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A GENERAL AND A SUGGESTED ECONOMIC APPRAISAL  
OF RAPID TRANSIT IN AUCKLAND - 1970.

(With Particular Reference to a Cost-Benefit  
Analysis).

A dissertation submitted in partial  
fulfillment of the requirements for  
the degree of Master of Social  
Sciences, University of Waikato.

R.K. DOUGLAS. 1971.

### ACKNOWLEDGEMENTS

Acknowledgements are due in the first instance to the Auckland Regional Authority for the research grant which made this study possible and for the facilities and information made available to me while engaged on the project. I am grateful for the opportunity of having been able to participate in such an interesting study. In turn it is hoped that this economic study will be of some practical value at a later stage, but if not, that it will at least point to the areas of future research need in this field: I would like to express my thanks, to Dr. M.A. Taylor of the Auckland City Council for useful comments and references; to the numerous other persons engaged on the rapid transit project and whose opinions, ideas and information helped shape this study; and to Miss B. Magoffin who typed the notational expressions. Finally, but most importantly, I am grateful for the time and valuable assistance given to me by Professor J.T. Ward.

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## INTRODUCTION

### 1.1 Aim and Orientation of the Study

The Auckland urban area's transportation needs have been the subject of much discussion and investigation in recent years. The Auckland Rapid Rail Symposium of August, 1969<sup>1</sup> was typical of this state of affairs. Partly as a consequence of this symposium, investigations as to the feasibility of a rapid transit system (specifically rapid rail transit) were re-opened after a lapse of approximately six years had not seen any positive action to implement the recommendations contained in the De Leuw Cather report, "A Regional Transit Plan".<sup>2</sup> The Minister of Finance, R.D. Muldoon, stipulated in his opening address to the symposium that a prior condition for Government financial assistance in respect to the capital cost of a transit system, was that a cost-benefit analysis should be undertaken in conjunction with the technical and planning investigations. At the same symposium, J.T. Ward<sup>3</sup> presented a paper suggesting broad guidelines and an indication of the approach that would be appropriate to such an economic analysis.

Having established the need for a cost-benefit analysis, the programme of research, begun at the beginning of 1970 and culminating in this report, was initially orientated toward the practical application of the guidelines suggested by Ward. The aim was to evaluate which, if any of the proposed transit systems was worthwhile on a net social benefit basis and the

1. Auckland Branch, N.Z. Institute of Engineers, Proceedings of the Auckland Rapid Rail Symposium, August, 1969.
2. De Leuw Cather and Company. A Regional Transit Plan, July, 1963.
3. Ward, J.T. "Cost-Benefit Analysis for Auckland's Rapid Transit System!" Proceedings of the Auckland Rapid Rail Symposium, August, 1969.

ranking of the various projects accordingly.

Such an empirical analysis did not prove possible within the year allocated to produce a meaningful result, the reasons being, the incompleteness of the updated transportation study and the incompleteness of the technical feasibility and cost estimation studies. It was therefore necessary to change the basic approach of this study from an empirical analysis to a suggested theoretical economic analysis. This however required something additional to the mere annotation of the possible benefits and costs of the various transit systems. Thus the emphasis of the study was shifted to those areas which are recognised in the literature as having a minimum theoretical basis and to those areas where noticeable information gaps existed and which would therefore have affected the ultimate accuracy of an empirical analysis.

Specifically these areas are:-

1. The determination of the base system or null alternative. The system providing the basis for the estimation of incremental costs and benefits.
2. The consideration of the transportation planning and economic approaches to measuring urban travel demand and the feasibility of using a consumer surplus approach as a theoretical basis for the measurement of direct benefits.
3. Detailed consideration of the output produced by the urban transportation planner as a basis for benefit measurement and the integration of the planning and economic approaches.
4. The imputation of the value of passenger travelling time.
5. The imputation of the value of commercial vehicle time savings.
6. The source of accurate vehicle operating costs to be used in benefit evaluation.

As previously stated the orientation of the study is a suggested general and economic appraisal of Auckland's proposed

transit systems with the objective being to provide a basis for an empirical cost-benefit analysis if contemplated in the future by the Auckland Regional Authority and other organisations responsible for the 1970 programme of investigations.

### 1.2 Nature of the Urban Transportation Problem.

The nature of the urban transportation problem is well outlined in the literature and a detailed analysis is therefore un-warranted. The problem in brief has two elements. Firstly, the problem of traffic congestion generally and secondly the decline in efficiency and usage of commuter rail and conventional bus transport. The first element is a result of the lag between the supply of urban road space and rising demand concomittant with rising levels of real income per capita. Where cities are readily adaptable to additional freeways and motorways (as in the American experience) the pressure of demand for urban road facilities culminates in such motorised metropolises as Los Angeles; - an urban environment heavily dissected and dislocated by urban motorways. As Buchanan<sup>1</sup> concludes "the American experience suggests that the belief that traffic congestion will itself set a limit to car ownership is invalid". On the economic side L.C. Fitch<sup>2</sup> writes that "indications in America are that the costs of providing road space for motor vehicle use in large high density urban centres often substantially exceeds the revenues generated by motor fuel taxes and other user charges". In addition heavy motor vehicle usage imposes unpriced social costs.

1. Buchanan, C.D. Traffic in Towns.

2. Fitch, L.C. and Associates, Urban Transportation and Public Policy.

The second element of the problem is in many aspects related to the first since conventional bus public transport is directly competitive for scarce road space with private transport, and its efficiency is therefore diminished by increasing traffic congestion. Coupled with rising car ownership and a reduction in the number of captive riders, patronage of public transport services has also diminished. The relative decline in revenue plus constantly rising expenditure (largely through wage payments) has meant increased operating losses and a tendency to cut uneconomic services, and the levying of increased fares. The undoubted inferior social status of public transport and the psychological impact of increased fares leads to a further decline in the level of usage. The vicious circle argument therefore prevails.

Oi and Shuldiner<sup>1</sup> report that budget studies of American urban families reveal the importance of travel and transportation; that the bulk of transportation expenditure is attributable to private transportation and that the proportion attributable to the private mode is increasing. Consumer preferences indicate increased use of private transportation particularly for recreational, shopping and other related trip purposes. The absolute decline in public transport usage is relatively more apparent in the off-peak hours, hence a further factor in the urban transport problem is the large investment

1. Oi, W.Y., and Shuldiner, P.C., An Analysis of Urban Travel Demands, pp. 10 - 22.

in public transport facilities which only attain maximum utilisation in the peak hours for the commuter work trip.

The solution to the problem according to many experts is the building of mass transportation systems which eliminate direct competition with the private mode and which radically improve downtown or central area accessibility. The argument that the rail mode is a viable alternative to the privacy and convenience of the private motor car is partly based on a least cost solution to increased urban travel demands. The fact that rapid rail transit is at the present time the most operationally feasible of the radically different types of transport is also not without importance.

On the other hand Wilbur Smith and Associates<sup>1</sup> contend that "it is recognised that better urban public transport facilities should be developed as a necessary urban service and not in general as replacements for urban highways". The issue is then, despite consumer preferences, can an urban area and the national economy afford the investment in both private and public facilities. Financial constraints may preclude one of these investments despite justification on a net social benefit basis. If private mode users cannot be diverted to the public mode it is extremely doubtful if any investment in public transport can be proved socially worthwhile. If investment is deemed desirable on the basis of some redistributive welfare criteria then the issue is again the source of finance and the ultimate source of the necessary subsidy, since it is generally evident that a public transport system is not self supporting on a user pays principle.

1. Wilbur Smith and Associates, Transportation and Parking for Tomorrows Cities.

### 1.3 Auckland's Urban Transportation Problem

Auckland by comparison with American urban areas possessing, building or contemplating rapid transit systems, does not have an extensively developed urban motorway system. The level of car ownership although high by world standards has not reached the American level or the expected saturation level, thus implying that increased demands are likely to be made for urban motorways, local streets and parking facilities rather than public transport services. An intuitive and somewhat superficial examination of peak hour urban road capacity suggests that Auckland does not yet suffer the crippling traffic congestion that prevails in other larger urban areas of the world.

Auckland's particular urban transport problem is the declining efficiency of the existing public transport system and the fact that increased operating losses are continually being met out of general local authority revenue. Despite temporary national Government relief measures this situation cannot continue indefinitely without some definite policy as to the future of public transport. Rather than rationalise the present disordered system of public transport in the urban area as a short term solution to the problem, a somewhat radically new and long term solution has been sought in the form of a rapid rail transit system. But, one of the persuasive arguments put forward for its justification is that the inevitable high land acquisition costs would be minimal since existing urban railway right of way could be utilised.

### 1.4 Applicability of Cost-Benefit Analysis:

Financial feasibility of a project entails a different type of approach than that adopted in a cost-benefit analysis. If a particular project can pay for itself in terms of revenue

then this may be an indication that it is socially worthwhile, provided that indirect costs are not significant. However, it is generally accepted that even despite a new equilibrium of public transport usage, a new public transport system cannot be self-supporting. Hence a necessary and concomittant step in the economic analysis of the proposed transit systems would be consideration of financial feasibility over the project life.

Hill<sup>1</sup> quotes McKean<sup>2</sup> as stating that "cost-benefit analysis was developed as a technique for examining plans with respect to their achievement of the single objective of economic efficiency. This objective may be broadly defined as the maximisation of net project or system contribution to the regional or national income. In the case of public transport investment the objective function is a proxy for regional or national income contribution and may be stated as the minimisation of urban transportation costs. In terms of the cost-benefit expression the objective function of economic efficiency is the maximisation of net present value.

Several writers suggest that the emphasis placed on economic efficiency (i.e. the expression of all desirable and undesirable effects or benefits and costs in monetary terms) may exclude consideration of other important urban community objectives. For instance Fitch<sup>3</sup> suggests that "one of the most significant things to be known about different transportation systems is their differential effect on the social,

1. Hill, M., "A Method for the Evaluation of Transportation Plans", Highway Research Record, No. 180, 1967.

2. McKean, R.N., Efficiency in Government Through Systems Analysis.

3. op cit.

economic and physical environment in which they operate. Questions of density versus dispersion, the arrangements of activities in space and patterns of living are involved, none of which are amenable to cost-benefit analysis as usually conceived". In attempting to provide some useful basis for decision making it must be assumed that such factors although important do not impinge on the usefulness of the validity of the results produced by the cost-benefit analysis. In so far as community objectives regarding aesthetic factors and environmental quality are incorporated in the broad view taken by the cost-benefit analysis, the only issue is whether monetary assessment of these factors represents their weighting or importance. Should particular significance be attached to specific objectives by policy makers, then as Hill<sup>1</sup> concludes, "the achievement of specified levels of particular objectives may serve as constraints on the acceptability of alternative plans".

In summary there are several basic reasons why a social cost-benefit analysis is required in addition to a financial analysis of Auckland's transit systems.

1. The impact of the investment in public transport extends beyond the users of the improved facility. Benefits theoretically accrue throughout the urban transport system.
2. The investment is sufficiently large so as to create external economies and diseconomies (externalities) which must be quantitatively assessed.
3. The benefit received for transport services and the costs incurred are not wholly reflected by monetary outlays. The

1. op cit.

social valuation of the benefits is therefore greater than the fares paid by public transport users and indirect taxes paid by urban road users. The real costs of urban road travel should include externalities such as congestion costs.

Having established the relevance of cost-benefit analysis as the method of economic appraisal appropriate to the Auckland study, the following sections endeavour to provide the background and the method of approach to the numerous problems that have become evident in a project whose magnitude extends to the total urban area.

## BACKGROUND INFORMATION

### 2.1 The Initial Step - Halcrow Thomas Report

An historical outline is a necessary step toward understanding the present urban transport situation in Auckland and to obtaining broad dimensions of the problems involved in the functioning of the urban transport system as a whole. Concern for the problems in the functioning of urban transport has no doubt been shown over a longer period than the twenty year period which this discussion will concentrate upon. However it was probably only at the beginning of the last twenty years that any definite moves were made toward improving urban transport, and public passenger transport in particular, in the Auckland urban area. In 1949, the New Zealand Government retained Sir William Halcrow and Mr. J.F. Thomas as Consultants to report on railway development proposals in the Auckland Metropolitan Area. The Thomas-Halcrow Report of 1950 advocated the electrification of and additions to the suburban rail routes. The report was accepted and adopted by the Central Government and some initial work was undertaken. However shortly after commencement, further progress was discontinued and the recommendations made in the Report were allowed to slide temporarily from the political scene.

It is significant that both the Halcrow-Thomas Report and the more recent De Leuw Cather Report<sup>1</sup> contained recommendations that sought to bring rail access to the heart of the central business district; improved CBD accessibility is basic to the ultimate success of any improved public passenger transport scheme. Hence there is some justification to regret

1. op cit.

a previous decision to relocate the Central Auckland railway station from its downtown site to its present location. On the other hand, one might reflect upon the possibilities that had the station remained at its downtown location as an unattractive, obtrusive and depreciating asset, it would have proved aesthetically unacceptable to an environment of new urban development and incompatible with the growing demands of current urban dwelling.

In the report produced by Halcrow-Thomas there were a number of significant recommendations and these are outlined as follows:-

- 1) "That the suburban railways of Auckland be rehabilitated and electrified as soon as possible between the limits of the City, Henderson and Papatoetoe or Papakura.
- 2) That the Morningside Deviation, commencing at the present Auckland Station and proceeding underground and joining the existing North Auckland Main Line at Kingsland, be constructed with sub surface stations in the City at Shortland Street, New Civic Centre (and at Victoria Park if found necessary later), also a new station at Arch Hill.
- 3) That connections be provided at Auckland Station to allow for trains from Newmarket running on to the new line to the City. The Total capital cost of the recommended scheme is \$10,913,000. The operating account should show a gain of \$26,000. The total miles of railway to be electrified is 40 and the number of passengers 25,000,000 to be carried annually, rising to 33,000,000 ultimately.
- 4) That expenditure upon arterial streets in the Auckland Metropolitan Area be restricted until results of the recommended schemes are seen.
- 5) The reconstruction of the Auckland Transport Board of the creation of a new traffic authority to administer all forms of public service transport in Auckland, including suburban railways the electrification of which should be conditional upon this.
- 6) That a special study be made of the car parking problem and its relation to the rehabilitation of the railways.
- 7) Conclusion - Our study of transport arrangements in Auckland leaves no doubt in our minds that the enquiry was most necessary, and it is in our opinion very desirable that a comprehensive scheme for the suburban railways should be decided upon at an early date".

Following the presentation of the Consultants' report a committee of enquiry was established in 1951 to evaluate the recommendation. A parallel can be drawn between the setting up of this committee and the setting up of the Committee by Government to report on the De Leuw Cather proposals. The parallel can be taken further since both Committees considered the patronage figures derived by the Consultants were too high. The 1951 Committee endorsed the Halcrow-Thomas recommendation regarding the single agency control of public passenger transport. Their recommendations stated,

"That a special authority with responsibility for the control and operation of passenger transport throughout the whole Auckland Metropolitan Area be set up by Statute and the Minister of Transport appoint an advisory body under Section 7 of the Transport Act to report on the constitution, powers and responsibilities of such an Authority, and pending the creation of the new authority to report on any matters relating to transport development and co-ordination as they arise....."

Following the Committee's report two further reports on the Auckland Morningside Deviation scheme were prepared in 1954. The first by Sir William Halcrow and partners, investigated civil engineering aspects of design and construction and the second by Messrs. Merz and McLellan investigated the cost and technical feasibility of electrifying the suburban rail system.

Towards the end of 1954 the Report of the N.Z. Railways Commission made several interesting points:-

Firstly - "On the basis of the recommendation made by the two firms of consulting engineers in reports of April and May 1954, the estimated cost of the Morningside Deviation with electrification of the Auckland suburban railway system between Henderson and Papakura is \$21,752,000. The overall project is estimated to take  $5\frac{1}{2}$  years to complete from the time instructions are given to proceed".

Secondly - "To ensure a reasonable financial return on the high capital expenditure involved it is essential that this modern form of rail transport receive the maximum possible public patronage, having regard to the necessity for other forms of public transport in the City of Auckland. For this reason the Commission is of the opinion that the carrying out of work should be conditional upon - the establishment of an overall public transport co-ordinating authority for the Auckland Metropolitan area, invested with powers to control and so ensure the orderly co-ordination of all means of public transport".

Thirdly - "The Commission is not satisfied that an effective co-ordinating transport authority for the Auckland Metropolitan Area can be readily established. Without essential control the co-ordination of public transport there can be no assurance that an electrified suburban rail system will attract adequate patronage, and for this reason the project cannot be considered as other than a doubtful proposition at the present time. In these circumstances the Commission is unable to recommend that the project be proceeded with".

## 2.2 The Master Transportation Plan for Metropolitan Auckland

The Master Transportation Plan was a move in the direction toward co-ordinating the functioning of the urban transport system. As such it endeavoured to assemble a great deal of basic information, to make comments on relevant previous proposals and to outline future transport developments.

"The plan commented on the fact that at that time the existing rail services in Auckland carried approximately 4% of the passengers carried by all forms of public passenger transport in the Metropolitan Area. That rail transport did not play a greater part in the Metropolitan passenger transport system was due primarily to the absence of stations in the central business area".

Other factors that were seen as contributing to this situation were the low population densities in some residential areas served by the railway, and the absence of road to rail feeder bus services.

In commenting on the Halcrow-Thomas Morningside Deviation proposal the plan stated that Auckland's most urgent transport problem was in respect of streets and that

the scheme or any similar scheme would not carry sufficient passengers to warrant deferring roading proposals.

"Evidence shows that these railway proposals would be very costly and would result in substantial increased losses to the Railway Department. The Committee cannot recommend embarking upon the Deviation proposals and is convinced that the situation will not alter materially until Auckland's population is two or three times the present figure".

The financial responsibility in respect of construction, maintenance and operation of the suburban railway system as proposed by Halcrow-Thomas was attributed to the N.Z. Railways Department.

The Master Plan revealed that a greater return on invested capital was possible for roading development as against rail development and that traffic congestion problems would be more readily alleviated if investment in urban motorways was pursued. The report states in a somewhat unreliable and unsubstantiated form that traffic congestion costs (in terms of time, petrol and other transport operating costs) based on forecasted traffic volumes utilising the existing roads, would be of the order of \$100m - \$200m between 1960 - 1970. The capital cost of proposed roading development was estimated at approximately \$30,000,000 in 1955 on what is assumed as 1955 prices and it was considered that the various stages of development would be completed by 1965 or at the latest 1970, a period of fifteen years. The projects were economically justifiable on the basis of the savings in transportation costs and that "they would protect and stabilize property values in the inner city area and in the urban area generally, and would provide an essential framework for an orderly and efficient development of the rapidly growing urban area". Financial problems

at the local authority level delayed the commencement date of the motorway scheme and further delays in the progress of implementation have substantially altered the original concepts. Re-assessment of transport needs was deemed necessary in 1963 as a consequence of the delays in implementing the motorway programme. There was concern not only at the steady trend toward chaos in Auckland's traffic conditions, but also at the increasing financial losses incurred by public passenger transport.

### 2.3 The Comprehensive Transportation Plan - 1965; A Regional Transit Plan - 1963; - De Leuw Cather and Company.

De Leuw Cather and Company were the Consultants retained to undertake the re-assessment of Auckland's transportation needs for a period of approximately twenty five years. The Comprehensive Transportation Plan presented a long range programme for transportation development and included motorways, expressways, arterial thoroughfares and local streets plus operational traffic improvements and automobile parking facilities. In addition, the Regional Transit Plan recommended:-

"A co-ordinated bus and rail rapid transit plan for public transportation service in the Auckland Metropolitan Region. The rail rapid transit facility would operate along trunk lines in the several principal corridors where railway facilities are now located, with an extension to downtown Auckland via an underground subway along Customs and Queen Streets to a terminus at the Civic Centre. The bus lines tributary to the rail rapid transit corridors will provide feeder services to the outlying rail stations".

The motorway plan outlined in the Master Transportation Plan of 1955 was augmented and modified as a result of the more sophisticated origin-destination surveys and traffic assignment techniques employed by the Consultants. Also significant in the assessment of roading requirements was the fact that the Consultants were able to employ a modal

split assignment based upon an improved service level of public transport in travel corridors served by both road and rail modes.

The roading development scheme as outlined by De Leuw Cather was programmed in two ten year stages, the latter stage ending in 1986. Based on 1965 prices the estimated costs were as follows:-

Table 1. Estimated capital costs of the De Leuw Cather roading proposals.

	1966 - 1976	1976 - 1986
Right of Way	\$21,020,000	\$ 1,570,000
Construction	\$49,860,000	\$58,050,000
Total:	\$70,880,000	\$59,620,000

No estimate of right of way costs was made beyond 1986, as these would have been incurred in the previous ten year period. No estimates were made for associated surface street and highway improvements but it was stated that the cost of this necessary part of the programme would be of the same order as the cost of the motorways and expressways. These cost estimates are conservative since inflationary trends were ignored and also some right of way costs were excluded.

It was stated by the Consultants that the direct benefits to the users of the improved highway facilities in the form of reduced running time and operating expenses, would be at least equivalent to the annual expenditure. (approximately \$7.0m/annum over 20 years). In addition uncongested traffic movement would ensure a more vigorous development of industry and commerce throughout the regional centres.

On the question of implementation of the scheme the Consultants emphasized:-

"that all elements of the transportation system are closely related and are dependent upon one another; the public transit improvements, motorways, surface street and highway system, operational improvements, and parking facilities. During the continuing course of accelerated motorway, highway and surface street construction and improvements, it will be necessary that all agencies co-operate closely so that the implementation programme can proceed economically and efficiently. Of particular importance is the integration of motorway construction and surface street and highway improvements where those facilities serve or augment the motorways".

Prior to reaching a decision that the most desirable public transit system was a rapid rail transit - feeder bus system, the Consultants evaluated an alternative scheme. The alternative was envisaged as an improved bus system and advocated a number of improvements over the existing bus transit system as operated by private companies and the Auckland Regional Authority. The proposals advocated the co-ordination of routes and the avoidance of duplicated services and that bus routes should be extended to serve newly developed areas. In addition, express bus operation on motorways was seen as an optimum solution to moving commuters in peak periods. Improved CBD distribution was deemed possible by the planning of two downtown delivery loops, each bus travelling along Queen Street only once. Additional terminal facilities were also required. It is significant that a similar recommendation was made in the Master Transportation Plan of 1955. The Consultants stated that:-

"It is of basic importance that public transit would play a major role in the integrated regional transportation system. Past experience in most Metropolitan centres as well as in Auckland, indicates that the proportion of transit users would continue to decline if transit services were confined to an all-bus system. The best that could be expected is that the number of transit passengers would remain constant or perhaps show a slight increase in future years".

A contrary opinion is expressed by Wilbur Smith and Associates<sup>1</sup> who consider that:-

"Planned urban freeway systems with conventional bus transit, generally will be able to accomodate all anticipated motor vehicle travel except for segments of selected corridors in very large urban regions. In some cases, demands would exceed roadway capacities in corridors with major topographic barriers. Major urban transit facilities will be desirable to relieve overloading of radical freeways in very large cities and to increase the central orientation of large metropolitan regions".

Increased traffic volumes in the CBD in future years would limit the functioning of an all bus system. However it was stated that the improved service of an all bus system (suburban rail passenger services eliminated) would increase patronage at a moderate rate to a level of 85,000,000 annual passenger trips in 1986 despite a qualification that many factors impinged on the possibility of obtaining accurate estimates of patronage for a period of twenty years.

Capital expenditure involved in implementing the scheme was estimated as follows based on 1964 prices:-

Table 2. Estimated capital cost of the De Leuw Cather bus system.

Bus equipment - 735 buses	- \$13,240,000
Depots (4)	- \$ 3,560,000
New bus terminal	- \$ 2,000,000
TOTAL:	- \$18,800,000

Capital expenditure for buses was based on existing and required assets, assuming that assets had served a useful life, an assumption that was a little unrealistic when it was estimated that the average age of a bus in the existing fleet was 9 years in relation to a useful life of 15 years. Annual revenue in 1964 based on an average fare of 9c per passenger was estimated at \$7,040,000 while annual expenses (excluding capital servicing charges) were estimated at

1. Wilbur Smith and Associates, Transportation and Parking for Tomorrows Cities.

\$6,640,000 - an operating net income of \$400,00 annually.

On the basis of the previous facts and a comparison of the two transit systems the Consultants concluded that the all bus system would not meet Auckland's needs in the future.

Consideration can now be turned to the co-ordinated bus and rail rapid transit system. It is apparent that this scheme, on the basis of the early decision reached with regard to the all bus system, was analysed in considerably more detail. Broadly the scheme was envisaged as being a rapid transit system with high frequencies of service and the utilisation of high speed transit vehicles capable of speeds approaching 60 mph. The rapid transit vehicles would utilise existing railways right of way and would operate on the existing rail tracks, thus necessitating the integration of freight and shunting services with services of rapid transit. Two stages of construction and implementation were proposed with the initial stage utilising existing rail tracks from Puhinui and New Lynn via Newmarket and subsequently to the central area via an underground extension up or approximately parallel to Queen Street. The final stage would extend these routes to serve more of the Metropolitan Area plus the incorporation of the east diversion line which would serve the Eastern Suburbs. A future possible development was the extension of the downtown route to link with the western route in the vicinity of the existing Mt. Eden Station.

In estimating patronage of the rail scheme, the Consultants considered that individuals would favour the rail mode because of dependability - it is significant that feeder buses, the operation of which determine the ultimate success of the rail scheme, are subject to delays and disruptions, similar to those of normal buses. User cost

reductions to diverted car users were also cited as a reason to justify the higher levels of patronage of the rail scheme in comparison to the all bus scheme. In assigning patronage to the rail scheme a number of transit diversion curves were utilised, based on the land use characteristics of the various zones - the density of population and households, the level of car ownership and the type of transit facility used. On these bases the estimated annual patronage of the rail scheme was 82,000,000 passenger trips in 1964 and 100,000,000 in 1986.

Capital expenditure was estimated on the same basis as the all bus system, that is all costs were calculated on 1964 prices. A summary of the capital expenditure is as follows:-

Table 3. Estimated capital costs of the De Leuw Cather rapid rail system.

<u>Feeder Bus System</u>	
Bus equipment (530 buses 1964 - 600 buses 1986)	\$ 9,600,000
Depots (3 approximately)	\$ 2,400,000
Sub-total	\$12,000,000
<u>Rapid Rail System</u>	
Downtown subway extension	\$10,800,000
Improvements to outlying stations	\$ 4,000,000
Electrification, trackage etc.	\$ 3,600,000
Maintenance and repair facilities	\$ 3,200,000
Transit vehicles (104 - 1964, 150 - 1986)	\$ 7,200,000
Sub-total	\$28,800,000
TOTAL:	\$40,800,000

Operating expenses were calculated for the two sub-systems in 1964. The estimate for the feeder bus system was \$4,600,000 and for the rail sub-system \$2,280,000.

Operating revenue in the same year, and assuming that fares were payable on a zonal basis independent of facilities used and number of transfers made, were calculated to be \$7,520,000 assuming a weighted - average fare of 9c per passenger. The calculation on a 1964 basis of revenue and expenditure and capital expenditure was made to allow a direct comparison with

the all bus system. However the construction phase of the rapid rail was five years and the first year of operation would have been 1970. Using straight line interpolation the estimated patronage was 87,000,000 annual passenger trips in 1970. In 1964 the surplus of revenue over expenditure would have been \$640,000 and in 1970 the surplus was estimated at \$740,000. In both instances capital servicing charges were excluded. Operating income was expected to increase in future years by 1% - 2% per annum.

On the question of administration it was stated that it was logical and practical that the Auckland Regional Authority control the operation of the co-ordinated system:-

"The Authority should be empowered to establish the routes, level of service, type of equipment, and the fare schedule for all transit services; and should have the authority with other public agencies or with private operators for transit services".

Although not calculated in definite monetary terms the benefits to the community as a whole if a rapid rail transit scheme was put into operation were considered as more than justifying the high initial capital expenditure:-

"The quality of transportation service in the form of better highways and speedier transit facilities will have a major influence on the area's development, on it's economy, and on the amenities it can offer it's citizens".

Finally, to endorse their conclusions with regard to the rapid rail transit scheme the Consultants stressed that the highway transportation network and the recommended public transit improvements were mutually interdependent and stated:-

"that the recommended public transit improvements are required to avoid additional and unnecessary highway improvements. The cost of additional highway facilities which would be required to replace the public transport programme is estimated to be far in excess of the total cost of the recommended transit improvements. We consider that an additional 10,000 parking spaces would be required in the

CBD, at a cost of some \$20m - if the public transit improvement programme is not implemented. Further it is estimated that six to eight lanes of new motorway facilities would be required to serve the CBD in addition to those included in the recommended plan, at a total cost of approximately \$16 million".

#### 2.4 Officials Committee Report on De Leuw Cather Proposals

Financial feasibility was not investigated by De Leuw Cather and Company and it was thus that Cabinet set up the Officials Committee in 1966. The Committee produced a report on the De Leuw Cather recommendations and this was released by Government in August 1967. In their report the Committee considered firstly, that the levels of patronage forecasted, for the rail system in particular, were optimistic; secondly, that the capital expenditure for the all bus system was over estimated and thirdly, that the capital expenditure for the rail scheme was conservative. They estimated the capital cost of the rail scheme as being \$52.2m in comparison to the De Leuw Cather estimate of \$40.8m. As a consequence of the lower patronage estimates made by the Committee, operating losses would have been greater than previously anticipated.

It is disturbing to find that the Committee did not fully appreciate the Consultants point of view when it was commenting on future traffic congestion. A lack of precise viewpoint is typified in the following statement:-

"If buses were used indefinitely, traffic congestion would increase to the stage where very heavy additional expenditure on roading would be required to enable road traffic to move with a reasonable degree of freedom. It could well be that such additional expenditure would exceed that necessary to introduce a bus/rapid rail service; on the other hand the rate of growth of the private car is such that additional expenditure on roading would be needed to relieve congestion in the 1980's in any case".

This statement tends to refute the whole purpose of the Consultants' investigations and the implicit conclusion adopted is that a great deal of investigation is still necessary before any definite conclusions and decisions can be made.

The Committee threw doubts upon the extent that the rapid rail scheme would alleviate traffic congestion problems. It was their collective opinion that completed and planned roading developments plus "reasonable planning and control", could contain congestion at an acceptable level for a number of years. For anything meaningful to be attached to the word congestion, it must be defined in precise terms. For instance, what is an acceptable level of congestion? Despite this lack of precise definition the Committee stated that:-

"It could be that in 15 to 20 years time the co-ordinated bus/rapid rail system would provide the only feasible method of moving large numbers of passengers to and from work at peak hours in a congested city".

An important and exceedingly relevant point which the Committee notes is as follows:-

"the absence of a definite exposition of future trends for the Auckland central business district and the lack of co-ordinated plans for the region gives weight and emphasis to the following comment of Buchanan and Partners<sup>1</sup> who undertook an assessment of planning in the central area of Auckland City:

Precisely what form or combination of forms of public transport would be most appropriate seems to us to still require more consideration. The De Leuw Cather Report dismissed somewhat summarily the possibilities of bus services of various kinds (feeder and express services) operating on the improved highway network. Our experience suggests that it will not be possible to make either bus or rail services pay in the conventional sense; but we think improved bus services might be more flexible, cheaper in capital outlay, and generally less of a liability than a rail service. But, as we mentioned we regard the matter as requiring a great deal of further study".

1. Buchanan, C. and Partners, City of Auckland; Planning in the Central Area on Assessment, July, 1966.

Despite the Buchanan recommendation that the all-bus system could be adopted because of flexibility and other factors, the Committee stated "that a firm decision should be taken now to ensure that a bus-rapid rail transit system could come into operation during the 1980's - a conclusion that postpones the issue rather than resolves it.

One of the major factors behind De Leuw Cather's recommendation of a rapid rail transit scheme was the fact that existing railways right of way could be utilised for the system, thus minimising the capital costs in comparison with a totally new system. It is to this factor in particular that responsibility can be attributed for delays in a decision to implement the scheme. The question of who pays for the rail part of the scheme, is a very pertinent one. The Officials Committee reported the Auckland Regional Authority as being prepared to meet the annual loan charges on the capital cost of rolling stock but that the source of capital and remaining capital servicing charges should be Government derived. The Minister of Finance, Mr. Muldoon stated in his opening address to the Auckland Rapid Rail Symposium<sup>1</sup> that "The Government is prepared to raise the necessary capital, but it is proposed that operating costs, plus interest on capital be recouped in the Auckland Region". The cost to the Government in this instance is the opportunity cost of the capital resources made available to the rapid transit system. This is a valid reason for evaluating the economic feasibility of the rapid rail project on an national basis, despite the fact that benefits will be essentially confined to the Auckland region.

1. op cit.

There are other substantial reasons for Government caution in respect of Auckland's rapid rail project. Not the least of these is the declining status of public passenger transport, both overseas and locally. Substantial increases in operating losses on public passenger transport services operated by local authorities and on suburban services by N.Z. Railways are sufficient reason for deferral of definite decisions. The case for improved public transit system rests on the numerous social benefits that accrue to these improved systems. But until these benefits can be conclusively substantiated within the New Zealand urban situation, no governing body can hope to make effective and responsible decisions.

#### 2.5 Committee of Enquiry into Urban Passenger Transport<sup>1</sup>.

The report of this committee was published in February 1970 and is indicative of possible Government policy on urban passenger transport. However some of the recommendations are directly relevant to the rapid rail project and others are interesting because they reiterate past recommendations by other committees and reports outlined in this discussion. An outline of significant recommendations is as follows:-

"That in Auckland, Wellington, Christchurch and Dunedin, urban passenger transport authorities be established."

"That the principal objectives of an urban passenger transport authority would be to ensure that the region is provided with passenger services of a reasonably high standard, taking into account both the needs of the area and its ability to finance the major portion of the cost of these services".

"That the primary function of such an authority would be to control and co-ordinate all scheduled urban passenger services within its area".

1. Report of the Committee of Enquiry into Urban Passenger Transport, Urban Passenger Transport, Transport in New Zealand, February, 1970.

"That the primary responsibility for the provision and financing of urban public passenger services should rest with the areas and particularly the urban regions receiving the benefit of these services".

"That an increase in the price of petrol should be used to provide a means of supporting and developing urban public passenger transport. (The rate of tax levied would not exceed 2 cents per gallon).

Specifically -

- a) That the remaining 1 cent of petrol tax being paid into the Consolidated Revenue Account be used towards the financing of national assistance for urban passenger transport, and
- b) That urban passenger transport authorities be empowered to levy a local petrol tax in the four metropolitan areas to help improve the position of urban passenger services".

It is apparent that in recommending a regional petrol tax, the Committee is attempting to redistribute the burden of increasing operating losses of local authority passenger services, currently borne by ratepayers and to resolve the hidden subsidy that rail freight services make to suburban passenger services.

With regard to capital grants the Committee recommended:-

"that the main type of Government assistance for urban passenger transport should be a scheme of grants or loans for capital expenditure. This would apply to new expenditure of a capital nature on urban public passenger services. An important exception may be where special arrangements are made with the Government in connection with a major new project such as a rapid rail scheme".

This recommendation does nothing to clarify the financial problems of Auckland's rapid rail project.

## 2.6 Summary

On the basis of the foregoing resume, it is possible to conclude that progress toward improving urban transportation generally in the Auckland urban area has been confined essentially to a system of urban motorways which is already many years behind schedule. Despite the appearance of a number of reasonably enlightened reports it is apparent that

the pressure of demand for improved transport facilities and the recommendations made by the previously cited reports, are insufficient to overcome the constraints imposed by the lack of financial resources and political bargaining power. It is an inescapable fact, that investment in improved urban transport facilities must compete for the country's resources on a nationwide basis and should be shown to be economically viable if it is deemed desirable that a particular project should require central government assistance.

On the question of minimal rates of progress one can summarise that after twenty years of reiterated recommendations there is still -

- (1) No regional control of passenger transport services - no rationalisation and attempt to reduce the cost to the community of duplicated services and lack of timetable co-ordination.
- (2) No implementation of an improved standard of public transport.
- (3) No upgrading of suburban rail passenger services.
- (4) A continuation of a do-nothing or do-little attitude.

## RAPID TRANSIT SYSTEM ALTERNATIVES

### 3.1 Recent Changes and Relative Merits

Current investigations of rapid transit in Auckland are based primarily on the De Leuw Cather alternatives outlined in the previous section. Current investigations similarly reflect an apparent bias toward a rapid rail transit scheme which is consistent with events overseas. For instance, the United States Government through its Mass Transportation Act 1964 is more amenable to capital aid for rail systems than it is to the more conventional bus systems. Wilbur Smith and Associates<sup>1</sup> list several proposed rapid transit systems for American cities but only one of these was a rapid bus transit system and at that time it had not been approved by the appropriate government authority.

Under the De Leuw Cather investigations the bus scheme alternative did not receive the same emphasis as the rail scheme. This was perhaps due to the fact that buses without special privileges of right of way are directly competitive with private transport, and this is merely a continuation of the current situation. In the period of time that has elapsed since the publication of the De Leuw Cather reports the rail scheme has altered in its basic concept since the latest proposal envisages rail transit vehicles operating on exclusive track. The range of possible alternatives has therefore increased. Potential changes in the basic concept of an all bus scheme are also apparent which would indicate that an objective evaluation of Auckland's transportation needs could be based on a number of possible alternatives

1. Wilbur Smith and Associates, Transportation and Parking for Tomorrows Cities, Table 13-60, P. 362.

ranging from a "do nothing" alternative to a capital intensive rapid rail transit scheme.

In view of the emphasis and merits advocated for rail systems it is appropriate to briefly consider some of the alternative merits of a bus transit scheme due to improved vehicle technology and faster in transit travel times has become more of a viable alternative to private transport, particularly for the peak hour commuter work trip. Wilbur Smith and Associates<sup>1</sup> list several advantages of bus transit which have relevance for Auckland because of its density of settlement, volume of CBD employment, level of car ownership and main corridor traffic volumes.

1. "All rapid rail transit systems now in operation in the United States, except the limited system in Cleveland which was built on an existing railroad right of way, were fully developed before the motor vehicle came into extensive use.
2. In most cities in the United States, feasibility studies for new rail transit systems have a difficult time finding volumes of potential riders sufficient to meet minimum costs for system maintenance and operation irrespective of fixed capital costs. Moreover there are only a few route miles where peak hour patronage forecasts exceed the capacity for bus rapid transit.
3. There are distinct advantages in planning for bus rapid transit as the first stage development within major transportation corridors, even when ultimate conversion to a rapid rail system is contemplated. Land intensification or the initial impact could be achieved with bus rapid transit.
4. Ten or more years normally elapse before an approved rail system is completed to a point where it can provide extensive service. A viable bus service can be initiated within the travel corridor early in the construction phase.
5. The bus mode offers greater flexibility than the rail mode and avoids transfers since the rapid transit bus can operate on the line-haul phase as well as the downtown distribution and residential collection phases. The system thus provides greater flexibility in adapting to unforeseeable changes in urban development and travel patterns and to changes in transport technology.

1. op cit.

6. The system offers an ease of conformity with the total urban planning process and the capacity to adapt readily to stage development of freeways and other transportation facilities".

The methods by which competition with private transport could be minimised are:-

1. "The reservation of bus lanes within freeways particularly in peak hours or the provision of special bus way routes. The provision of additional road capacity for the exclusive use of buses would need to be included in the capital cost of the bus rapid transit system. Such additional capacity however could also be used for private transport in off-peak hours.
2. The use of urban motorway metering, to improve capacity and traffic flow, and the selective metering of high passenger capacity vehicles".

It has been shown by Taylor<sup>1</sup> that Auckland's demographic and urban trip pattern statistics do not compare with those suggested by Wilbur Smith and Associates<sup>2</sup> as being the minimum criteria for consideration of the introduction of a rapid rail transit system. In view of the obvious initial advantages of a rapid bus transit system it is imperative that investigations into improved public transport should be conducted objectively by means of a cost-benefit analysis of all possible alternatives. The evaluation of system benefits and costs would then justify any preliminary judgement as to the optimum system.

### 3.2 The Base Alternative

The range of possible alternatives brings about the consideration of an important methodological point concerning the level of investment appropriate to the base-system or

1. Taylor, M.A. "Assessment of Transportation Needs", Auckland Rapid Rail Symposium, August, 1969.
2. op cit.

null alternative as it is frequently expressed. S. Joy<sup>1</sup> in an Australian Road Research article questions; "should the target year plan be compared with a "do-nothing" alternative or one which assumed a continuation of current levels of investment and maintenance expenditure? Of course, if any capital expenditure takes place beyond that which has already been made, or is committed to be made, this in itself should imply the existence of a plan of some kind". Despite the declining status of public passenger transport, urban growth will necessitate the extension of services into developing areas. As a consequence the levels of capital expenditure and operating costs may be expected to rise naturally without being directed at improving the level of service of public transport over the total urban area.

The problem stated briefly is whether the estimation of benefits and costs should be based on a null alternative which maintains the existing level of service of public transport or an alternative which does in fact do nothing about the urban transportation problem other than extend minimum services to new areas. Maintaining the current level of service would require some form of minimum transport plan and minimum capital investment. Doing nothing would inevitably aggravate the present difficulties of public transport since congestion in future years would be an inhibiting factor. At the same time a further possible consequence suggested by Fitch<sup>2</sup> is that faced with a lack of adequate transportation facilities people simply arrange their

1. Joy, S. "The Economic Evaluation of Comprehensive Land Use Transportation Plans", Australian Road Research, Vol. 3, No. 10, June, 1969.
2. Fitch, L.C. "Goals of Urban Transportation Policy", Ekistics, Vol. 29, No. 170, January, 1970.

lives differently with respect to where they live, shop and work etc.

The dilemma apparent is the at present unquantifiable impact of transport facilities on land use or the feed back effect<sup>1</sup> in urban transportation planning. Assuming (somewhat unrealistically) complicating factors, such as transportation induced land use changes, do not arise, Joy's<sup>2</sup> conclusion is relevant in this context in "that the only base system plan which should be used is a base system plan which depicts the transportation system as it is now or will be when current commitments are completed". Assuming also that rising car ownership will further reduce the number of persons captive to public transport and that traffic congestion will further reduce its economic efficiency then the requirement of a rapid transit system is that it not only halt the downward trend of public transport usage but also restore usage to at least the level prevailing in the base year of the plan.

Intuitively it seems inappropriate to assume that the urban transportation system will remain essentially unchanged for a period of 25 years. The assumption indicates that a major proposal can remain functional for the planning period despite rapid technological change.

The final consideration of this section is the enumeration of benefits accruing and costs incurred by each proposed alternative system in relation to the base system. The costs of each alternative scheme may be broken down into the following categories:-

1. Guidelines for Trip Generation Analysis, Bureau of Public Roads. Dept. of Transportation/Federal Highway Administration, June, 1967, Figure 1.
2. op cit.

1. Facility construction and land acquisition costs.
2. Facility operation, maintenance and administration costs.
3. Users costs.
4. Accident costs.
5. Dislocation, disruption, air pollution and other social costs which may be grouped and referred to as externalities.
6. Intangibles (e.g. aesthetics).

Benefits are defined as reductions in accident and user costs. Thus user costs incurred under the base system are correspondingly compared by category with those incurred under any of the proposed transit schemes. Although only investment in public transport is contemplated (a sub-system of the total urban system), benefits accrue over the total urban transport system. By contrast, capital and operating costs are confined only to the public transport system since it is assumed that no additional investment in urban roads is contemplated. These costs are therefore incremental to those incurred under the base system. Since it has been concluded that the base system appropriate to the Auckland study is the do nothing system, capital and operating costs incurred in future years additional to those of the base year, would relate only to the extension of services in developing areas of the urban region.

## PROJECT COSTS

Several types of cost are likely to be incurred if the planned investment in public passenger transport in Auckland is implemented. Firstly, direct costs which are directly attributable to the project itself and include capital costs during the construction phase and annual costs when the system commences operation. The other major costs are termed indirect or secondary costs in that they are not comprised of materials, equipment or labour costs used in the construction or functioning of the new system. These costs are incurred by the community as a whole during both the construction and operating phases, and take the form of disruption, dislocation and other social costs such as the presence of unaesthetic structures in established urban neighbourhoods. Indirect costs are frequently of an intangible nature and are less determinable than direct costs. Nevertheless they are real costs to the individuals and groups concerned and are too often passed over as being the price of "progress".

### 4.1 Direct Costs

Unfortunately any outline of project costs must be generalised since, of the various alternative schemes, only the rapid rail scheme had, at the time of writing, been costed with any degree of finiteness. Even then, decisions regarding route length, station spacing, service frequency, design speed, track gauge and seating space (or comfort level) on transit vehicles, had not been finalised therefore preventing the possibility of final cost estimates. Variation

of any of the aforementioned factors would invariably alter the total cost of a new system. Inability to make decisions regarding these important factors also implied that annual operating costs, as well as capital costs, could not be calculated. For any alternative new scheme the major direct cost categories that could be common are:-

1. Right of way costs.
2. Track or route costs.
3. Terminal facility costs.
4. Intermediary facility or station costs.
5. Transit vehicle costs.
6. Signalling and communication costs.

The rapid rail transit scheme is more capital intensive than the rapid bus transit alternative by reason of the greater investment in fixed facilities. However one of the advantages of the rapid bus scheme is that it could be phased into operation more rapidly due to the more extensive use of express buses on existing and planned motorways. Right of way and track costs would only be incurred if exclusive bus lanes were necessary. For the purposes of a theoretical analysis of costs of alternative systems, attention has been focussed on the rapid rail scheme because of the more finite exposition of its physical characteristics.

In summary form the possible direct costs of the rapid rail transit scheme are as follows:-

Table 4. Possible capital cost items of the Auckland rapid rail transit system.

I Rail sector.

1. Right of way (i.e. land purchase).
2. Tunnelling.

Table 4 Cont.

3. Excavation and retaining wall construction.
4. Track installation (wide or existing gauge) plus relocation of existing 3'6" track if transit vehicles are to operate on exclusive track.
5. Signal and communication systems.
6. Power supply and distribution systems.
7. Demolition of old suburban rail service stations.
8. Reconstruction and construction of suburban and downtown stations.
9. Terminal facilities plus maintenance workshops and equipment.
10. Rail transit vehicles or rolling stock.

II Feeder bus and road sector.

1. Improvements to roads carrying feeder buses and increased traffic volumes.
2. Additional bus terminal facilities.
3. Car parking facilities at suburban stations.
4. Additional buses for feeder services.

III Administrative sector.

1. Legal and administrative costs.

Lang and Soberman<sup>1</sup> report from American experience that engineering costs and contingencies are normally 10% and 15% respectively of total costs in respect of new construction. Comparable figures are used in New Zealand engineering studies.

1. Lang, A.S. and Soberman, R.M. Urban Rail Transit: Its Economics and Technology, p.p. 68 - 84.

Table 5. Possible annual cost items of the Auckland rapid rail transit system.

I Rail sector.

1. Maintenance of way and structures - Lang and Soberman state that those costs associated with the maintenance of all fixed facilities of a system - tracks, tunnels, bridges, power distribution systems, signal and communication systems are inclusive under the heading of maintenance of way and structures.
2. Maintenance of equipment. Costs under this category are those relating to the repair and upkeep of transit vehicles.
3. Operation of rail transit services. These costs are primarily labour costs.
4. Electric power costs.
5. Miscellaneous. This category includes such costs as administration, stationery and printing, materials handling and insurance etc.

II Feeder bus and road sector.

1. Maintenance of buses.
2. Operation of feeder bus services. This includes the routine conducting of services and is composed primarily of labour costs.
3. Fuel costs.
4. Maintenance of car parking facilities.
5. Replacement of feeder buses. This cost may be an annual one but it is more likely to be incurred in specific years.
6. Miscellaneous. Depending on the administrative organisation of transit services (bus and rail) this term could be incorporated under the rail sector.

The Auckland Regional Authority, in considering a rapid rail transit system, would probably deem it desirable to analyse the costs of similar systems in other urban areas of the world. Meyer Kain and Wohl<sup>1</sup> consider that despite the importance and variability of capital costs, little systematic analysis of their characteristics has been conducted. They state that "for urban rail systems, there is little cost experience in recent years on which to base cost estimates - and even less systematic analysis of how these costs might vary under different circumstances". A number of factors impinge on the ability to compare system costs. Some of the more important being right of way costs, or the amount of additional land purchase, topography, and geology in relation to route miles underground. Other considerations, such as the standard of facilities constructed, are automatically responsible for dissimilarities.

An important methodological aspect to consider in respect to capital costs is the project time horizon. In instances where the service life of an asset is shorter than the project analysis period, additional capital costs would be incurred when the asset became redundant. Where the service life of an asset is longer than the period of analysis some estimate of the depreciated value of the asset is required. This value is discounted to reflect present day values and subtracted from total discounted costs. It is pertinent to point out that service and economic lives need not correspond. Niebur<sup>2</sup> makes a distinction between the two and states that

1. Meyer, J.R., Kain, J.F. and Wohl, M. The Urban Transportation Problem, p.p. 171 - 195.
2. Niebur, H.D. "Preliminary Engineering Economy Analysis of Puget Sound Regional Transportation Systems", Highway Research Record, No. 180, 1967.

economic life "is that life which is ended at the time the services rendered by the facility could be produced at a lower cost by a new facility: Service life is the length of time the facility is used in its major original function without major rebuilding". Lang and Soberman<sup>1</sup> suggest that technological developments in rail transit, apart from elevated structures, are likely to have only a minor impact on cost structures. Hence service life and economic life may not be too dissimilar on the basis of current rates of technological advancement. However functional obsolescence is more likely to arise from technological development in competing modes of mass transport. Regardless of any tentative conclusions that can be currently drawn it is apparent that estimating the useful lives of capital assets is a hazardous task and one requiring discerning and careful judgement. Allowance for uncertainty of future developments can be made by underestimating service lives.

Direct costs are more readily identifiable and quantified than direct benefits in that they are more amenable to valuation through the market mechanism. That is the market prices for materials, labour and equipment provide the basis for cost estimates despite the fact that market prices are not perfectly competitive. Engineering estimates of costs should be made on the basis of prices prevailing or likely to prevail in the base year of the project - that is the first year of the construction phase. Costs are assumed to increase (due to inflationary trends) at the same time. That

1. op cit.

is, relative prices are expected to remain constant. The familiar cry "build it now while it is cheaper" is irrelevant if this important assumption is realistic.

#### 4.2 Indirect Costs

Indirect costs are not readily identifiable at this point. Even less reliable are estimates of the magnitude of these costs, however it can only be assumed that such costs will be incurred if a new transit system is constructed. The construction of a rapid rail transit system for instance, could be expected to disrupt manufacturing industry, particularly that located in close proximity to goods rail services (industries with private branch lines); it would disrupt existing passenger and goods rail services, thereby entailing greater time costs for travellers and causing delays in the forwarding of freight. The construction of a rail system could also impose restrictions on the movement of urban traffic particularly in the central downtown area. These would be in the form of additional time and vehicle operating costs and inconvenience.

The magnitude of the capital costs of a large scale investment such as a rapid transit system are to a large extent influenced by the right of way costs of the amount of additional land purchase necessary. Land required is purchased at prevailing market values and this value is regarded as being sufficient compensation to enable the displaced occupant to relocate in another part of the urban area with similar locational attributes. For the occupant of a residential area additional costs in the form of inconvenience are also incurred. These may be termed dislocation costs in that they

represent costs incurred through the breakdown of established patterns of urban living. Although such social costs are of an intangible nature they are real costs to the individuals concerned. However one of the assumed advantages of the proposed rapid rail scheme in Auckland, is that existing railways right of way could be utilised with the minimum of additional land purchase, hence dislocation costs would not likely be a serious social cost.

## BENEFIT MEASUREMENT AND URBAN TRAVEL DEMAND

At this point it is necessary to break the logical progression of events and to digress slightly and consider some theoretical aspects related to the estimation of benefits. It is apparent that one of the critical areas in the field of transport investment appraisal is the derivation of the demand functions for the services provided by the capital expenditure. A theoretical framework based on a consumer surplus considerations is an essential requirement for estimating benefits of investments in roads and mass transit facilities. Unfortunately theoretical considerations tend to be superceded by practical problems when an actual study is undertaken. This section is by way of a theoretical discussion, but the problems outlined and conclusions adopted are directly relevant to the economic appraisal of Auckland's transit systems.

Perhaps one of the best studies linking economic theory with a practical problem is the study of the American Interstate Highway System made by Friedlander<sup>1</sup>. Some of Friedlander's statements are directly relevant to the Auckland study. Firstly "in a purely competitive world where only primary factors are used to produce final goods, where there are no externalities or indivisibilities, and where there is a perfect foresight, there is no need to analyse public investments outside the market mechanism. Market prices reflect the social valuation of the resources used and of the

1. Friedlander, A.F. The Interstate Highway System, p.p. 5-7.

commodities produced, and private and social valuations are always equal. However in the real world imperfections do exist that make it necessary to go outside the market mechanism in evaluating public investment projects".

Secondly, "the need to evaluate a public investment outside the market mechanism primarily arises from externalities or indivisibilities created by the investment; under these conditions, the pricing system will fail to reflect adequately the true social costs and benefits of the investment".

With regard to the use of the consumer surplus basis for assessing direct benefits, Friedlander considers that "although the concept of consumers surplus has come under considerable attack, any cost-benefit analysis that specifically estimates the benefits from an indivisible investment outside of the market mechanism must employ consumer surplus calculations, whether they are implicitly or explicitly stated. The benefit estimates are simply proxies for the required compensating payments that measure the magnitude of the consumer surplus". In the field of highway investments, the use of consumer surplus analysis is explicit since benefits from a highway investment are usually regarded as the product of the cost saving from the investment and the levels of traffic using the improved highway. The identification of the cost savings and their magnitude and the before and after improvement volumes of traffic are therefore the critical factors to be evaluated. It is with the aid of a transportation study that such factors can be determined.

Walters<sup>1</sup> in relation to roading investment, considers that "the estimation of the parameters of demand functions is be-devilled by identification problems. The demand curve varies continuously almost over time of day and periods of the year, while the cost curve is apparently static, apart from social costs. The demand parameters are however very important for estimating the effects of road improvements". The problem of deriving demand functions is accentuated when investment in mass transit facilities is considered. This arises because the demand for urban travel is theoretically split into two demand functions - the demand for private transport or the demand for urban road miles of travel and secondly the demand for public transport. If a mass transit system is constructed, benefits accrue to both public transport users through the improved service level of public transport and to private transport users through reduced traffic congestion.

By way of a digression, Mohring and Harwitz<sup>2</sup> state that "several economists have argued that the plight of mass transportation in most cities today stems directly from the fact that it is an inferior good". Certainly the available empirical evidence regarding the elasticity of substitution (with respect to cost and fares) between the two modes suggests that little in the sphere of reducing transit fares or adopting marginal social cost road pricing, can change the

1. Walters, A.A. "The Theory and Measurement of Private and Social Cost of Highway Congestion", Econometrica, Volume 29, No. 4, October, 1961.

2. Mohring, H.D. and Harwitz, M. Highway Benefits, An Analytical Framework.

present balance between public and private modes.

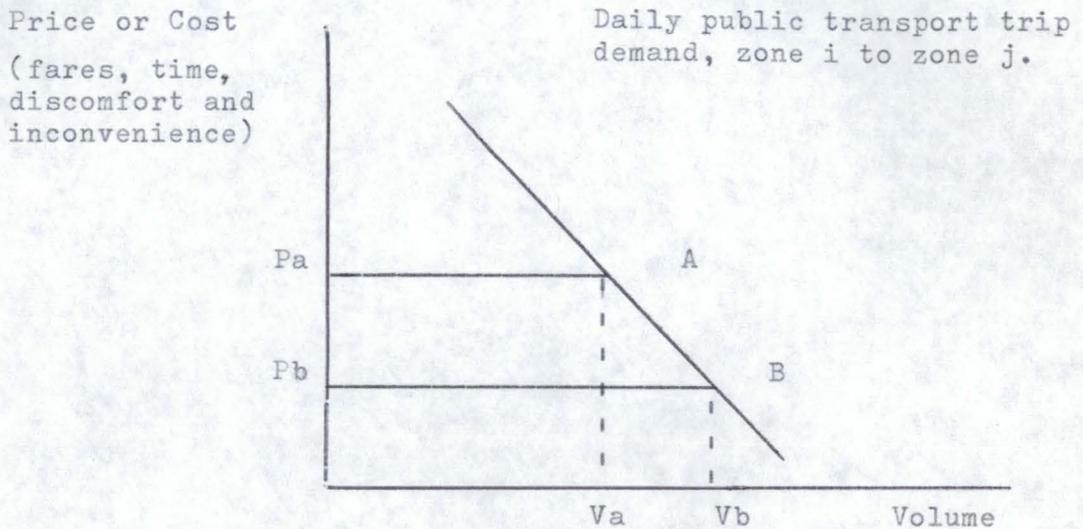
The two demands for urban travel are inter-related through choice of mode tripmakers and the use of the consumer surplus approach to benefit assessment is a complex problem because of this inter-relationship. The difficulty is further strengthened by the fact that transportation studies frequently adopt modal-split procedures based on socio-economic characteristics of trip makers as well as mode cost and time factors. Plowden<sup>1</sup> in some ways points to the basic problem in that transportation studies do not distinguish between demand and usage. The standard approach is to ascertain present usage, develop models that reproduce this usage and on this basis forecast future usage of urban transport facilities.

Conventional demand theory states that shifts along the demand curve are due to a change in the price of the commodity demanded. Shifts in the demand curve may arise from a change in the price of competing goods, changes in income and changes in tastes etc. If urban travel demand is analysed in terms of conventional demand theory the difficulties of attempting to use the consumer surplus approach are readily apparent. The price or cost of urban travel is made up of several components. In the case of public transport the price of travel includes, fares, time (door to door), discomfort and inconvenience. In the case of private transport the cost of travel includes, variable car operating

1. Plowden, S.P.C. "Transportation Studies Examined", Journal of Transport Economics and Policy, Vol. 1, No. 1, January, 1967.

costs, time (door to door) and discomfort (related to congested driving conditions). Consider a hypothetical demand curve for public transport trips possessing some degree of price elasticity (fig. 1). The introduction of an

Figure 1. Consumer surplus arising from a drop in price of public transport.



Note: Pricing policy assumed to be constant; Producer surplus equals zero.

improved level of service of public transport will induce a drop in the cost of travel and generate additional demand equal to  $V_b - V_a$ . The benefit of the investment is equivalent to the consumer surplus given by the area  $P_a - P_b \frac{1}{2}(V_a + V_b)$ , assuming the demand curve between A and B approximates a straight line. A similar hypothetical curve can be constructed for private transport. Friedlander<sup>1</sup> and Mohring and Harwitz<sup>2</sup> have measured highway benefits according to this approach but the demand curve related to a

1. op cit.

2. op cit.

single commodity. No substitute or competing commodity was present as in the case of the urban transport situation.

The introduction of a mass transit scheme to an urban area will theoretically reduce the various costs of urban road travel. This will again theoretically induce additional demand. At the same time the relative prices of the two modes have changed thereby causing shifts in the demand curves themselves. The measurement of the two consumer surpluses is therefore impossible

Unfortunately the transportation planning approach to forecasting travel demand explicitly or implicitly makes the assumption that all travel demand is fulfilled in some manner or other whether by public or private transport. That is, suppressed demand for urban travel is non-existent and that improving the service levels of the two modes does not generate or induce additional demand. Urban travel pattern forecasting is not related specifically to the price of the commodity urban travel but is a function of the socio-economic characteristics of the trip maker, a function of geographic factors, including location, type and intensity of land use, as well as transport system characteristics. The trip generation phase of the transportation planning process estimates future trip volumes between urban area zones on the basis of forecasts of income, growth, car ownership, demographic data and land use characteristics. Modal split prior to or after the distribution phase is therefore based on a fixed volume of interzone travel and the split between modes is determined by the relative changes in the time and/or monetary cost characteristics of the modes.

The case for upgraded public transport rests on the diversion of private users to the public mode. According to current transportation planning procedure, improving the service level of public transport would induce a larger volume of usage after improvement and a reduction in the volume of urban road users. In terms of consumer demand theory this would be represented by a leftward shift in the demand schedule for private transport and a rightward shift in the demand schedule for public transport. The total number of daily urban trips in an urban area with a rapid transit system would be equivalent to the total number in the same urban area without a rapid transit system. The rationale behind the transportation study states that the only major difference between the two urban transport systems is the shift in the balance of usage between public and private modes. Indeed the rationale behind the planning approach to demand forecasting implies that the demand for urban transport is price inelastic.

In short the demand for urban transport as measured by the unit of the trip is determined by numerous variables and as a result there is considerable difficulty in aggregating these variables into a single demand curve. Demand for urban transport is a derived demand with little or no intrinsic utility of consumption. Numerous factors such as the purpose of the trip, time of day of trip, and climatic and seasonal factors, have a profound influence on the level of demand. Numerous variables are potentially operative in causing shifts in the demand curve rather than price responsive changes. Unfortunately for the economist benefits

of transport investment are best related to price responsive changes.

The problem faced in evaluating benefits is the spatial aspect of urban travel patterns. Travel patterns are a function of spatial as well as economic factors since transport and land use are functionally interrelated. At present the logical and best approach in isolating predictable patterns in this cause and effect relationship has been the forecasting of land use and zonal socio-economic factors and the subsequent travel activity generated. Although behavioural demand models<sup>1</sup> relating specifically to economic factors have been recently developed, it is doubtful whether they are a better alternative to the conventional demand models based on the separate but interrelated components of trip generation, distribution, assignment and modal split. The difficulties may be summarised in this statement extracted from a Highway Research Board Report<sup>2</sup> on modal split. "It is unrealistic to expect that a high degree of precision is obtainable in predicting individual behaviour with respect to choice of modes and routes of travel, particularly in future or hypothetical situations. The variability of human choice are facts of life. On the other hand recognition of underlying factors that operate to produce roughly similar patterns of travel independently to some extent of time and place, even though such regularities are discernable in the aggregate, provides the only solid foundation for long range planning".

1. a) Charles River Associates, An Evaluation of Free Transit Service, Department of Transportation, Wash, D.C., Report No. 125-1.
- b) Kraft, G., and Wohl, M., "New Directions for Passenger Demand Analysis and Forecasting", Transportation Research, Vol. 1, No. 3, 1967.
- c) Domencich, T.A., Kraft, G., and Valette, J. "Estimation of Urban Passenger Travel Behaviour: An Economic Demand Model", Highway Research Record, No. 238, 1968.
2. Highway Research Board, Factors Influencing Modal Trip Assignment, National Co-operative Highway Research Programme, Report No. 57.

The economic demand model investigated by Domencich<sup>1</sup> and others was orientated toward the measurement of price elasticities and cross elasticities of demand for private and public transport. They concluded however that there was a lack of evidence of significant cross relationships between private and transit demands and that socio-economic factors rather than transportation system characteristics are the principal determinants of modal choice.

One final point worth consideration is that the price of urban travel depends on the period of the day when a trip is made. This arises because of the unique manner in which supply and demand are functionally inter-related. For urban road travel, supply as measured by road space is a function of the volume of usage. Although supply is technically fixed, the amount of road space is determined by the degree of congestion. Congestion determines the monetary and time costs of travel which subsequently affects the level of demand. The classification of daily travel into peak and off-peak periods is such that the total price of travel is consistent over that period. This is the approach adopted in the theoretical evaluation of project benefits outlined in the next section.

Discussion incorporated in this section on urban travel demand has been made at a generalised level. Although no specific mention has been made of the Auckland study the problems outlined in constructive endeavours to adopt economically sound methods of benefit evaluation are directly relevant to the Auckland situation. It is hoped to have shown that the use of the consumer surplus approach is desirable but

1. op cit.

impracticable on the basis of current methods of forecasting travel demand. The following section will further reveal the complexity of the situation. Despite indications that travel demand is price inelastic there are several instances where consumer surplus calculations are feasible. Even though volume of usage remains constant the surplus is equivalent to the product of the cost reductions and the volume of usage, e.g. car operating cost savings to undiverted car users. Complications arise out of the diversion factor whereby both volumes of demand and associated prices of travel change. The following theoretical outline of project benefits therefore only approximates a consumer surplus approach.

## PROJECT BENEFITS

### 6.1 Benefits and Beneficiaries

The following sub-section identifies the benefits and beneficiaries of a more efficient transport system through investment in public transport. For the sake of a potentially complete analysis it is assumed that traffic congestion is a real and economic problem in the Auckland urban area. On the basis of this assumption the following broad classes of beneficiaries are identifiable.

Table 6 Beneficiaries of the investment in rapid transit in Auckland.

A. Direct beneficiaries: Direct beneficiaries are users of the new public transport system. Three user classes are distinguishable:

- (a) Diverted users - includes trips made on the new public transport mode that were formerly made by private car or taxi.
- (b) Captive users - includes trips made on the new public transport mode that were formerly made by existing type public transport.
- (c) Generated users - includes trips induced by the lower costs of travel associated with the new public transport system.

B. Indirect beneficiaries: This class of beneficiaries refers to users of urban transport facilities other than the new public mode.

- (a) Undiverted users - includes trips made by private car, taxi commercial vehicle and CBD orientated existing type bus.
- (b) Generated users
- (c) Non-users or the community as a whole.

The benefits accruing to each class of beneficiary may be classified as follows:

Table 7. Benefits of the investment in rapid transit in Auckland.

A. Direct benefits\*

(a) Diverted users

1. Time savings.
2. Savings in car operating costs.
3. Savings in parking costs.
4. Savings in car ownership costs.
5. Improved comfort and convenience.

(b) Captive users

1. Time savings.
2. Improved comfort and convenience.

B. Indirect benefits\*

(a) Undiverted users.

1. Time savings to private car occupants.
2. Time savings to the occupants of CBD orientated existing type buses.
3. Time savings to taxis, and commercial vehicles.
4. Savings in vehicle operating costs (taxis, commercial vehicles).
5. Savings in vehicle ownership costs (commercial vehicles).
6. The easing of the physical and mental stresses associated with driving conditions in congested traffic.

(b) Reduced incidence of traffic accidents.

(c) Community wide benefits - externalities (unpriced effects).

1. Reduction of noise levels in heavily congested areas.
2. Reduction of atmospheric pollution in heavily congested areas.

\* Note - The category "generated users" has been dropped from the classification for reasons outlined in the previous section on urban travel demand.

The foregoing summary is similar in outline to that produced by Foster and Beesley<sup>1</sup>. It is apparent from this reference and others relating more specifically to highway improvements, that the benefits of investment in urban transport facilities are basically standardised. It is the valuation of these benefits and techniques of measurement due in part to local conditions and individual appraisal which tend to differ.

Given the state of knowledge of the important cost parameters determining the magnitude of the various benefits, it is possible to further classify benefits into quantifiable, potentially quantifiable, and non-quantifiable where potentially quantifiable implies that at present the relevant data is unobtainable for New Zealand urban travel conditions but could be obtained with additional research. Those benefits which are considered quantifiable are also capable of refinement through additional research. Intangible items such as comfort and convenience present virtually insurmountable problems in determining their monetary value.

Table 8. An assessment of quantifiable benefits.

I. Quantifiable

- (a) Direct benefits
  - 1. Time savings - diverted users and captive users.
  - 2. Savings in car operating costs.
  - 3. Savings in parking costs.
- (b) Indirect benefits
  - 1. Time savings - undiverted users.
  - 2. Savings in commercial vehicle operating costs.
  - 3. Savings in car operating costs.

1. Foster, C.D. and Beesley, M.E. "Estimating the Social Benefit of Constructing an Underground Railway in London", Journal of the Royal Statistical Society, Vol. 126, Series A, 1963.

Table 8. Cont.

	4. Savings in taxi operating costs.
II Potentially Quantifiable	
(a) Direct benefits	1. Savings in car ownership costs.
(b) Indirect benefits	1. Savings in commercial vehicle ownership costs.
	2. Savings in traffic accident costs.
III Non-quantifiable	
(a) Direct benefits	1. Improved comfort and convenience.
(b) Indirect benefits	1. The easing of the physical and mental stresses associated with driving conditions in congested traffic.
	2. Reduced costs associated with a decline in noise levels.
	3. Reduced costs associated with lowered air pollution levels.

The assumption made at the beginning of this sub-section was that traffic congestion is a major problem and that it is inhibiting the efficient movement of people and goods within the urban area. However the significance of the majority of benefits outlined is obviously dependant on the volume of car users that would be diverted to the improved public transport system.

#### 6.2 Transportation Study Output and the Symbolic Representation of Benefits.

As indicated at the beginning of this report, one of the critical areas of an economic analysis of this type is the relationship between economic factors and the mass of data on urban travel patterns. This sub-section endeavours to take a

comprehensive look at the possible utilisation of such data in terms of a symbolic analysis.

The original aim of this study was to utilise the output of the transportation study which was being updated in conjunction with the technical feasibility studies of the alternative public transport systems. At the time of preparation of this report, assignments to transport networks had not been completed, therefore eliminating the possibility of an empirical study of the benefits of the alternative transit systems. It was envisaged that the output would have been presented in the form of vehicle hours, vehicle miles, person hours and average link speeds as represented on the modelled public transport alternatives and urban road system. This information would then have made possible an economic evaluation at a reasonable refined level, subject to the assumption and forecasts made in preparing the modelled networks, land use classification, intensity of land use and projected population variables. The accuracy and acceptability of any economic evaluation would then have been subject directly to the accuracy of the estimates of the prior steps in the transportation planning process. Notwithstanding these limitations an economic analysis itself is not entirely free of simplifying assumptions and possible error, particularly with regard to the monetary valuation of time savings and unitary costs of vehicle operation.

It is frequently shown in transportation planning flow diagrams that cost-benefit analysis or economic evaluation

is one of the final phases of the transportation planning process. This implies that the prior steps of generation, distribution, modal split etc, are organised to achieve this objective. Although this end was not achieved in the latest investigations it is necessary to make this assumption when considering the economic evaluation from a theoretical viewpoint.

The following, up until the symbolic representation of quantifiable benefits, is an attempt to abstract from several papers, the important factors regarding network information in order to adopt appropriate and similar methods based on information that can be potentially produced from the Auckland Transportation Study. The discussion therefore focusses on the finite aspects of benefit measurement.

Several papers have appeared in Highway Research Board<sup>1</sup> publications which have indicated the potential of economically evaluating the traffic assignments to transportation networks. All these authors recognise that the testing of economic efficiency is a necessary step toward providing the basis for sound investment decisions. Further evidence as to the ability to utilise transportation study output, and more specifically to a public passenger transport scheme such as rapid rail transit, is provided by Development Research Associates<sup>2</sup> who undertook the economic appraisal of the Washington Area Rapid Transit System.

1. a. Haikalis, G. and Joseph, H. "Economic Evaluation of Traffic Networks". Highway Research Board Bulletin, No. 306, 1961.
- b. Bellomo, S.J., and Provost, S.C., "Two Procedures to Improve the Economic Evaluation of Alternative Highway Systems", Highway Research Record, No. 224, 1958.
- c. Harvey, T.M., "A Method of Network Evaluation Using the Output of the Traffic Assignment Process", Highway Research Record, No. 238, 1968.
2. Development Research Associates, Benefits to the Washington Area from the Adopted Regional Transit System.

Haikalis and Joseph<sup>1</sup> consider that "it is possible with a knowledge of the average daily traffic assignment to a given link in the road network, plus a description of that link - such as it's speed limit, traffic carrying ability, signal spacing and provision for access control, to determine the expected daily performance of traffic using that link. The measure of this performance in this study is the average daily speed". The significance of this factor, average daily speed, is that it provides the basis of measurement for user costs. Haikalis and Joseph used average daily speed in determining time and vehicle operating costs and extended its use to include traffic accident costs.

One of the output factors produced by a transportation study is a statement of vehicle hours of travel for each alternative system. This factor is important in the calculation of time savings benefits. Bellomo and Provost<sup>2</sup> suggest that the actual vehicle hours of travel for each alternative system should be based on an average peak and off-peak speed and have put forward the following expression.

$$VH = \sum_{i=1}^n PH_i \frac{D_i}{SP_i} + \sum_{i=1}^n OP_i \frac{D_i}{S_i}$$

where VH = total system vehicle hours of travel.

PHi = peak periods vehicular traffic.

1. Haikalis, G. and Joseph, M. "Economic Evaluation of Traffic Networks". • Highway Research Board Bulletin, No. 306, 1961.
2. Bellomo, S.J. and Provost, S.C. "Two Procedures to Improve the Economic Evaluation of Alternative Highway Systems", Highway Research Record, No. 224, 1968.

$D_i$  = length of link  $i$  (in miles).  
 $SP_i$  = average peak period speed of link (m.p.h.)  
 $OP_i$  = off-peak vehicular traffic.  
 $Si$  = average off-peak speed of link (m.p.h.)  
 $i$  = individual link in system.  
 $n$  = total links in system.

Time savings benefits can be calculated by making a comparison between total vehicle hours and total person hours spent on an improved system with total hours on the base system.

Harvey<sup>1</sup> suggests that benefit measurement should ideally be based on interzonal demand functions for networks which differ in levels of improvement of traffic carrying capacity and which therefore theoretically exhibit a variation in perceived user costs of travel. Interzonal travel demand according to present methods of forecasting is usually regarded as being fixed, irrespective of the difference between alternative networks. The short run effects on the geographic redistribution of trips, due to shifts in residential and employment locations arising from radical improvements in transport facilities, may be minimal and insignificant, hence the assumption that interzonal travel demand functions remain constant, irrespective of the network considered, may not be unreasonable. Where alternative networks exhibit variation, is in the selection of minimum paths of travel based on the time and/or cost characteristics of individual links in the network.

1. Harvey, T.N. "A Method of Network Evaluation Using the Output of the Traffic Assignment Process", Highway Research Record, No. 238, 1968.

It is evident that the basic unit of analysis in the economic evaluation process is the individual link. However the symbolic analysis appropriate to the Auckland study, would be best based on the zone-pair concept. The use of the inter-zonal concept facilitates the identification of benefits and beneficiaries which could be lost in the aggregate form, such as expressed by Bellomo and Provost<sup>1</sup>.

An examination of the ICES Transit Manual used in the Auckland Transportation Study, reveals that it is theoretically possible to obtain individual link volumes, speeds and travel times from the final assignment process. Vehicle operating costs and time costs are a direct function of travel speeds. However the manner in which this link speed data could be used to calculate user cost savings is open to further investigation. The work by Haikalis and Hoseph<sup>2</sup> suggests that a separate economic analysis computer programme would need to be used in conjunction with the traffic assignment programme. However the most pertinent question regarding the use of link speed data in the current study is whether sufficiently accurate vehicle operating cost data are available to apply to the data produced from the traffic assignment process.

Before considering the symbolic representation, it is appropriate to comment on a less detailed approach to the problem of evaluating the economics of the proposed public transport

1. op cit.

2. op cit.

schemes. This method could be more applicable to the Auckland situation where there is probably a lack of sensitivity in the forecasting models to such factors as time and capacity, due to the non-critical traffic volumes. There is also the serious handicap of a lack of relevant cost information. Development Research Associates<sup>1</sup> in their study of the economics of rapid rail transit for the Washington Metropolitan Area developed several formulae of which the expression "Time savings to constant users" is typical, - it is as follows:-

$$B_a = T_c - Y/60 (L_a - L_f) a.e.$$

where  $T_c$  = Daily constant transit commuters.

$Y/60$  = Value of time in dollars per minute.

$L_a$  = Portal to Portal commuting time (in minutes) in 1990 via the all bus system

$L_f$  = Portal to Portal commuting time (in minutes) in 1990 via the rail/bus system.

$a$  = Daily conversion factor.

$e$  = Annual conversion factor.

The factors of interest are the portal to portal times. These are average door to door travel times which can be determined from the final trip distribution estimation. Similarly total operating cost savings were represented by the following expression:-

$$B_c = \left\{ \frac{A'd}{hr} (D_a O_a) - A_d \cdot (D_f O_f) \right\} a.e'.$$

where  $A'd$  = Daily all purpose trips diverted to transit.

$hr$  = Persons per auto.

$D_a$  = Average trip length (all trip purposes) in 1990 by auto.

$O_a$  = Average cost of operating an automobile in dollars per mile.

1. op cit.

Df = Average trip length (all trip purposes) in 1990 by train.

Of = Average train fare cost per passenger mile.

a = Conversion of one-way trips into round trips.

e' = Special annualisation factor for all purpose trips.

Again the factors of interest are the average trip lengths. These can be estimated from the final trip distribution calculations. Provision is made in the ICES programme to output trip distributions on the basis of time and distance. Another pertinent factor in the Washington study was that the computer analysis was designed so as to delineate specific types of travellers and data peculiar to each traveller type. Four traveller types were recognised - constant transit users, diverted auto drivers and passengers, non-diverted auto drivers and passengers, and trucks. If an approach similar to the Washington study were adopted in analysing the Auckland schemes, it would be important to delineate user categories and determine the incidence of benefits.

#### Quantifiable Benefits

The following notational analysis of quantifiable benefits is based on interzone travel in order to facilitate a symbolic analogy of the possible events that could occur if an improved public transport system were adopted in the Auckland urban area. Quantifiable benefits are defined as user cost reductions, but the term user costs requires further elaboration because of the multi-modal characteristics of the urban transport system. User may refer to private vehicle users, public transport users and commercial users, each of

which has different user costs. These may be summarised as follows-

A. Private vehicle users costs:

- (a) Time - time spent travelling is assumed not to have any intrinsic positive value. (particularly appropriate to work trips) Time costs include excess travel time i.e. walk, waiting and transfer time.
- (b) Variable car operating costs (excluding indirect tax components) - a function of travel and distance travelled.
- (c) Car ownership costs. (excluding indirect tax components plus fees used to recover road facility costs.)
- (d) Parking costs - includes money outlays only.
- (e) Discomfort costs - mental and physical resources used in driving in congested traffic.

B. Public transport user costs:

- (a) Time - time spent travelling is assumed not to have any intrinsic positive value. Again time costs include excess travel time.
- (b) Fares.
- (c) Discomfort - discomfort of riding in poorly ventilated vehicles plus standing and sitting in vehicles with poor riding characteristics.
- (d) Inconvenience - inconvenience from lack of flexibility and dependance on timetables. Lack of privacy.

C. Commercial user costs:

- (a) Time - principally related to the drivers' wages.
- (b) Vehicle operating costs (excluding tax components) - a function of travel speed and distance travelled.
- (c) Vehicle ownership costs. (excluding indirect tax components and fees levied to recover road facility costs).

Explanatory notes on the symbolic methodology used:-

The three main user categories may be symbolised as follows:-

Public transport users	=	p
Private car users	=	c
Commercial users	=	v

The possible alternatives to be considered in the economic analysis may be represented by the following symbols:-

The urban transport system (base alternative) if existing public transport is in operation	=	ps
The rapid rail transit alternative	=	rr
The rapid bus transit alternative	=	rb
Other possible alternatives	=	r.....x

The number or volume of trips made on transport facilities in the urban area will vary according to which public transport system is in operation. Therefore let X denote the volume of trips made if existing public transport is in operation; Y the volume of trips if rapid rail transit is in operation; and Z the volume of trips if rapid bus transit is in operation.

Trip assignments are made on the basis that they represent normal weekday travel patterns. As already stated the assumption has been made that travel demand can be classified into two distinct periods - peak and off-peak. If trip assignments are made on an hourly basis, then conversion factors have to be applied in order that trip volumes be applicable to the respective time segments. The conversion

factors have to be applied in order that trip volumes be applicable to the respective time segments. The conversion factor for the peak period must be multiplied by 2 to represent a four hour peak period. Thus peak period trip volumes plus off-peak volumes = average daily traffic. To avoid complicating the benefit formulae it will be assumed that conversion factors have been applied to peak hour and off-peak hour trip assignments.

A major, but necessary assumption is that no trips will be generated in addition to those generated under the existing urban transport system. In other words no suppressed demand presently exists which could become fulfilled in future years if improved transport facilities were constructed. On the basis of this assumption the following categories of beneficiaries may be identified. These pertain to the rapid rail scheme only, and may be substituted by those pertaining to any other contemplated alternative.

Captive users =  $X_p$  = existing public transport trips.

Includes choice mode trips but these will be assumed to be captive to an improved scheme.

$Y_p$  = all public transport trips if rapid rail is constructed.

$Y_p = Y_p' + Y_p'' + Y_p'''$

where  $Y_p'$  = existing public transport trips diverted to rapid rail transit.

$Y_p''$  = diverted car users to rapid rail transit (includes car drivers and car passengers).

$Y_p'''$  = existing public transport trips not diverted to rapid rail transit (i.e. some existing type buses would continue to operate).

$X_c$  = existing private car trips.

Undiverted car trips =  $Y_c$  = private car trips if rapid rail is in operation.

$\pi_o$  = car occupancy rates under the existing urban transport system.

$\pi_r$  = car occupancy rates under the rapid rail system.

Diverted car users =  $Y_p'' = X_c \pi_o - Y_c \pi_r$ . Only a small diversion of car users implies that  $\pi_r$  can be taken as being equal to  $\pi_o$ . Note-under the assumption of a lack of suppressed demand;

$$X_p + X_c = Y_p + Y_c$$

The remaining classes of undiverted traffic include all other commercial users - trucks, vans and taxis. It is assumed that the volume of commercial vehicle trips will remain constant irrespective of which public transport scheme is in operation.

Three design years are currently envisaged and this enables the evaluation of benefits that might accrue to the respective upgraded urban transport systems in these years.

#### I Time Savings Accruing to the Rapid Rail Alternative.

(a) Captive users: Captive users are defined by  $X_p = Y_p' + Y_p'''$ .

Daily time savings (in minutes)

$$= [t_1 X_p - (t_2 Y_{p',\alpha} + t_3 Y_{p''',\alpha})]_i^j \quad \text{- peak period}$$

$$+ [t_4 X_p - (t_5 Y_{p',\beta} + t_6 Y_{p''',\beta})]_i^j \quad \text{- off-peak period}$$

where  $t_1$  = the door to door travel time in the peak period for present style public transport trips made from zone i to zone j.

$t_2..t_6$  = the respective door to door travel times corresponding to the various categories of trip makers and time of trip.

$X_{p\alpha}$  = the number of peak period present style public transport trips from zone i to zone j.

$Y_{p'\alpha}$  = the number of peak period rapid rail trips made by former public transport users from zone i to zone j.

$Y_{p''\alpha}$  = the number of peak period other public transport trips if rapid rail is in operation.

$Y_{p\beta}$ ,  $Y_{p'\beta}$  and  $Y_{p''\beta}$  may be similarly explained for the off-peak period.

$[ ]_i^j$  = inter-zone travel from zone i to zone j and therefore represents one way travel.

Annual time savings  $ATS_{1976}$

$$= \$D \left\{ \sum_{x=1}^n A [t_1 X_{p\alpha} - (t_2 Y_{p'\alpha} + t_3 Y_{p''\alpha})]_i^j \right\}^{M_1} + \left\{ \sum_{x=1}^n A [t_4 X_{p\beta} - (t_5 Y_{p'\beta} + t_6 Y_{p''\beta})]_i^j \right\}^{M_2}$$

where  $\sum_{x=1}^n A$  = the summation of all inter-zone travel; n = the total number of zones in the urban area.

$M_1$  = the peak period weighted monetary value of time (dollars/minute) due to the variation in trip purpose.

$M_2$  = the off-peak period weighted monetary value of time (dollars/minute) due to the variation in trip purpose.

D = the number of normal weekdays in a year.

The monetary value imputed to time according to trip purpose would be determined from the summation of public transport trip volumes by purpose for the total urban area for each period and calculating a weighted average on this basis rather than determine the respective trip volumes by purpose for each pair of zones.

(b) Diverted users. The standard procedure for estimating the number of users of a particular mode in a choice of mode situation is the modal split model and its associated transit diversion curves. However an important methodological point arises in the calculation of time savings if the modal split model is based on a time variable. In most cases car journey time (or door to door travel time) will tend to be faster than transit travel time. This fact is borne out by statistics produced by Wilbur Smith and Associates<sup>1</sup> pertaining to urban travel in large metropolitan areas of the United States. The independent variable that could be used in the modal split diversion curves is the ratio of a transit time factor relative to a car journey time factor. If these ratios are reduced by implementing a rapid transit scheme, then depending on the slope (or sensitivity of the curve to the independent variable) of the diversion curve in the relevant range, a large or small volume of car users will be diverted to the public mode. The implication is that despite the reduction in the time advantage of car users a number of these have been diverted and as a

1. Wilbur Smith and Associates, Transportation and Parking for Tomorrow's Cities, Table 24, p. 98.

consequence have made trips entailing a greater time cost. It can be assumed that those diverted commuters who lose time will cancel the time savings accruing to other diverted car users. It can also be assumed that diverted car users who now make trips involving longer travel time, are compensated to a greater extent by other benefits such as out of pocket expense savings and reduced tension and fatigue.

(c) Undiverted car users.

Daily time savings (in minutes).

$$\begin{aligned}
 &= [t_1 Y_{ca} \pi_o - t_2 Y_{ca} \pi_r]_i^j && \text{- peak period} \\
 &+ [t_3 Y_{c\beta} \pi_o - t_4 Y_{c\beta} \pi_r]_i^j && \text{- off-peak period}
 \end{aligned}$$

where  $t$  = the appropriate door to door travel time for trips made from zone  $i$  to zone  $j$ .

Note - these times are interdependent of those used in the previous expression.

Annual time savings  $ATS_{1976}$

$$= \$D \left\{ \sum_{x=1}^n A [t_1 Y_{ca} \pi_o - t_2 Y_{ca} \pi_r]_i^j M_1 + \left\{ \sum_{x=1}^n A [t_3 Y_{c\beta} \pi_o - t_4 Y_{c\beta} \pi_r]_i^j M_2 \right\} \right\}$$

(d) Other undiverted traffic. This category includes trucks, vans and taxis.

Daily time savings (in minutes).

$$\begin{aligned}
 &= [t_1 X_{va} \pi - t_2 Y_{va} \pi]_i^j && \text{- peak period} \\
 &+ [t_3 X_{v\beta} \pi - t_4 Y_{v\beta} \pi]_i^j && \text{- off-peak period}
 \end{aligned}$$

where  $\pi$  = vehicle occupancy rate.

$t$  = the appropriate origin to destination travel times and are equivalent to the time costs of undiverted car users.

Annual time savings  $ATS_{1976}$

$$= \$ D \left\{ \sum_{x=1}^n A [t_1 X_{v\alpha} \pi - t_2 Y_{v\alpha} \pi]_i^j M_o \right\} + \left\{ \sum_{x=1}^n A [t_3 X_{v\beta} \pi - t_4 Y_{v\beta} \pi]_i^j M_o \right\}$$

$M_o$  = monetary value of time savings for each vehicle class. The suffix o may denote:-

$MTr$  = weighted average value of time savings for trucks in recognition of the variation of truck classes utilising urban roads, or

$MT$  = weighted average value of time savings for taxi occupants including the driver.

$\pi$  = vehicle occupancy rate.

$v$  = the commercial vehicle class which should be subdivided into the respective sub-classes.

Finally, it was previously indicated that the symbolic analysis as presented might not lead directly to an evaluation of the economic benefits accruing to the new system. As an alternative, annual time savings benefits could be computed from the normal weekday assignments to the public transport system and urban road system by expressing the benefit in terms of the difference in average trip duration for the two systems, that is between the rapid rail alternative and the base of null alternative. However this still requires some identification of diverted and undiverted traffic. Merely summing person hours on the respective networks would be inadequate due to the diversion factor and would lead to an under-estimate of the time benefit to existing public transport users and an over-estimate of the benefit to undiverted traffic.

## II Car Operating Cost Savings Accruing to the Rapid Rail Alternative.

Two classes are distinguishable within this category.

Firstly variable car operating cost savings will accrue to the diverted car user. Secondly, variable operating cost savings will theoretically accrue to the undiverted car user as a result of reduced traffic congestion and the consequent increase in travel speeds over the urban roading system.

(a) Diverted car users. The actual calculation of this benefit appears somewhat difficult due to several alternatives available to the diverted car user with regard to the use of his car.

Firstly he may abstain from using the car entirely. Secondly he may take a "kiss and ride" journey to the rapid rail station and either the car may return to the origin of the trip and then remain unused or another person may use the car for the purposes of another or other trips. Finally the diverted car user may retain the use of his car and park it in close proximity to the rapid rail station. For simplicity it will be assumed that the diverted car user opts for the first alternative. Unfortunately on the basis of this assumption an over-estimate of the benefit is likely.

Assuming the car driver bears the cost of operating his car then,

Daily car operating cost savings

$$\begin{aligned}
 &= \$ \left[ (c_{\alpha} s_{\alpha}^{ps} - f_{rr}) d(X_c - Y_c) \right]_i^j && \text{- peak period} \\
 &+ \left[ (c_{\beta} s_{\beta}^{ps} - f_{rr}) d(X_c - Y_c) \right]_i^j && \text{- off-peak period}
 \end{aligned}$$

- where  $s_{\alpha}^{ps}$  = the average peak period travel speed between the two zones, (on base system road network).
- $s_{\beta}^{ps}$  = the average off-peak period travel speed between the zones, (on base system road network).
- $c_o$  = variable car operating cost per mile corresponding to the average peak travel speed.
- $c_u$  = variable car operating cost per mile corresponding to the average off-peak travel speed.
- $f_{rr}$  = the fare per mile via rapid rail transit.
- $d$  = the distance (in miles) between zones  $i$  and  $j$ .

Annual car operating cost savings - ACOCS<sub>1976</sub>

$$= \$ \left\{ \sum_{x=1}^n A [(c_o s_{\alpha}^{ps} - f_{rr}) d (X_c - Y_c)]_i^j + \sum_{x=1}^n A [(c_u s_{\beta}^{ps} - f_{rr}) d (X_c - Y_c)]_i^j \right\} D$$

where  $D$  = the number of normal weekdays in a year.

$\sum_{x=1}^n A$  = the sum of all inter-zonal travel.

The savings accruing to the diverted car user are essentially out of pocket expense savings and may not necessarily be perceived in their entirety by the beneficiary.

(b) Undiverted car users.

Daily car operating cost savings.

$$= \$ [(c_o s_{\alpha}^{ps} - c_q s_{\alpha}^{rr}) d Y_c]_i^j \quad \text{- peak period}$$

$$+ [(c_u s_{\beta}^{ps} - c_v s_{\beta}^{rr}) d Y_c]_i^j \quad \text{- off-peak period.}$$

where  $s_{\alpha}^{rr}$  = the average peak travel speed via the road system between zones  $i$  and  $j$  if rapid rail transit is in operation.

$s_{\beta}^{rr}$  = the average off-peak travel speed if rapid

rail transit is in operation.

Annual car operating cost savings ACOCS<sub>1976</sub>

$$= \$ \left\{ \sum_{x=1}^n A[(c_{o\alpha} s_{\alpha} ps - c_{q\alpha} s_{\alpha} rr) d Y_c] + \sum_{x=1}^n A[(c_{u\beta} s_{\beta} ps - c_{v\beta} s_{\beta} rr) d Y_c] \right\}^j D$$

As an alternative to the method outlined, an approximation of car operating cost savings could be estimated by measuring the difference between the urban road systems with respect to car miles produced when the alternative public transport systems are operative. This method requires the use of a "static" weighted car operating cost per mile in contrast to a cost per mile which varies according to speed of travel. The method is biased toward the diverted car user since it excludes the situation where the diverted car user only reduces out of pocket expense savings to the new level of out of pocket expenses which is the rapid transit fare. This apparent error would be counteracted by the implicit rather than the explicit inclusion of cost savings to undiverted car users as was adopted in the other approach.

### III Commercial Vehicle Operating Cost Savings

The less complex alternative to measuring vehicle operating cost savings as just discussed, does not by contrast appear appropriate to commercial vehicles, since it was assumed earlier that the same volume of commercial vehicle trips would be made irrespective of which public transport system is in operation. Hence total commercial vehicle miles would tend to remain constant under this assumption.

Commercial vehicles only benefit from reduced traffic congestion if it can be shown that increased speeds are the ultimate effects of the diversion of car users to public transport.

The formula appropriate to this benefit measurement is similar to that expressed for undiverted car users.

Annual vehicle operating cost savings - AVOCs<sub>1976</sub>

$$= \$ \left\{ \sum_{x=1}^n A \left[ \left[ (k_o s_{\alpha} ps - k_q s_{\alpha} rr) dY_v \right]_i^j + \left[ (k_u s_{\beta} ps - k_v s_{\beta} rr) dY_v \right]_i^j \right] \right\} D$$

where  $k$  = the average vehicle operating cost per mile appropriate to the average travel speed.

$Y_v$  = the number of commercial vehicle trips.

The above general formula should be expanded to include each vehicle class. For example, the cost per mile for trucks would be taken as a weighted average due to the range of truck types operating within the urban area. The derivation of this weighted cost figure could be made from a knowledge of the distribution of truck types using urban roads at each major time period. For taxis  $k_o = c_o$  (variable cost per mile for cars).

#### IV Parking Cost Savings

The incorporation of this benefit appears valid if the demand for parking facilities (short term and long term) exceeds the capacity and provided that consumer savings in parking costs do not lead to a decline in revenue of the authority providing the facility. In other words transfer payments should be ignored. The validity of including possible parking cost savings is also dependent on a decision whether rapid transit parking facilities are to be priced. If parking areas are to be priced then parking cost savings at downtown destinations would tend to be offset by the charges levied at the suburban stations. An approximation of the potential parking cost savings can be estimated from the number of CBD trip destinations diverted to rapid transit. Attention has been focussed on the central business district since the majority

of parking facilities in the urban area are located in this sector and also the CBD is the major trip attractor.

Assuming zero parking charges at rapid transit suburban locations, daily parking cost savings can be expressed as follows:-

Daily parking cost savings,

$$= \begin{aligned} & \$ \left[ pc_{\alpha} \{ (X_c - Y_c) Dt \} \right]_i^{j(Dt)} && \text{- peak period} \\ & + \left[ pc_{\beta} \{ (X_c - Y_c) Dt \} \right]_i^{j(Dt)} && \text{- off-peak period} \end{aligned}$$

where  $pc_{\alpha}$  = average parking cost incurred in the morning peak period including free parking facilities.

$pc_{\beta}$  = average parking cost incurred in the off-peak period.

$(X_c - Y_c) Dt$  = the number of car trips diverted to transit with downtown destinations.

$j(Dt)$  = a zone in the central business district.

The above expression therefore represents parking cost savings for diverted car users with trip origins in zone  $i$  and destinations in zone  $j$  of the CBD.

Annual parking cost savings - APCS<sub>1976</sub>

$$= \$ \left\{ \sum_{x=1}^{n(Dt)} A \left[ pc_{\alpha} \{ (X_c - Y_c) Dt \} \right]_i^{j(Dt)} + \sum_{x=1}^{n(Dt)} A \left[ pc_{\beta} \{ (X_c - Y_c) Dt \} \right]_i^{j(Dt)} \right\}_D$$

where  $\sum_{x=1}^{n(Dt)} A$  = interzonal travel with downtown destinations.

The assumed benefit resulting from parking cost savings would require further investigation particularly with regard to the projected supply of parking facilities. Parking patterns are assumed to bear some relationship to trip purpose, hence supply and demand will be influenced by trip types diverted to rapid transit.

The foregoing discussion and symbolic analysis of quantifiable benefits is strictly theoretical and is in no real way related to actual experience. The significance of the benefits that have been outlined is very much dependent on the diversion of the peak period car commuter to the public mode of transport. It is hoped that this important factor will be placed in its correct perspective outside of theoretical considerations at a later point.

### 6.3 The Monetary Valuation of Benefits

Unlike investment in forestry development or water resource projects the expected yields associated with investment in urban transport are of a more diffused and intangible nature. Although the capital and, to a lesser extent, operating costs of transport facilities, are quite readily identified and calculated, benefits present particular problems. Apart from the difficulties of estimating future patterns of travel demand, the values imputed to user cost reductions are the subject of a good deal of arbitrary and intuitive decision. Because there appears to be no correct approach and even more importantly no basis for suggesting one, it is appropriate to consider the methods adopted in similar and related projects and on this basis to consider the most appropriate approach that could be followed in the economic evaluation of the proposed transit schemes for Auckland.

I Time - The valuation of time benefits presents by far the greatest problem in evaluating the economics of the proposed projects for several reasons. Time benefits are usually the major part of total benefits of investment in urban transport projects and highway improvements. Such projects are to a large extent justified economically on the rather dubious

grounds of time savings benefits. Unfortunately, there is no satisfactory market relationship which provides the basis for imputation; the closest approximation is the wage rate which in a perfect economic world is the marginal rate of substitution between income and leisure.

Foster and Beesleys<sup>1</sup> cost-benefit study of the Victoria Line in London revealed that time savings benefits were approximately fifty per cent of present day value total benefits. The economic assessment of the London - Birmingham Motorway<sup>2</sup> showed that sixty per cent of total benefits were comprised of working time savings. Assumptions regarding the utilisation of time saved had to be made in order to justify this figure. Leisure time savings were excluded from the assessment due to the difficulties of valuation. The Stanford Research Institute<sup>3</sup> reported that approximately forty per cent of direct benefits in the form of time savings would accrue to the rapid transit system proposed for the Southern California Rapid Transit District. Finally the study undertaken by Development Research Associates<sup>4</sup> of the Washington Area rapid transit system revealed that time savings were seventy per cent of total benefits.

An extremist view recorded by St. Clair and others<sup>5</sup>, states that "there is some disposition to regard the measurement of benefits as nothing more than an exercise or as a tool of propaganda or publicity for the particular type of improvement that is advocated. This is particularly true in the use of time

1. op cit.

2. Coburn, T.M. Beesley, M.E. and Reynolds, D.J. The London Birmingham Motorway, RRL, Road Research Technical Paper, No. 46.

3. Stanford Research Institute, Benefit-Cost Analysis - Rapid Transit System - Southern California Rapid Transit District.

4. op cit.

5. St. Clair, G.P., Todd, T.R. and Bostick, T.A., "Highway User Benefits", Highway Research Record No. 138, 1966.

savings and the even more subjective comfort and convenience factor". While not entirely sharing this view it is apparent that more rational means need to be sought to solve this intractable problem; despite imperfect knowledge the attempt to place monetary values on these intangible factors is a move in the correct direction to provide the basis for more effective decision making.

A number of approaches have been adopted in valuing consumer time savings. St. Clair and others have listed four such approaches:-

- 1) The trade-off method - here the value of time is measured through increased speed as against the increased costs in the form of fuel, tyres, etc. associated with the increased speed. The approach has been used in relation to road improvements.
- 2) The willingness to pay method - the mean value of time is measured statistically by comparing the preferences for travelling on toll roads and alternative free roads.
- 3) The wage rate principal - the valuation of time is valued at the salary or wage rate.
- 4) The alternative cost method - under this approach the value of motorists travel time is determined by the highway costs that are incurred to provide time savings of a given magnitude.

It is apparent that what little work has been done in this field relates more specifically to highway investment. Irrespective of this handicap the second and third methods do have some apparent basis for further investigation since they relate more to the individual consumer and his behaviour.

Moses and Williamson<sup>1</sup> similarly state that "two techniques have most commonly been used to estimate that part of highway benefits accounted for by savings in travel times. One ignores the problem of consumer choice between alternative modes, - the income or productivity method values travel time according to the worth of time in work and assumes that individuals are free to choose the combination of income and leisure that is optimal. The second method rests on there being a choice between modes (or between alternative routes for the same mode) with different time and money outlay characteristics". This has been termed the pure cost approach whereby travel time savings are valued according to the money cost differentials between the modes and routes.

The main advocates of the latter approach are Claffey<sup>2</sup> and Thomas<sup>3</sup>. One of the main difficulties in this approach lies in isolating the time savings benefits from other road user benefits and apportioning the toll differential accordingly. Claffey's researches evaluated an average passenger car users value of time as being 2.37 cents per minute. This is a contrast to the 2.58 cents per minute of \$1.55/hour/passenger car (or \$0.86/hour/person) recommended by the American Association of State Highway Officials<sup>4</sup> in 1960. The study undertaken by Thomas estimated the value of travel time for commuting motorists from

1. Moses, L.M. and Williamson Jnr., H.M. "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation", Journal of Political Economy, Vol. 71, No. 3, June, 1963.
2. Claffey, P.J. "Characteristics of Passenger Car Travel on Toll Roads and Comparable Free Roads", Highway Research Board Bulletin, No. 306, 1961.
3. Thomas, T.C. "Value of Time for Commuting Motorists", Highway Research Record, No., 245, 1968.
4. American Association of State Highway Officials, Road User Benefit Analysis for Highway Improvements, Washington; AASHO, 1960.

the behaviour of motorists in eight areas of the States where the individual faced a choice between a toll road and a free road in their trips to and from work. The results of the study enabled a recommendation of "the use of \$2.82 per person hour as the value of travel time savings for commuter trips of more than ten minutes and more than five miles in highway economy studies". Thomas considers that "even though a value of time factor has been used for years in highway economic analysis, relatively little reliance can be placed on the accuracy of the values chosen. The most common value \$0.86 per person per hour (AASHO) can be justified only in that it represents current opinion of a logical and practical value. Research into the value of time has increased in recent years, but even the latest efforts are unsuccessful in determining values that can be used with confidence in a variety of situations".

To a certain extent, any decision to place a value on time saved on trips made for purposes other than work will depend on the number of possible alternatives available for which that time can be utilised. Stated in a slightly different way, time is not an homogeneous quantity having equal value from one time period to another. Moses and Williamson<sup>1</sup> point out that the willingness to pay studies frequently do not distinguish between trips made for different purposes. However, Thomas' study, was in fact confined to the commuter work trip. Another similar study of the value of time to the commuter was undertaken by Lisco<sup>2</sup> who concluded that typical suburban commuters are willing to pay at a rate approximately fifty per cent of their wage rate to save on their trips to work.

1. op cit.

2. Lisco, T.E. "Value of Commuter's Travel Time - A Study in Urban Transportation", Highway Research Record, No. 245, 1968.

Quarmby<sup>1</sup> records from his studies that walking and waiting times are worth between two and three times in-vehicle times, therefore yielding an average value of time equivalent to one quarter to a third of the wage rate. Lisco's studies similarly revealed that in vehicle times were not valued as greatly as terminal or excess travel time.

Reconsidering the question of time utilisation, Tipping<sup>2</sup> states that "time is inextricably bound up with so many other non-monetary factors as to make its separate evaluation very dubious. There is the theoretical objection that the value of time depends on the consumption mix for which time is needed". Thus time is a complementary good and confers a level of satisfaction in association with the activity involving the utilisation of time. For non-work activities it could be argued that the greater the number of alternative uses of a certain time period the greater the value of that time. The same reference also states that "if working time can be saved and put to some other productive use then there is a benefit to the economy. If working time is saved and converted into leisure time, then there is a benefit to the individual concerned and this could be measured theoretically at the rate appropriate to the individual. Hence the monetary value of time savings argument can be approached from a point of view of producer or consumer.

Another apparent difficulty related to time utilisation which is particularly relevant to the current study is the

1. Quarmby, D.A. "Choice of Travel Mode for the Journey to Work", Journal of Transport Economics and Policy, Vol. 1, No. 3, September, 1967.
2. Tipping, D.G. "Time Savings in Transport Studies", Economic Journal, Vol. 78, No. 312, December, 1968.

valuation of dissimilar increments in time savings. Of necessity time savings benefits are averages and the measurements of these are biased toward the summation of total time savings accruing to broad categories of trip types and as such, the individual valuation of a given time interval is lost in the aggregate form. The dilemma that is apparent can be expressed by querying whether one thousand people saving one minute is equivalent to 100 people saving 10 minutes. St. Clair<sup>1</sup> suggests however that there is some evidence that many motorists behave as if minute time savings were a major objective.

The most notable contribution on the other major approach to time valuation is that of Wingo<sup>2</sup>. He states that "in a perfectly competitive economy, the primary condition for the optimum allocation of labour among production possibilities is the equivalence of the worker's marginal value of leisure with the marginal cost of labour to the firm or the wage rate. Implicit in conventional labour market theory is the assumption that the amount of a worker's input into the production process is equal to the amount of leisure time he gives up. In fact, however, this equivalence does not hold, the worker gives up more leisure time than he puts into work, and the difference is the time spent travelling on the journey - to work". The necessary free-choice assumption is irrelevant in an imperfect labour market with its institutionalised wage and salary agreements. (In some instances the opportunity costs of leisure time may be greater than the wage rate and may be equivalent to

1. op cit.  
2. Wingo, Jr. L., Transportation and Urban Land, p.p. 52 - 61.

the overtime rate). Wingo states that "given the fact that industry purchases labour at the manifest hourly wage rate, the inference arises that the time-costs of the journey to work enter the production costs of the local firms as a component of their labour costs". Empirical evidence is provided by firms located on the periphery of large urban areas which have to offer premium wages and transportation cost concessions to induce labour to make the extended work trip.

When Foster and Beesley<sup>1</sup> made their economic appraisal of the Victoria Line, they used values of 7s. 3d. per hour for journeys made in working time and 5s. per hour in non-working time - this was stated as being an arbitrary value. Dawson<sup>2</sup> states that current valuation of non-working time by the British Ministry of Transport is placed at 3s. per hour. By contrast the Traffic Research Corporation Ltd.<sup>3</sup>, in the Merseyside Area Land Use Transportation Study, suggest that individuals on average were prepared to pay 7/6d. per hour on the journey to work. This evaluation was based on an analysis of how much people were prepared to pay to travel by car when this offered a time advantage - this figure was therefore a measure of convenience as well.

In concluding this section, the consumer valuation of time appropriate to the current study of rapid transit for the Auckland urban area would appear to be optimally based on an hourly average wage rate. The results of "willingness to pay" studies

1. op cit.

2. Dawson, R.F.F., "Highway Project Appraisal", Planning and Transport Research and Computation Co. Ltd. 1968.

3. Traffic Research Corporation Ltd., "The Definition of Economic Evaluation Procedures", M.A.L.T.S. Technical Report No. 17, 1969.

based on an American experience would be difficult to apply even though there appears to be some consistency in the results of their research. These results are inextricably linked with levels of income and living standards and on that basis, parallels are hard to draw. Comparable studies have not been undertaken in New Zealand therefore eliminating the possibility of a similar approach.

Taking Wingo's<sup>1</sup> theoretical exposition as the basis for the valuation of time savings accruing to trips made for work purposes, analysis of recent salary and wage statistics<sup>2</sup> reveals an average hourly wage rate\* of \$1.20 per hour. This average figure is applicable to both car commuters and public transport commuters even though there tends to be an income differential between the two types of urban travellers.

The valuation of non-work time is more difficult. As a theoretical base it is suggested that average earnings be applicable to hours of work activity plus hours of leisure activity. Thus non-work time would be valued at a rate of approximately 40% of the average hourly wage rate, i.e. \$0.45 per hour.

Due to the apparent dissention in opinions of the appropriate value of time it is imperative that any benefit analysis including the factor of time savings should also incorporate a sensitivity analysis. That is a range of monetary values should be imputed to time. Economic worth of the proposed schemes should be tested on the basis of three values for the same time

1. op cit.

2. New Zealand Dept. of Statistics, New Zealand Prices, Wages, Labour 1968. Tables 30, 32.

\* inclusive of overtime, bonuses and all allowances and special payments.

factor. It is suggested that the appropriate values could be:-

- 1) the basic values calculated for work and non-work time factors.
- 2) 50% of these basic values.
- 3) 25% of these basic values.

#### Time Savings to Commercial Vehicles.

The most comprehensive reference on commercial vehicle time savings is the special report published by the Highway Research Board<sup>1</sup>. It lists four methods by which time can be theoretically valued. Two of the approaches are similar to those outlined for private cars - the willingness to pay method and the alternative cost method. Neither of these appear to have a practical application by reason of the lack of empirical data and non-applicability to the project currently being considered. The other two methods are termed:-

- 1) the net operating profit (revenue) method.
- 2) the cost savings method.

The net revenue approach is based on the premise that time savings are used to operate additional revenue miles at a reduced average cost per mile. The method assumes that the increase in output of transportation service increases over a range in which marginal revenue and marginal variable costs are constant. Practical applications of this approach have therefore made a number of finite assumptions regarding revenues and costs. An hour of time saved was calculated as being equivalent to:-

- a) average hourly wage rate of drivers.
- b) net operating profits (after income taxes) reduced to an hourly basis.

1. National Co-operative Highway Research Programme Report 33, Values of Time Savings of Commercial Vehicles.

The cost saving method is based on a reduction of those costs which are not variable with miles of operation. It assumes that time savings lead to a saving in resources required to perform a given volume of output.

Both methods purport to be based on the theory of the firm. "The net operating profit method is an application to the trucking industry of the profit maximising principle. Those costs which are variable only with hours of operation will not increase when a firm operates additional revenue miles in the time saved due to a technological change". The key determinant regarding the utilisation of this approach is the elasticity of demand for road carrier service. If potential demand before improvement exceeds the supply of road carrier service then the opportunity exists for the performance of additional revenue miles. The cost saving method is "an application to the trucking industry of the principle of cost minimisation under conditions where those costs which are variable with hours of operation, are reduced as a result of time savings which decrease the hours of operation, even though the same number of revenue miles are operated". Beesley and Reynolds<sup>1</sup> evaluated time savings for the London-Birmingham motorway on this cost savings approach - one hour of time costs (maintenance and establishment costs) and interest for one hour on any saved vehicle investment costs. Both approaches agree that drivers' wages are a valid approximation of the value of time saved. The question of fixed cost savings is debatable and is best excluded from current consideration.

Data that would give an indication of the elasticity of demand for trucking services in Auckland is non-existent hence a minimum approximation of the value of time to commercial

vehicles is provided by the wages of the vehicle occupants. Because drivers wages vary with truck capacity it is necessary to know the average wage for each major truck class and the distribution of these truck classes within the urban area. Although probably not relevant in the current situation the long run effects of more optimal vehicle fleet utilisation may be a subsequent reduction in the number of vehicles to produce the same level of output. Knowledge of the utilisation of time saved and the determinants of road carrier demand are therefore the crucial factors necessary for an empirical study. An empirical study would also have to take cognisance of the structure of the trucking industry.

The value of time saved for ancillary vehicles (vehicles not operated on a hire or reward basis) can be measured on the same basis as licensed goods service vehicles. This suggestion is based on the argument that a firm operating an ancillary vehicle or fleet of vehicles recognises the opportunity costs involved, i.e. the real costs of ancillary vehicle operation are equivalent to the costs that a competitive carrier would incur plus the percentage profit factor. However in some cases where economies of scale are possible and vehicle fleet utilisation is maximised in relation to a licensed vehicle, a commercial or industrial firm operating its own fleet of vehicles will be able to distribute its goods at a lower cost than a licensed carrier. The measurement of time savings accruing to ancillary vehicles according to the net operating profit approach would therefore depend on the elasticity of demand for the firms product(s).

In conclusion it is suggested that the appropriate valuation of commercial vehicle time savings for the Auckland cost-benefit

study should be the wages of the vehicle occupants. The potential for these time savings to accrue to commercial vehicles and the significance of this time in relation to daily patterns of operation is the other major consideration on this topic.

#### The Relevance of Time Savings to Commercial Vehicles.

J.M. Owens<sup>1</sup> in his investigation into the economics of truck operations in urban areas of Australia produced some interesting results. He states "that it is well known that the pattern of urban goods movement differs in space and time from the peak hour commuter movement". This is also supported by the findings of Wilbur Smith and Associates<sup>2</sup> in their statement "when truck activity is related to automobile traffic, the pronounced auto peaks are not evident for truck travel. Moreover the greatest truck activity occurs between the two passenger car peaks". Other salient facts are as follows: In the United States, the percentage of trucks in the general traffic flow ranges from 10% - 20% of any traffic count irrespective of city size or particular land use. Almost 75% of trucks operating within the urban area are light trucks and in the typical twelve hour working day (6.00 a.m. - 6.00 p.m.) the average truck is in motion only 21% of the time. Owens' analysis of the freight forwarding sector of the trucking industry showed that "the influence of traffic delays on the travel time of trucks on collection and delivery work is considerable, stationary delays plus excess running time amounted to between 19% and 42% of total travel time in the cases studied. However because of the rather high proportion of total operational time spent at the depot and at clients premises, traffic delay amounted to only 5% to 8% of total operational time".

1. Owens, J.M. "Economics of Truck Operations in Urban Areas", Proceedings 2nd Conf. Australian Road Research Board. 1964.

2. Wilbur Smith and Associates, Motor Trucks in the Metropolis.

The results produced by Wilbur Smith and Associates and Owens indicate the insignificance of minor time savings that will likely accrue if a rapid transit system is adopted in Auckland. Research on commercial vehicle time savings in general has largely been orientated toward inter-city trucking operations where reduction in time length of line haul operations are significant. The utilisation of minor time savings will not enable additional revenue miles nor will it lead to a significant saving in resources needed to produce the same output of road carrier service. Over and above these suppositions it still has to be shown that the diversion of peak period car commuters leads to decrease in urban traffic congestion and an increase in urban road speeds.

The principles outlined are equally as applicable to taxi operation. Any time savings accruing in periods of peak demand may lead to additional revenue miles. However if the same volume of demand is forthcoming then the savings in time cannot be utilised. If it is assumed that total hours of operation remain constant then time savings do not lead to a saving in the costs of vehicle operation or drivers labour costs - real or opportunity.

It has been intimated that some existing type CBD orientated buses would continue to operate within the Auckland urban area irrespective of whether a new public transport system is adopted. Time savings therefore would theoretically accrue to this class of traffic. Time is an important component of bus operating costs due to the high proportion of total cost attributable to drivers wages. Although any significant changes in bus operating costs will be reflected in the cost side of the cost-benefit analysis it is pertinent to point out that assumptions regarding time

utilisation are necessary if the time saved is a valid benefit or cost reduction. Thus time savings should lead to more optimal labour utilisation and in the long run more optimal utilisation of vehicles as reflected by a decline in the rate of increase or replacement of buses.

## II Vehicle Operating Costs

Mention was made previously that the use of link speed data in relation to vehicle operating cost reductions was dependant on available cost data. The handicap imposed by the apparent lack of relevant data suggests that detailed investigations into these benefits on the basis of theoretical speed changes is unwarranted. It does not appear feasible to rely on American cost data due to the dissimilarity in travel conditions and vehicle size and the closest approximation to New Zealand conditions are the results produced by two Australian investigations. The desirability of sensitive cost information as a basis for benefit assessment is obvious. One of the objectives of the study undertaken by Pelensky and others<sup>1</sup> was to provide a practicable method for the calculation of benefits to road users to be expected from road or traffic management improvements in urban areas. Comprehensive data were produced on the variable cost components of car operation at speeds ranging from 5 mph to 32 mph. The study was approached from the point of view of the individual car user and did not attempt to exclude indirect tax components. The real cost of resources used in the urban transportation sector is the major concern of a cost-benefit analysis approached from a national viewpoint; hence sales tax and petrol tax should be excluded from the capital cost and variable cost components.

1. op cit.

In the event of speed changes over the urban roading system not being detectable by the incorporation of capacity constraints in the modelled networks, then static average cost figures could be used to measure the benefit of vehicle operating cost savings. It would be assumed that total annual miles would differ between road networks according to which public transport system was in operation. Depending on closer investigation the source of such cost data could be in the case of private cars, the work of Currey<sup>1</sup> and the N.Z. Ministry of Transport<sup>2</sup>. In the case of commercial vehicles, various possible sources are the N.Z. Ministry of Transport, the work of Winfrey<sup>3</sup> and the N.Z. Ministry of Works.

### III Vehicle Ownership Costs

Several cost-benefit studies of transit investment have endeavoured to incorporate reduced ownership costs as a quantifiable benefit. The impact of a new public transport system could be profound and could be instrumental in reducing the rate of growth of vehicle ownership. It appears particularly difficult to incorporate this as a quantifiable factor and reliance on intuition and individual assessment is necessary. Just what impact rapid transit would have in this sphere would be determined by the reduced levels of traffic congestion.

1. Currey, G.R.B. "A Survey of Private Vehicle Operating Costs", Australian Road Research, Vol. 4, No. 3, March 1970.
2. Economic Research and Planning Division, N.Z. Ministry of Transport, Car and Truck Operating Costs, January, 1970.
3. Winfrey, R. Economic Analysis for Highways.

The relevant savings in ownership costs would be:-

- a) capital cost (exclusive of indirect tax).
- b) insurance costs.
- c) fees and licence costs.
- d) garaging costs.

The inclusion of time depreciation costs and interest charges would lead to a double counting if the vehicle purchase price was also included.

Projected rates of car and commercial vehicle ownership would have to be compared on a with or without rapid transit basis before any quantitative assessment could be made.

#### Unquantifiable and Intangible Benefits.

One of the critical areas regarding the usefulness of cost-benefit analysis as a decision making tool is the determination of the magnitude and significance of unquantifiable and intangible benefits. Hence it is usual to find a qualitative analysis of these factors accompanying the results of the discounting of the monetary costs and benefits.

In the current study, in order to increase the effectiveness of a cost-benefit analysis of public transport investment, additional investigation of the less easily quantified benefits is required. The cost of traffic accidents is a case in point.

A qualitative analysis of the indirect benefit of traffic accident cost savings and externalities and intangibles such as aesthetics, traffic noise and air pollution costs, is not possible since none of the alternative schemes have been defined with reasonable certainty and secondly because of the inhibiting factor of a lack of research findings. Notwithstanding these limitations, it would be necessary to have a considerable diversion

of vehicular traffic at present entering the congested central urban area in order to reduce the incidence and seriousness of traffic accidents and to reduce the intangible social costs.

External effects such as the long run effect on the prices of goods and services in the urban area arising from induced locational changes appear equally difficult to determine.

#### 6.4 Summary of Quantifiable Benefits

In the final analysis the benefits which can be assigned monetary values are time savings, vehicle operating cost savings and parking cost savings. It was previously stated that travel demand could be estimated for three non-consecutive years (1976, 1981 and 1996). It is necessary to impute annual monetary values to benefits over the project analysis period, thus benefits accruing in intermediate years would have to be estimated by simple interpolation accordingly;

$$\frac{B_i(1981) - B_i(1976)}{5}$$

where B = benefit

i = a particular benefit category

In summary and tabulated form the annual direct and indirect benefits that are to be discounted to present day values - are as follows.

Table 9. Quantifiable benefits accruing over the project life.

Quantifiable Benefits	PERIOD						Total Present Discounted Value
	Construction period 5 years; no benefits	Year 6			Year 7....Year N		
<u>A. Direct Benefits</u>		Annual Value \$(000)	P.D. Value \$(000)				
a. Time Savings 1.							
1. Captive public transport users.	Nil	O	A	P	O	A	P
b. Car operating cost savings.	Nil						
c. Parking cost savings.	Nil						
Annual Total							
							Same format as year 6.
							"
							"
							"
<u>B. Indirect Benefits</u>							
a. Time savings.							
1. undiverted car users.	Nil	O	A	P	O	A	P
2. Commercial vehicles.	Nil						
b. Car operating cost savings - undiverted car users.	Nil						
c. Commercial vehicle operating cost savings							
Annual Total							
							"

where N = project analysis period: O = optimistic imputed value of private individual time savings;  
A = average or best estimate of the value of time; P = pessimistic value of time.

It is assumed that the construction period would be five years hence benefits would accrue initially in year 6. However this assumption may not be realistic since the financial constraints imposed by a large capital cost system may necessitate a staging of the various elements of the investment plan. This could mean a modification in the basic concept of a particular alternative and reinforces the need to undertake a financial feasibility study along with the cost-benefit analysis.

## INVESTMENT CRITERIA AND RELATED ASPECTS

### 7.1 The Appropriate Interest Rate.

The determination of the appropriate discount rate is the major conceptual problem of cost-benefit analysis. The impression conveyed in review articles (Prest and Turvey<sup>1</sup> and Henderson<sup>2</sup>) indicates that there is no general consensus of opinion as to the specific or appropriate discount rate which takes account of the marginal productivity of investment and time preference. Henderson concludes his article by stating that "the main issues which arise in formulating investment criteria for public enterprises are far from settled,.... this results from inevitable differences of opinion about what is practicable or tactically wise. When it comes to translating broad objectives into decision rates and operating procedures, what appears to be the most suitable course of action is bound to depend on judgements about how much can be done in given circumstances". The gap between theory and practice is noticeably wide.

Feldstein<sup>3</sup> notes that currently "most economists have begun to recognise that in a mixed economy with market imperfections and multiple interest rates no single discount rate can be taken as a measure of both time preference and the productivity of capital. Nevertheless, much cost-benefit writing has been a search for such a single discount rate with

1. Prest, A.R. and Turvey, R., "Cost-Benefit Analysis: A Survey", The Economic Journal, Vol. 75, No. 300, December, 1965.
2. Henderson, P.D., "Investment Criteria for Public Enterprises," in Public Enterprise, (Ed.) Turvey, R., p.p.86 - 169.
3. Feldstein, M.S., "The Social Time Preference Discount Rate in Cost-Benefit Analysis", The Economic Journal, Vol. 74, June, 1964.

normative significance for public expenditure decisions".

Feldstein<sup>1</sup>, in another paper records that the long-term government borrowing rate has been used to find the discounted present value of annual benefits and costs ever since cost-benefit calculations were first made during the 1930's by the United States Bureau of Reclamation and Corps. of Engineers. The Australian Treasury Dept.,<sup>2</sup> has suggested a discount rate of 5.5 per cent for Australian conditions. This rate consists of two elements - the long term bond rate at 5 per cent and an allowance for risk and uncertainty of 0.5 per cent. Feldstein has criticised the theoretical weaknesses inherent in the use of such a discount rate; these are, that interest on the public debt is not the "cost of capital" to the government and secondly that the long term rate is not equal to the risk-free return expected to be realised on capital invested in alternative uses".

Alternatively two other types of discount rates have been advocated; the social time preference rate and the social opportunity cost rate. The social time preference function assigns current values to future consumption streams and according to Feldstein "is a normative function reflecting society's evaluation of the relative desirability of consumption at different points in time". The social time preference function must reflect public policy and social ethics and incorporate a judgement about future economic

1. Feldstein, M.S., "Opportunity Cost Calculations in Cost-Benefit Analysis", Public Finance, Vol. 19, No.2, 1964.
2. Commonwealth of Australia, "Investment Analysis", Supplement to the Treasury Information Bulletin, July, 1966.

conditions. The social opportunity cost of a public investment project is the value to society of the foregone next best alternative investment project. Expressing the value as an internal rate of return yields the social opportunity cost rate.

It is not one of the purposes of this report to examine in detail the theoretical arguments and criticisms associated with each discount rate concept. It has been argued that either the STP or the SOC rates should be used exclusively, but recent literature has recognised that both rates need to be incorporated in evaluating public investment projects (Eckstein<sup>1</sup> and Feldstein<sup>2</sup>). Feldstein<sup>3</sup> records that "a more sophisticated concept of the social opportunity cost rate that is becoming widely accepted by American economists and that has been recommended to the United States Bureau of the Budget for general use, is a special weighted average of market interest rates and corporate investment yields, designed to recognise the incidence of taxation and to reflect funds withdrawn from both consumption and investment". As already noted it is now advocated that this weighted average interest rate be combined with the social time preference rate. The practical application of this approach is limited by the difficulties in empirically determining the social opportunity cost rate.

Much of the cost-benefit writing has been concerned with the duality problem of differing interest rates in the public and private sectors if a social discount rate is used. In deriving a social opportunity cost rate reference is made to the productivity of investment in the private sector as the

1. Eckstein, Otto, "A Survey of the Theory of Public Expenditure Criteria" in Public Finance, (Ed.) Houghton, R.W., p.p.216-276.
2. Feldstein, M.S., "Net Social Benefit Calculations and the Public Investment Decision", Oxford Economic Papers, Vol. 16, March, 1964.
3. op cit.

opportunity cost of funds withdrawn from the private sector. The social opportunity cost value should therefore reflect the source of funds and their productivity in these alternative uses. The practical economist however, is necessarily involved in sub-optimisation where investment decisions in the public sector are subject to budgetary constraints or capital rationing. Thus as Feldstein<sup>1</sup> asserts public investment projects in practice, are likely to be financed by funds withdrawn both from alternative public projects and from the private sector.

In selecting an interest rate appropriate to New Zealand conditions for a public investment such as a rapid transit system it is necessary to consider the source of finance for the project and the nature of the projects excluded by the use of resources in the marginal project. In practice it is doubtful that investing in the public project is going to displace any potential private investment and/or consumption, due to the budgeting of limited expenditure in the public sector. Investing in the public project is more likely to displace alternative public projects. Measuring the social opportunity cost of such projects is difficult since many of the spillover of indirect effects frequently defy monetary assessments.

In addition to raising finance by taxation the Government may borrow internally or externally. Feldstein, in general has criticised the use of the internal long term government interest rate on the grounds that it is the instrument of monetary policy and is therefore politically exogenously determined. Specifically, J.T. Ward<sup>2</sup> has pointed to its

1. op cit.

2. Ward, J.T., "Cost-Benefit Analysis for Auckland's Rapid Transit System", Auckland Rapid Rail Symposium, August, 1969.

inappropriateness to New Zealand conditions.

Prest and Turvey<sup>1</sup> have concluded that "discussions about social rates of time preference, social opportunity cost, etc., do not cut very much ice in most empirical work, and we have not been able to discover any cases where there was any convincingly complete application of such notions". Ward<sup>2</sup> has noted that New Zealand is currently paying approximately 8 per cent on external borrowing and suggests that this rate should be applied to the discounting of costs and benefits of internal projects. This rate reflects the "cost of capital" rather than a specific evaluation of social time preference. By using a discount rate in excess of the long term security rate, greater economic efficiency is obtained in the public sector.

In their cost-benefit analysis of the Victoria Line, Foster and Beesley<sup>3</sup> incorporated a sensitivity analysis in the form of a range of interest rates. The same procedure should be adopted for the Auckland study. Although the discount rate has been selected on the basis of what appears to be logically appropriate, the use of a sensitivity analysis allows for any incorrect judgement or evaluation of social time preference by decision makers. The discount rates appropriate to the Auckland cost-benefit analysis of rapid transit can be set at 6 per cent, 8 per cent and 10 per cent.

## 7.2 Project Life

The project analysis period is often governed by the economic life of the project. In the case of a rapid transit system, the capital assets have varying service lives. For instance, Meyer, Kain and Wohl<sup>4</sup> in general, place the economic

1. op cit.

2. op cit.

3. op cit.

4. Meyer, J.R., Kain, J.F. and Wohl, M., The Urban Transportation Problem, Table, 57, p. 178.

life of the rail track and stations at 50 years as against 30 years for the rolling stock. Foster and Beesley<sup>1</sup> underestimated the economic life of the Victoria Line to guard against obsolescence and decided on a fifty year period. The difficulties of accurately determining the useful life of a project have been outlined previously. As an aside, it should be noted that the higher the discount rate and the longer the period, the less the significance assumed by any errors incurred in estimating the life of an asset.

Despite the problems imposed by the uncertainty of future technological developments the project analysis period is restricted by the benefit side of the analysis. Transportation planners consider it unreasonable to expect that urban travel demand can be forecasted with any degree of reliability for periods greater than twenty five years. Reasonably reliable estimates of annual benefits are therefore restricted to this time period. In deciding on a project analysis period of twenty five years, estimates of the value of non-depreciated assets are required.

### 7.3 Treatment of Uncertainty

In this study several methods have been advocated in allowing for various types of uncertainty. These are firstly, the use of contingency allowances in estimating project costs; secondly, the use of a range of values imputed to provide individual time savings; and thirdly, the incorporation of a sensitivity analysis in the form of a range of discount rates. Various sources point out that uncertainty can also be allowed for by limiting the economic life of the project. Such a procedure is an adjustment for technological advance but is a matter for subjective judgement.

By the use of a sensitivity analysis of discount rates on adjustment for a risk premium addition has in a sense been made. The Australian Treasury Information Bulletin<sup>1</sup> notes that this type of adjustment is appropriate where uncertainty about the magnitude of costs and benefits is greater at the latter stages of a project. Public transport investment fits this category. However as Henderson<sup>2</sup> suggests, the size of the risk premium is arbitrarily determined.

An overriding factor of uncertainty is contained in the estimation of urban travel demand. Experience from completed transportation studies often shows forecasted levels of inter-zone travel to be incorrect by quite large margins in later years. Allowing for this element of uncertainty would lead to a complicated matrix of results which could in turn lead to problems of interpretation as to the appropriate or acceptable result. In any case the normal estimates of travel demand provided by the transportation study would have the highest probability of being realised.

The suggested adjustments for uncertainty are subjectively determined and are not based on any formal probability concepts. Nevertheless allowing for every possible form of uncertainty would inevitably complicate the task of the decision maker. Too many assumptions limit the practicability of cost-benefit analysis.

#### 7.4 Investment Criteria

The arguments concerning the optimum criterion (present value v internal rate of return) are essentially academic and the ranking of projects is usually similar whichever criterion

1. op cit.

2. op cit.

is used, provided that the internal rate of return approach yields a unique result. Both criterion require the determination of a social rate of discount. Intuitively the net present value approach is more acceptable by reason of the psychological advantage it possesses in making a direct comparison of benefits against costs. Use of the internal rate of return approach would probably show most projects yielding some form of a return, but screening alternatives by use of the minimum acceptable social rate of return is slightly less convincing when the results are to be interpreted by non-economists.

Symbolically stated the net present value decision formula can be expressed as:-

$$\frac{b_1}{(1+i)} + \frac{b_2}{(1+i)^2} + \dots + \frac{b_n}{(1+i)^n} > \frac{c_1}{(1+i)} + \frac{c_2}{(1+i)^2} + \dots + \frac{c_n - s}{(1+i)^n}$$

where  $b_1 \ b_2 \dots \dots \dots b_n$  = series of annual benefits in year 1, 2,.....n.

$c_1 \ c_2 \dots \dots \dots c_n$  = series of annual costs in year 1,2,...n.

$i$  = appropriate social rate of discount.

$s$  = value of non-depreciated assets.

In the absence of constraints, the criterion may be formally stated as - select all alternatives where the present value of benefits exceeds the present value of costs and in turn accept the alternative which maximises net present value.

With specific reference to the rapid transit alternatives proposed for Auckland, the possible costs and benefits enumerated in previous sections can be drawn together for the final analysis. Following the classification given on page 33, the absolute costs of each alternative may be expressed symbolically as follows:-

$K_j$  = construction costs.

$O_j$  = operating costs of new public transport facilities.

$O'_j$  = operating costs of other public transport services.

$U_j$  = urban transport facility user costs.

$A_j$  = costs of traffic accidents.

$E_j$  = externalities.

where  $j$  = 1,2,3, etc., and,

1 = base alternative.

2 = rapid rail transit alternative.

3 = rapid bus transit alternative.

4.....m = other possible alternatives.

Benefits of a new scheme are defined as reductions in user costs, traffic accident costs and externalities. In the case of the rapid rail transit scheme benefits may be expressed as follows:-

$U_1 - U_2$  = user cost savings (includes direct and indirect benefits)

$A_1 - A_2$  = savings in traffic accident costs.

$E_1 - E_2$  = reduced externalities.

Costs of a new scheme are incremental to those incurred under the base alternative. In relation to the rapid transit scheme costs may be expressed as follows:-

$K_2 - K_1$  = rapid rail facility construction and land acquisition costs (incremental capital costs).

$O_2 - O_1$  = operating costs of rapid rail system facilities less the operating costs of extended facilities of the base system.

$O_x$  = operating costs of existing public transport services that are subsequently replaced by rapid rail transit services.



in this study. The significance of possible constraints would be more easily determined when investigations were in the final stages and alternatives had been more clearly expounded.

One of the frequently cited objectives associated with transport investment is to minimise transportation costs. Thus in addition to the net present value criterion for selecting the optimum project, an alternative criterion would be to select the alternative which minimised urban transportation costs. Both criterion yield the same results as is shown by the following rearrangement of cost and benefit categories:-

net present value criterion

$$(U_1 - U_2) + (A_1 - A_2) + (E_1 - E_2) > (K_2 - K_1) + (O_2 - O_1) - O_x$$

Transposing terms pertaining to each alternative;

$$\text{i.e. } K_2 + O_2 - O_x + U_2 + A_2 + E_2 < K_1 + O_1 + U_1 + A_1 + E_1$$

Substituting for  $O_x$  ( $O_x = O'_1 - O'_2$ );

$$K_2 + O_2 + O'_2 - O'_1 + U_2 + A_2 + E_2 < K_1 + O_1 + U_1 + A_1 + E_1$$

$$\text{i.e. } K_2 + O_2 + O'_2 + U_2 + A_2 + E_2 < K_1 + O_1 + O'_1 + U_1 + A_1 + E_1$$

By expressing each alternative in terms of absolute costs a decision can be made as to the best alternative, thus:

$$\text{Base alternative } C_1 = K_1 + O_1 + O'_1 + U_1 + A_1 + E_1$$

$$\text{Rapid rail alternative } C_2 = K_2 + O_2 + O'_2 + U_2 + A_2 + E_2$$

$$\text{Rapid bus alternative } C_3 = K_3 + O_3 + O'_3 + U_3 + A_3 + E_3$$

Where  $C_1$ ,  $C_2$  and  $C_3$  are total public and private costs for the urban transport system.

The advantage of the cost-effectiveness approach (in theory) is that the base alternative enters directly into the decision

formula, whereas in the cost-benefit analysis where incremental costs and benefits are compared, the base alternative is retained only if the proposed alternatives have a negative net present worth. In practice, the approach or criterion adopted, would depend on the method of estimating benefits. For instance if time savings were determined by estimating the change in time of travel and multiplying by the respective user category annual volumes then the cost-benefit approach should be adopted. If however time savings were determined by estimating the annual total person and vehicle hours performed on each alternative system then a cost-effectiveness analysis would be appropriate.

Table 10. Social benefit and cost balance sheet.\*

Item	Alternative I (Rapid rail transit)			Alternative II (Rapid bus transit)			Alternatives III...
	Interest Rate			Interest Rate			
	6%	8%	10%	6%	8%	10%	
Assumed: 5 yr Construction period, 25 yr Project analysis period.	PDV\$(000)	PDV\$(000)	PDV\$(000)	PDV\$(000)	PDV\$(000)	PDV\$(000)	
A. Direct Costs							
(a) Capital costs	....	....	....	....	....	....	
(b) Annual costs	....	....	....	....	....	....	
less							
(c) Terminal non-depreciated value.	....	....	....	....	....	....	
B. Indirect Costs	....	....	....	....	....	....	
C. Total Costs	....	....	....	....	....	....	
D. Direct Benefits**	....	....	....	....	....	....	
E. Indirect Benefits	....	....	....	....	....	....	
F. Total Benefits	....	....	....	....	....	....	
Social Net Present Worth (F - C)	....	....	....	....	....	....	

\* Partially derived from table 9.

\*\* Includes the most logical value of private individual time savings.

## 7.5 The Final Analysis:

The following is a suggested programme of important considerations leading to the choice of the optimum alternative. It assumes that the cost-benefit approach is adopted.

- (I) Summary of quantifiable benefits and costs (Table 10, Page 108).
- (II) Qualitative evaluation of unquantifiable indirect costs.
- (III) Qualitative evaluation of unquantifiable indirect benefits and intangibles.
- (IV) Evaluation of relevant constraints.
- (V) Evaluation of significant assumptions and consideration of the possible means of improving cost and benefit estimates and minimising the subjective element contained in major assumptions.
- (VI) Recommendation as to the optimum alternative.

## VITAL ISSUES AND CONCLUSIONS

### 8.1 Possible Solutions and the Diversion Issue.

The solution to the urban transportation problem essentially involves a shift in the balance of usage between the public and private modes of urban transport; more specifically, a shift away from the peak period use of the private car for trips whose destinations focus on the central urban area. A number of alternatives have been suggested, but seldom implemented, to promote the necessary change or impose restraint. Possible alternatives range from "doing nothing" to undertaking revolutionary new investment. Both of these alternatives are impracticable. The first because doing nothing implies a denial of the congestion problem or that congestion will eventually rationalise both transportation facility usage and land use according to the free market principle but at the expense of considerable social cost in the form of sprawled uncoordinated development. The second because technical constraints and cost currently prohibit such developments. Between these two extremes lie two other main alternatives; the regulation and control of transport facilities, and secondly, the implementation of new but traditional investment. The first of these alternatives attempts to increase the capacity and service level of urban roads through a minimum of investment - through more optimum road and facility pricing, through institutional changes such as staggered working hours, larger volumes of goods deliveries in off-peak hours, reducing vehicle size and through such factors as the encouragement of car pooling and the more extensive use of off-street loading facilities. Apart from the political and technical constraints there is not a universal agreement as to the validity of marginal social cost

pricing of urban roads. Sharp<sup>1</sup> and Lichfield<sup>2</sup> have pointed to some inherent defects of the congestion tax and its inability to optimally allocate resources. In an imperfect economic world the dominance of second best criteria in related spheres of economic activity may eliminate the advantages of adopting an optimum road pricing system.

Most attempted solutions of the urban transportation problem have been of the second type, either through providing urban roads and motorways or when scarce urban land limits space for new roads through the upgrading of the public transport system. The optimum outcome of the public transport approach is dependent on the diversion of car users to the public mode. Although a desirable objective of investment in public transport would be to improve the transport opportunities of those who for various reasons do not have access to private transport, when the investment is considered in terms of the second of the main objectives (relieving traffic congestion) and the social benefit and cost calculation, the diversion factor is the crucial issue.

One of the recommendations embodied in an OECD<sup>3</sup> report on urban transportation suggested that "there is no urgent need to improve the speed capabilities of rail vehicles for intra-city transportation. More attention should be devoted rather to improvements in the quality of public transportation service in order to provide the urban traveller with meaningful alternatives to private transportation. Most of the empirical evidence tends to suggest that constructing rapid transit does not attract the

1. Sharp, C.H., "Congestion and Welfare Reconsidered", Journal of Transport, Economics and Policy, Vol.2, No.1, January, 1968.
2. Lichfield, N., "Planner/Economists View of Road Pricing". Traffic Engineering and Control, Vol.9, No.10, February, 1968.
3. Panel Report, Future Directions for Research in Urban Transportation, OECD, 1969, pp. 20 - 21.

private car user in significant volumes. Wohl's<sup>1</sup> investigations reveal that rapid rail transit has been able to avoid passenger reductions in some instances, but only through the extension of the system or through other capital improvements, the full costs of which are not attributed to the transit system or by the users. He quotes the cases of New York, Chicago, Philadelphia, Boston and Toronto where patronage has generally declined over the last seven or eight years. Several causal factors could be operative in this decline, eg. changing CBD employment structure. Two of the comparatively new systems and extensions operating in North America, Cleveland and Toronto, increased patronage for approximately two years after the completion date, but thereafter patronage steadily declined. Wohl therefore concludes that "the mere construction of a rapid rail transit facility or system will not magically increase ridership and be self supporting".

Wilbur Smith and Associates<sup>2</sup> suggest that both land use trends and consumer preferences point toward increasingly car dominant urban regions and that in terms of current transport capabilities most urban areas are capable of adapting to motorized transport. It is also suggested that neither economic analysis nor transportation history suggest a significant return to public transportation, despite its continued importance in selected situations. The selected situations are where travel corridor densities approach a threshold such that rapid rail or bus transit potentially have

1. Wohl, M., "Urban Transportation Myths", Traffic Engineering, Vol. 35, No. 8, May, 1965.

2. Wilbur Smith and Associates, Transportation and Parking for Tomorrows Cities.

a cost advantage over a car dominant urban transport system, (detailed system cost comparisons have been made by Meyer, Kain and Wohl<sup>1</sup>).

The Buchanan report<sup>2</sup> recognised the inevitability of the private car and its dominance as the major traffic problem. Consequently one of the important recommendations made in the report was the need to modify transport routes and land use to preserve accessibility and environmental standards - a need therefore to structure and adapt the urban area to enhance the advantages of the private vehicle. Greater use of public transport was also advocated but only through realistic alternatives and through creating increased public awareness of the urban transport problem, its costs and trade-offs.

If left to free choice and under present pricing policies, rising car ownership and consumer preference point toward expanded demands for urban road capacity. The study by Moses and Williamson<sup>3</sup> of a sample of Chicago commuters revealed a reasonably inelastic demand for private transport. It was found that to divert 50% of car users to public transport the daily cost of travel would have to rise by \$1.20. Low elasticities of substitution were also revealed by the fact that if fares were reduced to zero less than one fifth of car users would be diverted to public transport. Hedges<sup>4</sup> has noted that the study undertaken by Charles River Associates for the U.S. Department of Transportation evaluated the following effects of free transit in the Boston area:

1. Meyer, J.R., Kain, J.F. and Wohl, M., The Urban Transportation Problem, pp. 171 - 309.
2. Buchanan, C.D., Traffic in Towns.
3. Moses, L.N., and Williamson, H.F., "Value of Time, Choice of Mode and the Subsidy Issue in Urban Transportation", Journal of Political Economy, Vol. 71, No. 3, June, 1963.
4. Hedges, C.A., "An Evaluation of Commuter Transportation Alternatives", Highway Research Record, No. 296, 1969.

(a) free transit would reduce car work trips only by 6 to 7 per cent and would have an even smaller impact on non-work, off-peak trips; (b) the fare elasticity of demand for transit travel was only about 0.17 per cent; and (c) the cross elasticity of demand for car travel with respect to transit fares was only 0.138 for work trips.

Although comparatively few studies have been undertaken of demand elasticities and cross elasticities between modes, the results of completed studies are sufficient to indicate a low response by car users to changes in pricing or travel costs. More significantly when basic comparisons between Chicago, Boston and Auckland are made, the American cities exhibit characteristics far more conducive to high capacity public transport usage. Boston and Chicago possess populations and central city and urban area population densities greater than Auckland and the American cities evolved under dissimilar periods of prevailing transport technology. Wilbur Smith and Associates<sup>1</sup> find that population density patterns generally reflect a city's age and the modes of intra-urban transport that prevailed during its formative years. An interesting graph shows that Chicago and Boston in 1960 had population densities of approximately 14 - 16 thousand, while the respective central cities reached a population of 350,000 between 1870 and 1880. In contrast San Diego, California (with 1960 population of 836,000) achieved a comparable central city population in 1952 but had a density of only about 2.8 thousand per square mile. Bearing in mind that measures of size and concentration are artificially biased by definitions of urban limits, Auckland had a central city population of 151,800 in 1968\* (total

1. Wilbur Smith and Associates. Transportation and Parking for Tomorrows Cities, Figure 7, p.15.

\* Source: New Zealand - Population, Migration and Building Statistics, 1967-68, Dept. of Statistics, Tables 11 and 12.

population, 577,300) and an overall population density of 3.2 thousand per square mile. Wilbur Smith and Associates<sup>1</sup> also note that the highest densities of car ownership are found in the old central cities such as Philadelphia and Boston. Auckland's pattern of development - low population density and more rapid population growth in outer suburban areas, has in part been stimulated by the increased use of the private car. Thus if demand elasticities were evaluated in Auckland it would be logical to expect that the results would indicate a low response by car users to improvements in the level of service of public transport. Coupled with the information derived from American experience of rapid rail transit the insignificant substitution effects would tend to indicate that a large scale investment is not the solution to Auckland's urban transportation problem and the financial difficulties of public transport. Nothing is more evident than the fact that there is no easy answer to the problem. Superficially the solution appears to require a realistic alternative to the private car appropriate to the density of urban development, in association with a system of restraints on the use of urban roads, or alternatively, more efficient use of the capacity of the private vehicle. Here again it is necessary to make the qualification that imposition of a system of restraints may further encourage decentralization and urban sprawl.

## 8.2 Urban Transportation and Land Use

Plowden<sup>2</sup> has noted the generally accepted principle that the control of transport facilities is the most powerful means available to the town planner to bring about a desired pattern

1. op cit.

2. op cit. p.24.

of land use. Yet one of the most important factors inhibiting the development of an efficient public transport system is the decentralization of the central city. Meyer et al.<sup>1</sup> consider that in addition to technological developments in transport and freight handling, high labour costs and advancing technology have made it desirable for more manufacturing operations to be placed on a continuous process or automatic material handling basis, thereby increasing space requirements and forcing industry to relocate in areas where the cost of land is not prohibitive. At the same time decentralizing forces have been only slightly counter-balanced by other developments such as expanded managerial control functions.

One of the popular arguments for building rapid transit is the possible secondary benefit of central area redevelopment. Meyer et al., investigated the validity of this hypothesis in relation to American cities and found an inverse relationship between public transport use and urban growth (including both the central city and outer rings). The cause of this relationship is that central cities with well developed public transport systems are usually older cities which generally exhibit slower growth rates and have less vacant land. Current urban transport technology does not appear therefore to act as a centripetal force in urban development. In addition urban renewal programmes tend to reinforce natural decentralizing tendencies. Hearle and Niedercorn<sup>2</sup> state that "within project areas the major impact of renewal is to double the land area devoted to industrial uses and to triple the area used for public

1. op cit. pp. 44-48.

2. Hearle, E.F.R., and Niedercorn, J.H., The Impact of Urban Renewal on Land Use, Rand Corporation, RM-4186-RC, June, 1964.

purposes. Residential area is sharply reduced, commercial area increased and street area remains approximately constant. Urban renewal projects, if current practice continues, are changing substantially the land use character of the area where they are located. Since such projects occur mainly in older sections, and such sections tend to be toward the centres of the cities, urban renewal appears to accelerate rather than retard the decentralization of residential population".

The interrelationship between transportation and land use indicates the dynamic nature of an urban area and the problem of defining the appropriate objectives of urban transport investment. In this respect Meyer et al.,<sup>1</sup> consider that "the rate of adjustment of urban location decisions to new technological conditions, if not the absolute character of these decisions, will always be influenced and sometimes obfuscated by the inertia of existing circumstances and commitments. Urban change tends to proceed in a slow evolutionary fashion. The net effect is to create a complex set of urban problems in which it is sometimes difficult to identify basic trends, much less solutions. However, a cogent, well defined set of hypotheses about urban change is discernable and their testing against available data is essential to the design of better transportation policies for urban areas". The interrelationship between transportation and land use now raises the question of whether cost-benefit analysis is the appropriate technique in analysing the impact of a major transport investment in an urban area. It has already been indicated that the transportation planning process cannot quantify the feed back effect of

1. op cit. p. 24.

transportation on land use. In other words land use patterns and intensity are forecasted over the project analysis period on the basis that the new system will not radically alter the previous forecasts. Wilbur Smith and Associates<sup>1</sup> point to the fact that transportation facilities have had distinct but varying impacts on urban development. The well quoted examples of major impact are Toronto's Yonge Street Subway and Cleveland's rapid rail system where many high rise buildings have been induced to locate within its environs. In fact one of the popular justifications for rapid rail transit is the large increments in local tax revenue from an expanded tax base because of land value changes. However these changes may only represent a redistribution of urban activities and a transfer of land values. Such changes are therefore excluded from the calculation of benefits because of the transfer effects and because increases in land values are a form of double counting. Improved accessibility leads to land value increases but this value is measured by the saving in transportation costs. It is possible that alternative transport systems may induce patterns of land use such that a particular alternative minimises transportation costs or maximises land values over the urban area as a whole. The choice of the optimum alternative would depend on the ability of a cost-benefit analysis to take account of the secondary costs and benefits associated with the induced changes in land use activity. The dynamic nature of an urban area and the numerous linkages between changing activities renders the economic evaluation of urban transport investment a

1. op cit.

complex and probably impossible task. Thus Troy and Neutze<sup>1</sup> are led to conclude that "once we admit land use changes into our decision making system, the simple benefit cost analysis, which aims to maximise net benefits from transport, becomes inappropriate".

### 8.3 Conclusion

At the outset of this study it was assumed that questions of density versus dispersion, patterns of living, and the changing spatial arrangement of urban activities, would not affect the validity of the results of a cost-benefit analysis of public transport investment. In support of this assumption Hoover<sup>2</sup> states that "most urban transport studies ignore the effect of alternative transportation policies upon the developing land use pattern of the area involved. Most of the prominent designers of such studies have explicitly denied the existence of any significant feedback effect". Yet at the close it is apparent that land use is responsive to improvements in transportation, even though there is uncertainty as to the magnitude of these responses in specific urban regions. Hence within the narrow framework of minor and insignificant induced land use changes, the main aim of this study has been to suggest a method whereby alternative public transport projects in Auckland could be evaluated on a social benefit and cost basis utilising data from engineering studies and the updating of the Comprehensive Transportation Study undertaken by De Leuw Cather and Company<sup>3</sup>.

As the study progressed it became increasingly evident that much of the information necessary to complete an investigation

1. Troy, P. and Neutze, M., "Urban Road Planning in Theory and Practice", Journal of Transport Economics and Policy, Vol.3, No. 2, May, 1969.
2. Hoover, E.M., "Motor Metropolis: Some Observations on Urban Transportation in America", Journal of Industrial Economics, No. 3, June, 1965.
3. op cit.

of this magnitude was not available. Little research has been undertaken to ascertain the magnitude and monetary costs of important externalities of urban transport investment. The factor of time savings has been shown by various researchers to bear some relationship to income yet the value imputed to time saved by users is to a large extent arbitrarily determined. Another important consideration is the fact that as real income per capita rises the value of travel time changes. Vehicle operating cost information is limited in extent, the nearest reliable data to be used in user benefit calculations would be that derived from two studies<sup>1</sup> undertaken in Australia. In addition traffic accident costs, their incidence and severity in relation to traffic conditions have not been determined in New Zealand. Finally there is little or no information to support an evaluation of environmental effects although this is a situation not unique to the Auckland study.

In addition to information gaps, a second major conclusion is that the estimation of benefits based on the measurement of consumer surplus is the appropriate means of correcting for the fact that the benefit received for transport services is not wholly reflected by monetary outlays. In most cases the benefit perceived by the user would be less than the actual benefit since the user is probably not aware of the costs of congestion or total vehicle operating costs per mile. The aggregation of all travel costs under the one demand function enables the consumer surplus to be measured after service level improvements have been made. However urban travel demand is not specifically estimated according to the variation in total

1. op cit.

travel costs but is based on a complex interrelationship of user socio-economic factors and transport system characteristics. In addition to this handicap the two competing modes situation of urban transport leads to shifts in the demand schedules. The measurement of benefits therefore exhibits considerable disparity between theory and practice.

Troy and Neutze<sup>1</sup> have stated in their article that "transportation studies fall short of providing a good basis for road planning precisely because they lack the kind of economic criterion provided by benefit cost analysis. The more advanced studies do compare a number of alternative improvements in the network, each designed to give about the same level of service (benefits), but the implicit investment criteria are still crude. Compared with transportation studies, benefit cost analyses usually rest on naive estimates of network effects. Everything points to a marriage of benefit cost analysis with the transportation study technique. Unfortunately this is much more easily said than done and the attempts made so far have not been successful. Even the fairly limited comparisons between the costs of a small number of alternative networks, which have been made in some of the more advanced studies, are very expensive". In this study an attempt has been made to link the transportation study technique with the economic evaluation through a series of symbolic formulae. Whether or not this attempt has been successful is open to further investigation since achieving a desirable result would depend on whether the transportation planner could produce the data represented in the formulae. Certainly no reference has been made to the

1. op cit., p. 142.

inevitably high computational costs that would be incurred in an investigation of this type. Of necessity, there must be a trade-off between the costs and accuracy of extensive investigations and the decision-making value of a cost-benefit analysis based on naive estimates. Even the latter approach would require considerable basic or background research before a cost-benefit study of rapid transit in Auckland could be satisfactorily concluded.

In concluding his paper to the rapid rail symposium J.R. Dart<sup>1</sup> suggested that "the rapid rail scheme may prove to be so remote from the resources that are likely to be made available for it, that it will be shown to be an excuse for doing nothing at all towards the improvement of public transport services". The fact that no finance has been specifically and tentatively allocated to the proposed solutions of Auckland's urban transportation problem may well support Dart's claim. In other words, no budgetary constraint has been imposed on the various rapid transit alternatives. Wohl<sup>2</sup> has stated that "part of the urban transport problem stems from lack of clarification or specification, part from lack of understanding, and part from lack of knowledge. These difficulties can be traced to our failure to conduct transport system analyses and our failure to ask and answer questions such as; For whom is the system being designed? What are the goals and objectives of the community or area for whom the system is being designed?" Within this context, greater clarification of urban transport policy and planning objectives in Auckland and a good deal of basic

1. Dart, J.R., "Transportation and Town Planning", Auckland Rapid Rail Symposium, August, 1969.
2. Wohl, M., "Urban Transportation Myths", Traffic Engineering, Vol. 35, No. 8, May, 1965.

research is required before a realistic economic appraisal of rapid transit can be made. In view of the high cost of such studies a prerequisite study goal would be a genuine concern to solve the problem and the testing of a number of alternatives of varying levels of capital expenditure.

In the meantime it appears that the minimal rate of progress of the last twenty years toward a solution, will likely continue. Dart<sup>1</sup> has pointed to an inhibiting "schizophrenic" attitude as is evident by the siting of state housing (lower income groups) areas remote from acceptable public transport facilities and a reluctance to discourage non-essential car movement in the city core. There is also little optimism to be derived from the fact that larger overseas cities have failed to grapple with the congestion problem.

1. op cit.

## BIBLIOGRAPHY

- American Association of State Highway Officials, Road User Benefit Analysis for Highway Improvements, Washington: AASHO, 1960.
- Auckland Branch, N.Z. Institute of Engineers, Proceedings of the Auckland Rapid Rail Symposium, August, 1969.
- Bellomo, S.J., and Provost, S.G., "Two Procedures to Improve the Economic Evaluation of Alternative Highway Systems", Highway Research Record, No. 224, Highway Research Board, Washington D.C., 1968.
- Buchanan, C.D., and Partners, City of Auckland; Planning in the Central Area, an Assessment, London, July, 1966.
- Charles River and Associates, Inc., An Evaluation of Free Transit Service. Cambridge, Mass., 1968.
- Claffey, P.J., "Characteristics of Passenger Car Travel on Toll Roads and Comparable Free Roads", Highway Research Board Bulletin, No. 306, Highway Research Board, Washington D.C., 1961.
- Coburn, T.N., Beesley, M.E., and Reynolds, D.J., The London - Birmingham Motorway: Traffic and Economics, R.R.L., Road Research Technical Paper, No. 46, H.M.S.O., 1960.
- Commonwealth of Australia, "Investment Analysis", Supplement to the Treasury Information Bulletin, Commonwealth Treasury, Canberra, July, 1966.
- Currey, G.R.B., "A Survey of Private Vehicle Operating Costs", Australian Road Research, Vol. 4, No. 3, March, 1970.
- Dart, J.R., "Transportation and Town Planning", Proceedings Auckland Rapid Rail Symposium, August, 1969.
- Dawson, R.F.F., "Highway Project Appraisal", Planning and Transportation Research and Computation Co. Ltd., 1968.
- De Leuw Cather and Company, Report on a Comprehensive Transportation Plan for the Auckland Regional Authority. San Francisco, October, 1965.
- De Leuw Cather and Company, Report on a Regional Transport Plan for the Auckland Regional Authority. San Francisco, July, 1963.
- Development Research Associates, Benefits to the Washington Area from the Adopted Regional Transit System, Los Angeles, California, 1968.
- Domencich, T.A., Kraft, G., and Valette, J., "Estimation of Urban Passenger Travel Behaviour; An Economic Demand Model", Highway Research Record, No. 238, Highway Research Board, Washington D.C., 1968.

- Eckstein, O., "A Survey of the Theory of Public Expenditure Criteria", in Public Finance, (Ed.), Houghton, R.W., Penguin Modern Economics, 1970.
- Feldstein, M.S., "Net Social Benefit Calculations and the Public Investment Decision", Oxford Economic Papers, Vol. 16, March, 1964.
- Feldstein, M.S., "Opportunity Cost Calculations in Cost-Benefit Analysis", Public Finance, Vol. 19, No. 2, 1964.
- Feldstein, M.S., "The Social Time Preference Discount Rate in Cost-Benefit Analysis", Economic Journal, Vol. 74, June, 1964.
- Fitch, L.C., "Goals of Urban Transportation Policy", Ekistics, Vol. 29, No. 170, January, 1970.
- Fitch, L.C., and Associates, Urban Transportation and Public Policy. Chandler Publishing Co., San Francisco, 1964.
- Foster, C.D., and Beesley, M.E., "Estimating the Social Benefit of Constructing an Underground Railway in London", Journal of the Royal Statistical Society, Vol. 126, Series A, Part 1, 1963.
- Friedlander, A.F., The Interstate Highway System. North-Holland Publishing Co., Amsterdam, 1965.
- Future Directions for Research in Urban Transportation, (Panel Report) O.E.C.D., Paris, 1969.
- Haikalis, G., and Joseph, H., "Economic Evaluation of Traffic Networks", Highway Research Board Bulletin, No. 306, Highway Research Board, Washington D.C., 1961.
- Harvey, T.N., "A Method of Network Evaluation Using the Output of the Traffic Assignment Process", Highway Research Record, No. 238, Highway Research Board, Washington D.C., 1968.
- Hearle, E.F.R., and Niedercorn, J.N., The Impact of Urban Renewal on Land Use, Rand Corporation, RM-4186-RC, June, 1964.
- Hedges, C.A. "An Evaluation of Commuter Transportation Alternatives". Highway Research Record, No. 296, Highway Research Board, Washington D.C., 1969.
- Henderson, P.D., "Investment Criteria for Public Enterprises", in Public Enterprise, (Ed.), Turvey, R., Penguin Modern Economics, 1968.
- Highway Research Board, Factors Influencing Modal Trip Assignment, National Co-operative Highway Research Programme, Report 57, Highway Research Board, Washington D.C., 1967.
- Highway Research Board, Values of Time Savings of Commercial Vehicles, National Co-operative Highway Research Programme, Report 33, Highway Research Board, Washington D.C., 1966.

- Hill, M., "A Method for the Evaluation of Transportation Plans", Highway Research Record, No. 180, Highway Research Board, Washington D.C., 1967.
- Hoover, E.M., "Motor Metropolis: Some Observations on Urban Transportation in America", Journal of Industrial Economics, Vol. 13, No. 3, June, 1965.
- Joy, S., "The Economic Evaluation of Comprehensive Land Use Transportation Plans", Australian Road Research, Vol. 3, No. 10, June, 1969.
- Kraft, G., and Wohl, M., "New Directions for Passenger Demand Analysis and Forecasting", Transportation Research, Vol. 1, No. 3, 1967.
- Lang, A.S., and Soberman, R.M., Urban Rail Transit: Its Economics and Technology. M.I.T. Press, Cambridge, Mass., 1964.
- Lichfield, N., "Planner/Economists View of Road Pricing", Traffic Engineering and Control, Vol. 9, No. 10, February, 1968.
- Lisco, T.E., "Value of Commuters Travel Time - A Study in Urban Transportation", Highway Research Record, No. 245, Highway Research Board, Washington D.C., 1968.
- McKean, R.N., Efficiency in Government Through Systems Analysis. John Wiley and Sons, Inc., New York, 1958.
- Meyer, J.R., Kain, J.F., and Wohl, M., The Urban Transportation Problem. Cambridge, Mass., Harvard University Press, 1965.
- Ministry of Transport, Traffic in Towns (Buchanan Report). H.M.S.O., London, 1963.
- Mohring, H.D., and Harwitz, M., Highway Benefits, An Analytical Framework. Northwestern University Press, Evanston, Illinois, 1962.
- Moses, L.N., and Williamson, H.M., "Value of Time, Choice of Mode and the Subsidy Issue in Urban Transportation", Journal of Political Economy, Vol. 7, No. 3, June, 1963.
- New Zealand Ministry of Transport, Car and Truck Operating Costs. Economic Research and Planning Div., M.O.T., January, 1970.
- New Zealand Ministry of Works, Vehicle Operating Costs, unpublished report.
- Niebur, H.D., "Preliminary Engineering Economy Analysis of Puget Sound Regional Transportation Systems", Highway Research Record, No. 180, Highway Research Board, Washington D.C., 1967.
- Oi, W.Y., and Shuldiner, P.C., An Analysis of Urban Travel Demands. Northwestern University Press, Evanston, Illinois, 1962.
- Owens, J.H., "Economics of Truck Operations in Urban Areas", Proceedings 2nd Conference Australian Road Research Board, 1964.

- Pelensky, E., Blunden, W.R., and Munro, R.D., "Operating Costs of Cars in Urban Areas", Proceedings 4th Conference Australian Road Research Board, Part I, 1968.
- Plowden, S.P.C., "Transportation Studies Examined", Journal of Transport Economics and Policy, Vol. 1, No. 1, January, 1967.
- Prest, A.R., and Turvey, R., "Cost-Benefit Analysis: A Survey", Economic Journal, Vol. 75, No. 300, December, 1965.
- Quarmby, D.A., "Choice of Travel Mode for the Journey to Work", Journal of Transport Economics and Policy, Vol. 1, No. 3, September, 1967.
- Report of the Committee of Enquiry into Urban Passenger Transport, Urban Passenger Transport in New Zealand. Govt. Printer, Wellington, February, 1970.
- Sharp, C.H., "Congestion and Welfare Reconsidered", Journal of Transport Economics and Policy, Vol. 2, No. 1, January, 1968.
- Smith, Wilbur, and Associates, Motor Trucks in the Metropolis. New Haven, Connecticut, August, 1969.
- Smith, Wilbur, and Associates, The Potential for Bus Rapid Transit. New Haven, Connecticut, February, 1970.
- Smith, Wilbur, and Associates, Transportation and Parking for Tomorrows Cities, New Haven, Connecticut, 1966.
- Stanford Research Institute, Benefit-Cost of Rapid Transit System for Southern California Rapid Transit District. Menlo Park, California, 1968.
- St. Clair, G.P., Todd, T.R., and Bostick, T.A., "The Measurement of Vehicular Benefits", Highway Research Record, No. 138, Highway Research Board, Washington D.C., 1966.
- Taylor, M.A., "Assessment of Transportation Needs", Proceedings Auckland Rapid Rail Symposium, August, 1969.
- Thomas, T.C., "Value of Time for Commuting Motorists", Highway Research Record, No. 245, Highway Research Board, Washington D.C., 1968.
- Tipping, D.G., "Time Savings in Transport Studies", Economic Journal, Vol. 78, No. 312, December, 1968.
- Traffic Research Corporation Ltd., The Definition of Economic Evaluation Procedures, M.A.L.T.S. Technical Report, No. 17, 1969.
- Troy, P., and Neutze, M., "Urban Road Planning in Theory and Practice", Journal of Transport Economics and Policy, Vol. 3, No. 2, May, 1969.

U.S. Dept. of Transportation/Federal Highway Administration,  
Bureau of Public Roads, Guidelines for Trip Generation  
Analysis. Washington D.C., June, 1967.

Walters, A.A. "The Theory and Measurement of Private and Social  
Cost of Highway Congestion", Econometrica, Vol. 29, No. 24,  
October, 1961.

Ward, J.T., "Cost-Benefit Analysis for Auckland's Rapid Transit  
System", Proceedings Auckland Rapid Rail Symposium, August,  
1969.

Wingo, L., Transportation and Urban Land. Resources for the  
Future Inc., Washington D.C., 1961.

Winfrey, R., Economic Analysis for Highways, International  
Textbook Co., London, 1969.

Wohl, M., "Urban Transportation Myths", Traffic Engineering,  
Vol. 35, No. 8, May, 1965.

### ADDITIONAL REFERENCES

- Beesley, M.E., "The Value of Time Spent Travelling: Some New Evidence", Economica, Vol. 32, May, 1965.
- Beesley, M.E., and Walters, A.A., "Some Problems in the Evaluation of Urban Road Investments", Applied Economics, Vol. 1, No. 4, January, 1970.
- Badcock, B.A., "Rapid Rail: Panacea for Auckland's Transport Problems", Town Planning Quarterly, No. 19, March, 1970.
- Drake, G.L., and Kraft, M.A., "Motor Vehicle Accident Costs in the Washington Metropolitan Area", Highway Research Record, No. 188, Highway Research Board, Washington D.C., 1967.
- Demaree, A.T., "Cars and Cities on a Collision Course", Fortune Magazine, Vol. 82, No. 2, 1970.
- Ganz, A., "Emerging Patterns of Urban Growth and Travel", Highway Research Record, No. 229, Highway Research Board, Washington D.C., 1968.
- Glassborrow, D.W., "The Road Research Laboratory's Investment Criteria Examined", Oxford University Institute of Statistics Bulletin, Vol. 22, No. 4, November, 1968.
- Goldin, K.D., "Three Aspects of Highway Efficiency", Journal of Transport Economics and Policy, Vol. 2, No. 3, September, 1968.
- Hall, P., "Transportation" Urban Studies, Vol. 6, No. 3, November, 1969.
- Irwin, N.A., "Criteria for Evaluating Alternative Transportation Systems", Highway Research Record, No. 148, Highway Research Board, Washington D.C., 1966.
- Johnson, M.B., "On the Economics of Road Congestion", Econometrica, Vol. 32, No. 1-2, January - April, 1964.
- Kraft, G., "Economic Aspects of Urban Passenger Transportation", Highway Research Record, No. 285, Highway Research Board, Washington D.C., 1969.
- Kuhn, T.E., Public Enterprise Economics and Transportation Problems. University of California Press, Berkley, 1962.
- Manheim, M.L., "Transportation Problem Solving and the Effective Use of Computers", Highway Research Record, No. 148, Highway Research Board, Washington D.C., 1966.
- Maass, A., Design of Water Resource Systems. Manmilan, London, 1962.
- Ministry of Transport, Cars for Cities. H.M.S.O., London, 1967.

- Ministry of Transport, Road Pricing: The Economic and Technical Possibilities (Smeed Report). H.M.S.O., London, 1964.
- Neuburger, H., "User Benefit: Transport and Land Use Plans", Journal of Transport Economics and Policy, Vol. 5, No. 1, January, 1971.
- Neutze, G.M., "Pricing Road Use", Economic Record, Vol. 40, No. 90, June, 1964.
- Perazich, G., and Fischman, L.L., "Methodology for Evaluating Costs and Benefits of Alternative Transportation Systems", Highway Research Record, No. 148, Highway Research Board, Washington D.C., 1966.
- Reynolds, D.J., "The Cost of Road Accidents", Journal of the Royal Statistical Society, Vol. 119, (series A), Part 4, 1956.
- Sherman, R., "A Private Ownership Bias in Transit Choice", American Economic Review, Vol. 57, No. 5, December, 1967.
- Smith, W.S., "Transportation Planning", Journal of Urban Planning and Development Division, Proceedings A.S.C.E., Vol. 93, June, 1967.
- St. Clair, G.P., "Congestion Tolls - An Engineers Viewpoint", Highway Research Record, No. 47, Highway Research Board, Washington D.C., 1964.
- U.S. Department of Commerce, Bureau of Public Roads, Modal Split: Documentation of Nine Methods for Estimating Transit Usage. Washington D.C., December, 1966.
- Winch, D.M., The Economics of Highway Planning. Toronto University Press, Toronto, 1963.
- Wohl, M., and Martin, B.V., Traffic Systems Analysis. McGraw Hill, New York, 1967.

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