditional method is sufficiently partial to be misleading and therefore in error. The difference in maintenance and VOC savings between the two methods is mainly because, in the correct method, the network effect offsets some of these savings due to added costs on other links.

**A confusing and diverting error**

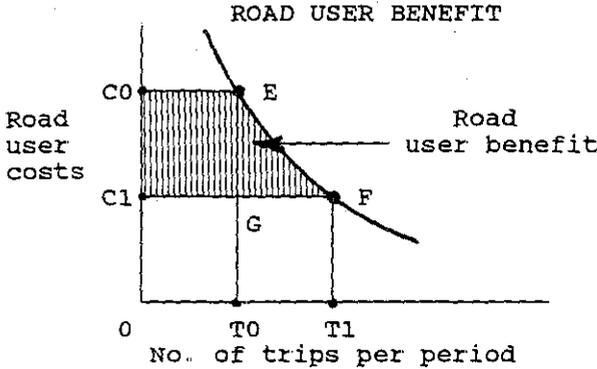
One problem that has inhibited acceptance of the method to compute personal travel benefits is that it appears to be a modification of the traditional method, so that people become confused. The savings in VOC etc are, of course, simply the change in consumption in economic prices ( $p_1 \cdot q_1 - p_0 \cdot q_0$ ), however, to illustrate the confusion, a method, which can be seen in recent literature, is given below. This is to compute road user benefits (UB) from user time savings and VOC savings using the formula:-

$$UB = 1/2 \cdot (T_0 + T_1) \cdot (C_0 - C_1)$$

where  $T_0, T_1$  are the before and after trips  
and  $C_0, C_1$  are the before and after user costs

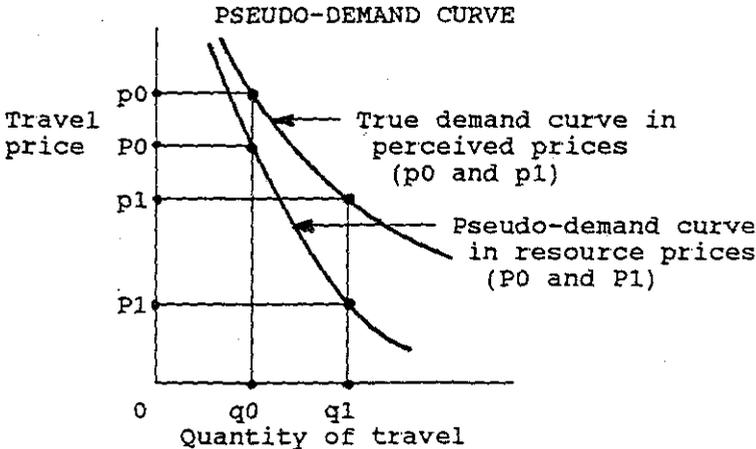
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and explain that, in the diagram below, the area E.F.G represents the consumer surplus for generated trips, but that the area C0.C1.G.E represents new benefits for existing users. This is quite wrong, because the benefits represented by this area simply change from perceived benefits (ie they had to pay for them) to consumer surplus benefits (that they did not have to pay for).



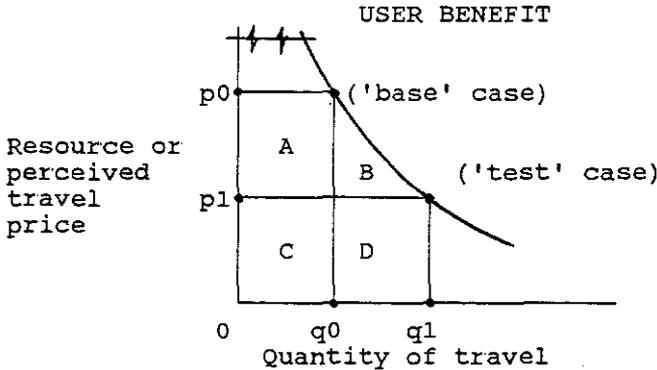
In this context the process of paying for the benefit is only important in that 'paying' (in perceived prices) establishes the demand. It is irrelevant to the economic evaluation, as it is simply a transfer payment like fares.

This explanation also mixes up perceived prices with economic prices. The user costs are valued in economic costs, but a demand curve can only be for perceived or behavioural costs and consumer surplus is valued in these terms. Drawing a pseudo-demand curve drawn from resource prices in the diagram below illustrates the problem.



The pseudo-demand curve may be shifted from, and have different elasticities to, the normal demand curve and will give erroneous results if used to predict trip generation.

Further confusion arises if it is assumed that resource costs and perceived costs are the same. Then it has been argued that the procedure outlined above is the same as the correct method, involving a computation of personal travel benefits and making a 'resource correction' to allow for the resources consumed (travel time, VOC etc.).



In terms of the areas labelled in the diagram above:-

$$\begin{aligned}
 \text{User benefit} &= \text{Travel benefit} - \text{Resource correction} \\
 &= \text{Travel benefit} - (\text{new cost} - \text{old cost}) \\
 &= (B+D) - ((C+D) - (A+C)) \\
 &= A+B
 \end{aligned}$$

The 'resource correction' represents items (b) - (d) above.

The above set of statements are true only when perceived and resource prices happen to be exactly the same. If the 'generalised cost' structure is examined, as set out below, then it is obvious that this coincidence is very unlikely.

$$\text{Generalised cost} = \text{Travel time}(p) \text{ (for all travellers)} + \text{VOC}(p) + \text{Parking fees (private riders)} + \text{Fares (transit riders)}$$

$$\text{Resource cost} = \text{VOC}(r) + \text{travel time}(r) \text{ (for all riders)}$$

where

$$\text{Time}(p) = \text{Person's own valuation of his time including comfort, uncertainty and other proxy items}$$

$$\text{Time}(r) = \text{Economic valuation of actual productive time}$$

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VOC(p) = Perceived value of VOC (little more than petrol costs but including taxes)

VOC(r) = Economic value of VOC (but less taxes etc.)

Of course perceived VOCs are likely to be much less than VOCs in resource costs, but perceived values of personal time are likely to be higher than resource values of time. So, while it is conceivable that the two cost equations could coincidentally be equal, it is highly improbable.

The presence of this confusing and diverting error is most unfortunate and it is quite commonly found in practice.

### **Implications of, and resistance to, the corrected method**

The difference between the two methods is not just the changed results, which only require quite small changes in computational effort, but is fundamental in theoretical approach and also has serious implications for forecasting techniques, which lead to some resistance to its acceptance.

The theory will not allow the practitioner to be myopic and preoccupied with the immediate environs of the road and its users, but looks at personal travel and freight movement as elements of the surrounding economy. It concentrates on travel and freight pricing impacts as the key to economic development and recognises that, through this mechanism, road improvements can become a lubricant to economic change. This focus places greater emphasis on economics rather than engineering skills, but, as there are so few practising economists, there is resistance to change.

As the above PNG project shows, only a small amount of new travel makes quite a difference in the results. As personal travel benefits exist only when travel is induced, the difference in the two methods also requires that travel forecasting techniques must accurately estimate new trips.

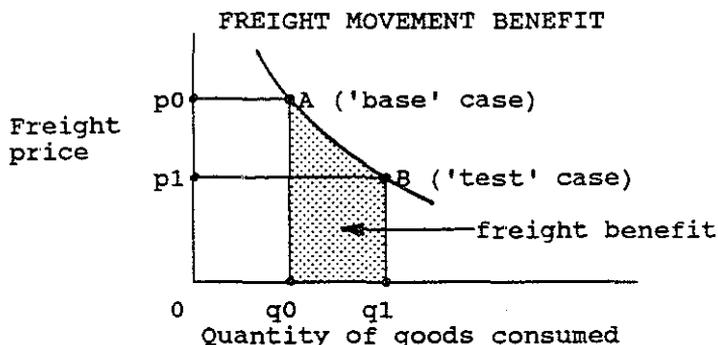
There is no room for confusion about pseudo-demand curves, but it is often claimed it is too difficult to establish the travel demand curve. However, this only involves small sample O/D surveys. The procedure is set out in NAIRN (1977) and involves calibration of initial assumptions relating to the perceived value of travel time but is not highly sensitive to quite large changes in this assumption.

Some practitioners believe that traffic generation due to road improvements is negligible or so small as to not justify the forecasting effort it requires. However, if the road improvement has reduced travel or freight prices, then trip generation is undeniable. The price elasticity of demand for activities or consumption involving travel or

freight movement is not zero. As a corollary, it is not really possible for those who model changes in a transport network with fixed O/D trip tables to carry out economic evaluation correctly. Even where trip generation models are sensitive to changes in the network, it is very important to ensure that trip generation is not over-estimated simply because this relationship has not been iterated to its equilibrium. (See NAIRN & PARTNERS 1986).

**Freight movement economics**

Freight movement economic evaluation methodology relies on exactly the same principles and procedures as personal travel economics. One relates to the movement of people to participate in economically desirable activities, the other to the movement of goods for consumption.



The consumption of general goods is price elastic and, insofar as their market price can be reduced because the freight cost is reduced by transport improvements, a benefit is attributable to transport system improvements.

$$\text{Freight benefit} = 1/2 * (q1 - q0) * (p1 + p0)$$

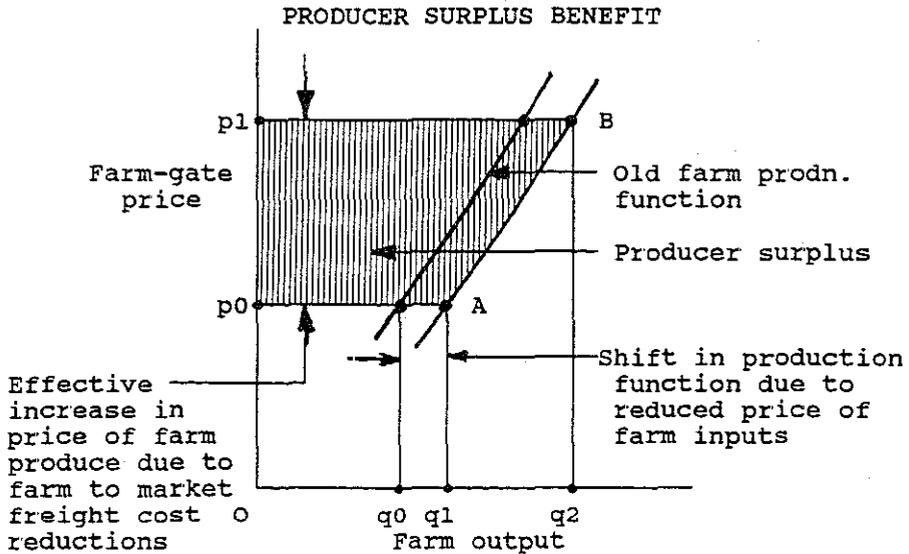
Gross freight price elasticities generally range between 0.9 and 1.05, but should reflect the degree to which savings in VOC or drivers wages etc. are in fact passed on by the freight industry in the form of reduced freight prices. Usually the freight industry is highly competitive and cost reductions translate into price reductions in the short term, however freight is not an unrestricted market and this needs to be investigated in each application.

**Industrial production**

The World Bank 'producers surplus' methodology shifts emphasis away from consumption of freight to the production functions of industry and it is suitable for all forms of

urban or rural industrial development impacts, not just the rural agricultural setting in which it is explained below.

The method presumes that freight price reductions have two effects. Farm inputs, such as fertilisers, are cheaper at the farm-gate if freight prices are reduced, and this shifts the production function so that more farm output is produced. In addition, if the farm-to-market freight cost is reduced, this is equivalent to an increased farm-gate price for the farm output, which in turn induces increased production. The method is set out in the diagram below:-



The area  $p_1.p_0.A.B$  is the producer surplus attributable to the road or freight service improvement. The elasticity of the production function is usually taken to be the gross export price elasticity (because this is usually easily obtained in developing countries) although this should relate to the total market elasticity not just exports. However, in assessing the elasticity, it is also important to review the marketing chain to assess the degree to which potential freight cost savings are translated into price reductions. This is more specific for each industry or crop and needs careful assessment in each application.

Computing the shift in the production function typically involves case study investigations into a sample of farms (or industries) and is much more cumbersome. Typically the freight component in the cost of inputs is higher than that for outputs so this shift can be an important element in the computation of benefits. It is probably due to these requirements that the method has not been so widely used.

Care needs to be taken to ensure that travel benefits, freight benefits and producer benefits do not overlap where all three types are included in the one evaluation.

### CONCLUSIONS

At a recent conference one speaker expressed the wish that the economic evaluation of road projects would become so automated that it could be carried out without involving qualified highway engineers. It is an ironic twist that part of his wish is likely to be fulfilled as the directions in which economic evaluation technology is moving will increasingly require non-engineering skills.

The paper has shown that, due to confusing explanations of methodology in the past, transport economic evaluation technology in some parts of the industry in Australia has not absorbed innovations of the 1970's and so has been led into a position where results frequently understate the benefits available and where economic priorities are being distorted. This is because the traditional method is only a partial evaluation, which is sufficiently incomplete as to be incorrect. In addition, some practitioners are using a modified method, which is wrong in theory as well.

In the context of documenting the need and priorities for road funding in Australia and ensuring that funds are well spent, the requirements for economic methodology and skills for the near future in Australia far outstrip the current achievements and it will be necessary to upgrade evaluation performance, particularly in the area of freight movement and in relation to export industries, if Commonwealth and State interests are to converge. The need is not just for corrected methodology but the buildup of economic skills in State Road Authorities also needs to be accelerated.

### ACKNOWLEDGEMENTS

In writing this paper, which labels some practices as out-of-date and, by being incomplete or theoretically confused, erroneous, the author has been careful to ensure that this criticism applies only to recent works, not those which are out-of-date simply due to the passage of time. He has also been careful to refer only to published explanations, where they exist, and must express some sympathy with those authors who have avoided economic jargon in order to provide comprehensible texts and, in so doing, may have felt the need to simplify the theory. The responsibility for the implied criticisms are the author's and they must, in turn, withstand their professional scrutiny.

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The author also wishes to express his thanks to those who, in the interests of enhanced professional progress, encouraged the writing of the paper and provided reference material or other advice for this purpose.

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