# Urban Transport: Capital Requirements 1977/78 to 1979/80

## Report

This is the fourth report prepared by the BTE on capital investment needs of transport in urban areas. It differs in a number of important respects from the earlier reports in that it deals with investment needs for roads as well as for public transport; it analyses the demand for and supply of urban transport as a whole rather than simply presenting the results of evaluations of specific capital investment proposals; and the report includes some consideration of urban areas outside the State capital cities.

BUREAU OF TRANSPORT ECONOMICS

# URBAN TRANSPORT: CAPITAL REQUIREMENTS 1977-78 TO 1979-80

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# FOREWORD

This is the fourth report prepared by the BTE on capital investment needs of transport in urban areas. It differs in a number of important respects from the earlier reports in that it deals with investment needs for roads as well as for public transport; it analyses the demand for and supply of urban transport as a whole rather than simply presenting the results of evaluations of specific capital investment proposals; and the report includes some consideration of urban areas outside the State capital cities.

The study was carried out within the Economic Evaluation and Transport Engineering Branches under the overall direction of G.R. Carr. The study team comprised A.B. Smith, A.J. Shaw, and H. Souter, together with the staffs of their respective sections.

The BTE gratefully acknowledges the considerable assistance received from various bodies during the course of this study. Advice provided by the various State government transport operating authorities was invaluable in developing public transport investment programs. The Commonwealth Bureau of Roads provided previously unpublished information and other assistance in relation to the road investment programs.

The BTE also thanks the members of the Australian Transport Advisory Council and their advisers for comments on an earlier draft of this report. All comments have been given consideration and many have resulted in revisions to the text. While it has not been possible to incorporate all suggestions they will be useful in preparing similar reports in the future.

(G. K. R. REID)
Acting Director

Bureau of Transport Economics,
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## SUMMARY

This report is concerned primarily with investment needs for transport facilities and services in urban areas over the period 1977-78 to 1979-80. The report does not propose specific courses of action, either in relation to the general urban environment, of which urban transport is only one facet, or in relation to the identification and the financing of specific proposals for urban transport improvements. The information presented in the report is intended to provide a basis for decisions relating particularly to the need for investment in urban transport systems and the likely order of magnitude of funds required.

The levels of investment presented in the report are primarily the result of investigations into road investment needs conducted by the Commonwealth Bureau of Roads as reported in their Report on Roads in Australia 1975, and of evaluations by BTE of urban public transport proposals generated in consultation with the States. These investigations have been complemented by interpretive studies of historic trends in investment and associated levels of user demand as well as by studies of economic efficiency in the provision and operation of urban transport systems. The levels of investment derived should not be regarded as precisely determined investment budgets, but rather as indicating the orders of magnitude of investments that might be justified under a particular set of expectations regarding user demand, acceptable service levels and other operating conditions.

The early chapters draw on historic data to describe trends in the supply of and demand for urban transport and examine the efficiency of current urban transport resource use practices. This information is used to draw inferences for future urban transport resource use patterns. Estimates of capital expenditure needs for the period 1977-78 to 1979-80 are presented in the final chapter. The more important issues discussed in the report are summarised below.

Roads are by far the most important part of the urban transport system. They cater not only for private motor vehicle travel, but also for the major part of the public transport task and nearly all of the urban freight movement task.

Historic trends in real capital expenditure indicate that investment in urban roads increased rapidly throughout the 1960's until 1972-73. Since then it has declined in each successive year. In recent years the three levels of government, that is, Commonwealth, State and local, have each contributed about one-third of this expenditure although these shares have fluctuated from year to year.

The level of capital expenditure by government authorities on urban public transport has been quite small in comparison with roads expenditure and, until 1974, was financed entirely by State and local government authorities. Real public transport expenditures displayed an average growth rate of 7 per cent per annum in the eight years to 1970-71. In the period since that date, faster growth has been observed with an average rate of 13.6 per cent per annum in real terms. It is estimated that the Commonwealth will finance around 38 percent of the estimated $130 million of government authority capital expenditure on public transport in the six State capital cities in 1976-77.

Over 70 per cent of capital expenditure on urban public transport in the first half of this decade was spent on rail, although the rail task was smaller than the combined bus and tram tasks. The apparent bias towards rail would be less obvious if expenditure on road-based public transport included an appropriate cost component for the provision and maintenance of road task.

Since investment needs are in large part demand responsive, future trends in the demand for urban transport services have been projected. Historic statistics indicate that demand for motor vehicle travel has been growing but at a decreasing rate, whereas demand for public transport has been declining slowly. One major factor behind these divergent trends has been the relative dispersal of population and economic activity in urban areas. This has resulted in strong growth of the travel market favouring the private vehicle and a relatively static market in areas in which public transport has a comparative advantage. In addition, increasing car ownership levels together with rising real public transport fares would have reinforced these trends.

Turning to future trends in urban transport demand, private car travel is expected to increase rather more slowly than it has in the past. The average rate of growth in vehicle kilometres performed by cars and stationwagons is forecast to slacken by about 2.5 per cent per annum over the next five years compared with the last five years. This is in line with forecasts of a declining population growth rate (from the 2.1 per cent per annum between 1966 and 1974 to about 1.4 per cent per annum between 1974 and 1981) and of declining rates of growth in car ownership levels(from the average per capita rate of 3.8 per cent per annum between 1970 and 1975 to about 2.0 per cent per annum in the subsequent period to 1981).

Public transport patronage levels are expected to remain relatively static over the foreseeable future.

These broad trends in demand will not apply across all components of the urban transport travel market. For example, while the overall public transport task is not expected to grow, positive growth rates are expected in some specific sub-markets. Therefore, while new investment may not be warranted in some parts of the urban transport sytem, substantial investment would be warranted in others.

The report stresses that capital expenditure is not the only means available for improving the level of transport service in urban areas. Improvements to operating procedures could provide considerable benefits to the community at a relatively low cost. Increasing interest has been shown in the potential for such improvements and experiments with measures such as reserved bus lanes, priority roads and area licensing have been conducted in recent years and some such measures are currently being implemented.

Investment needs for roads and public transport in urban areas have been assessed and investment programs comprising projects which have benefit-cost ratios of at least one using a discount rate of 10 per cent are presented in Chapter 4. The economically warranted capital investment program for urban road construction, which was developed by the Commonwealth Bureau of Roads, amounted to $2,939 million in 1974-75 prices for the five year period 1976-77 to 1980-81. The economically warranted State capital city public authority capital investment program for new public transport projects, which was developed by BTE, amounted to $630 million in 1974-75 prices for the three year period 1977-78 to 1979-80. Additional capital investment of about $215 million is required over the period for public transport projects already underway in these cities.

The investment needs of private public transport operators in urban areas have not been thoroughly investigated in this report. However, average annual investment in vehicle replacement has been estimated to be around $9.5 million in 1974-75 prices. This implies investment needs of around $28.5 million in constant prices over the three year period 1977-78 to 1979-80.

Investigations were made of the sensitivity of the economically warranted programs to changes in some of the parameters used in the project evaluations. Both the roads and public transport programs were found to be sensitive to changes in the discount rate. The public transport program was found to be more sensitive than the roads program to parameter variations which affect the indirect costs and benefits of the individual projects. This was mainly because a larger part of the public transport program relies on non-financial benefits to existing travellers and attraction of new patronage. Since less confidence can be attached to these benefits in comparison with operating cost savings, the public transport program is less robust in this respect than the roads program.

The investment programs developed would not constitute feasible expenditure programs for the three year period 1977-78 to 1979-80 because various financial and physical resource constraints would prevent the implementation of some projects. The program recommended by the Commonwealth Bureau of Roads after taking such considerations into account is two-thirds of the warranted program. This level of capital investment implies a rate of growth in real investment of about 7.5 per cent per annum over the five year period examined. The BTE has not carried out all the investigations necessary to recommend a program of capital expenditure for urban public transport. However, capital investment needs can be put into historical perspective by projecting observed trends into the future.

Preliminary results of a BTE study of capital formation in transport indicate that State capital city public transport authority capital requirements over the period 1977-78 to 1979-80 would be about $317 million in constant 1974-75 prices. This estimate is based on preserving the relationship between capital and output that existed over the period 1955-56 to 1970-71 and maintaining estimated 1975-76 demand levels. The marked increase in the rate of growth in capital spending on urban public transport that has been evident since about 1971-72 would seem to indicate that the assumption of a constant relationship between capital and output is questionable. Projecting this recent trend in capital spending would result in a level of investment of about $505 million over the three year period 1977-78 to 1979-80.

Although the different methods of projecting capital investment needs for urban public transport in the State capital cities produce quite different results, some conclusions have been drawn. The projection based on maintaining the relationship between capital and output that was observed over the period 1955-56 to 1970-71 was considered to be too low mainly because recent policies directed towards improving the level and quality of service provided by urban public transport systems are expected to continue into the near future.

It was also concluded that investment needs as determined by cost-benefit analysis would represent an overestimate of the desirable level of warranted spending over the period. This was mainly because considerable uncertainty attaches to the estimation of the indirect benefits and costs of public transport capital investment projects, especially those derived from estimates of traffic generation. To make some allowance for these uncertainties, the warranted investment program for the triennium was reduced to $713 million in 1974-75 prices.

However, since this would mean increasing the recent rate of growth in capital expenditure on public transport in the State capital cities quite significantly, a somewhat lower level of spending would seem appropriate. A level of spending somewhat higher than the $505 million implied by recent expenditure trends would reinforce the recent trend towards improving the quality and level of service provided by public transport in those cities.

# CHAPTER 1 - INTRODUCTION

## TERMS OF REFERENCE

This study has been undertaken at the direction of the Minister for Transport, the Honourable P.J. Nixon. The BTE was directed to investigate and report on resource use in urban transport in Australia and to give particular consideration to

- historical financing arrangements for urban transport
- the economic efficiency of current practice resource usage in urban transport
- future resource requirements in urban transport.

The BTE was advised that in undertaking this study it was free to investigate and report on other matters relevant to resource usage in urban transport.

## SCOPE OF THIS REPORT

The responsibility for providing for the movement of people and goods within urban areas lies basically with State and local governments where the public interest in this regard and the powers to deal with the problem reside. Current Commonwealth government policy recognises that this is the case, but also recognises that there is a need for the Commonwealth government to continue to assist State and local governments to improve their urban transport systems. At the same time, the policy recognises that such assistance has its limits and that it must be delivered in a manner which gives each area the opportunity to develop its own solution tailored to its own needs. That is, while the Commonwealth may provide financial assistance for urban transport systems, the responsibility for planning the systems and for implementing the plans lies with State and local government authorities. The Commonwealth has, of course, a more direct responsibility for urban transport in the territories. There are no urban areas in the Northern Territory.

The extent and form of Commonwealth financial assistance for urban transport has varied significantly over time. Up until 1974, financial assistance was provided to the States for road expenditure only. However, in 1974 the Commonwealth government legislated to extend its financial assistance programs to provide for capital expenditure on approved urban public transport projects and for expenditure on approved urban transport planning and research projects. This assistance is currently provided under separate legislation for roads, urban public transport and planning and research.

In the past, the Commonwealth Bureau of Roads (CBR) has provided advice on the levels of financial assistance the Commonwealth government should provide to the States for roads. Although the BTE does not have a standing charter to provide similar advice, it has, at the request of the Australian Transport Advisory Council, prepared three reports on capital investment in urban public transport which have been used by the Commonwealth government in developing urban public transport financial assistance programs.

The reports prepared by the two Bureaux have differed quite markedly. Whereas the primary purpose of the CBR reports has been to recommend Commonwealth financial assistance programs for roads, the BTE has simply reported the results of economic evaluations of specific public transport capital investment projects submitted to it by State authorities. Although it would be appropriate for the BTE and CBR to adopt a consistent and mode co-ordinated approach to the provision of advice on urban transport financial assistance programs, it has not been possible for such an approach to be developed in time for use in formulating the legislation due in 1977. It is strongly suggested that the development of a consistent and mode co-orddinated approach should be one of the first tasks undertaken by the new body resulting from the amalgamation of the BTE and CBR so that it can report to the Minister in time for the information to be used in the formulation of the legislation following that introduced in 1977.

The BTE has prepared this report on resource use in urban transport to provide an initial basis for the Commonwealth government in making decisions about the directions and extent of its involvement in urban transport for the purposes of framing the 1977 legislation. In so far as the report deals with both roads and public transport in urban areas, the study sets the scene for future studies directed towards advising the Commonwealth government on total programs of assistance for urban transport.

The study is concerned primarily with investment needs for transport facilities and services in urban areas over the period 1977-78 to 1979-80. The information presented in the report provides a basis for decisions relating particularly to the need for investment in urban transport systems and the order of magnitude of funds required. The report does not propose specific courses of action or suggest what should be done either in relation to the general urban environment, of which urban transport is only one facet, or in relation to the identification and the financing of specific proposals for urban transport improvement.

The levels of investment reported are derived from investigations into road investment needs conducted by the CBR, as reported in 1975[1], and of evaluations conducted by BTE of urban public transport proposals generated in consultation with the States. They are not the result of detailed planning studies by BTE which are, as noted earlier, basically the responsibility of State and local government authorities. The investigations by the CBR and BTE have been complemented by interpretive studies of historic trends in investment and associated levels of user demand, as well as by studies of economic efficiency in the provision and operation of urban transport systems. The levels of investment derived should therefore not be regarded as precisely determined investment budgets, but rather as indicating the orders of magnitude of

(1) Commonwealth Bureau of Roads, Report on Roads in Australia 1975, Melbourne, 1975.

investments that might be justified under a particular set of expectations regarding user demand, acceptable service levels and other operating conditions.

The study is limited to investment in roads, government operated public transport services and privately operated bus services. No explicit consideration of investment in para-transit services, private transport, or commercial and ancilliary freight transport operations has been included. Quite clearly, however, these operations have been implicitly considered in estimating road investment needs.

In general, the study can best be described as an attempt to draw together and report on the past and present performance of urban transport in Australia and, using this information, to draw inferences about future resource use in this sector. The study has not been designed to reach definitive conclusions, but rather to form the initial phase of a longer term study of urban transport.

## DEFINITION OF URBAN AREAS

For the purposes of this study the BTE adopted the same definition of urban areas employed by the CBR in its recent investigations. Urban areas are defined as:-

- Capital Cities - the Statistical Division boundaries of Sydney Melbourne, Brisbane, Adelaide, Perth and Hobart, and the Statistical District of Canberra;
- Provincial Cities with populations exceeding 75,000 in the 1971 Census - the Statistical Districts of Newcastle, Wollongong and Geelong;
- Other Provincial Cities with populations exceeding 40,000 in the 1971 Census - Ballarat, Bendigo, Townsville, Toowoomba, Gold Coast, Rockhampton and Launceston.

## OUTLINE OF THE REPORT

The report provides three types of information about resource use in urban transport. It first describes historical trends in capital expenditure on urban transport and Commonwealth government involvement in its financing. This information is contained in Chapter 2.

Secondly, in Chapter 3, the economic efficiency of current practice resource usage is examined. Historic trends in the demand for urban transport services are outlined and the major factors responsible for generating these trends investigated. Discussion on the efficiency of the various modes of the urban transport system, both at an aggregate level and in the performance of specific tasks follows. Some conclusions are drawn regarding the utilisation of existing transport systems.

Finally, in Chapter 4, the information presented in earlier chapters is combined with the results of evaluations of urban transport investment proposals to draw inferences about the future investment needs for urban transport in Australia.

# CHAPTER 2 - GOVERNMENT FINANCING OF URBAN TRANSPORT INVESTMENT

Future financial responsibilities for the provision of transport facilities in urban areas should be formulated against the background of present and past financial responsibilities of the various levels of government. This chapter therefore provides a brief review of the financial contributions of governments to urban transport and of past capital expenditure patterns.

## HISTORICAL PERSPECTIVE ON FINANCIAL CONTRIBUTIONS OF GOVERNMENTS TO URBAN TRANSPORT

With the exception of the Australian Capital Territory and the Northern Territory, the Commonwealth government has no direct responsibility for the provision, operation or financing of either urban roads or urban public transport. State and local governments share this responsibility in the case of urban roads, while State authorities have direct responsibility for urban public transport except in Queensland where State and local government authorities each operate public transport services.

Nevertheless, the Commonwealth government has made finance available to the States for capital expenditure on urban transport. The extent and form of such assistance has varied over time. Commonwealth financial assistance for urban transport is currently provided for road construction and minor improvements in road traffic engineering and road safety, for capital expenditure on approved public transport projects and for planning and research.

Although the Commonwealth government has no direct responsibility for the planning, provision or operation of urban transport in the States it has played an influential role in the development of urban transport systems through its financial assistance programs. This influence stems not only from the injection of additional funds for urban transport capital works, but also through the sponsorship of transport research and planning.

## HISTORICAL PATTERN OF CAPITAL EXPENDITURE ON URBAN TRANSPORT

### Expenditure on Urban Roads

Public authority expenditure on urban roads for the years for which data is available over the period 1958-59 to 1975-76 is shown in Table 2.1.(1) These estimates include expenditure associated with road maintenance and with minor improvements for transport operations and road safety. A marked increase in real urban road expenditure over the period until 1972-73 is apparent. The expenditure figures since 1972-73 show a reversal of this trend.

The distribution of urban road expenditures between States by road type over the period 1969-70 to 1975-76 is given in Table 2.2. The data indicates that the recent decline in urban local road expenditure occurred in all States.

### Expenditure on Urban Public Transport

Expenditure on urban public transport in the six State capitals for the period 1963-64 to 1974-75 is given in Table 2.3.(2) It is evident that expenditure on urban public transport has accelerated in recent years; doubling over the period 1970-71 to 1974-75. It is also evident that urban rail(3) systems have historically accounted for the greater share of total capital expenditure on urban public transport, its proportion of the total varying from a low of 63 per cent to a high of 91 per cent and averaging 77 per cent over the period examined.

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(1) Current expenditure estimates were deflated by the GNE deflator prior to 1960-61 and by the CBR road price deflator after that date.
(2) Current expenditure estimates were deflated using the public fixed capital expenditure deflator.
(3) Urban rail in this report refers to fixed track urban transport systems other than trams.

TABLE 2.1 - CAPITAL AND MAINTENANCE EXPENDITURE ON URBAN ROADS[1]

($ million, 1974-75 prices)

| Year | Arterial | Local | Total |
|---|---|---|---|
| 1958-59 | | | 152.00 |
| 1959-60 | | | 179.27 |
| 1963-64 | | | 261.00 |
| 1964-65 | | | 281.10 |
| 1965-66 | | | 301.20 |
| 1969-70 | 295.70 | 254.78 | 550.48 |
| 1970-71 | 316.06 | 232.50 | 548.56 |
| 1971-72 | 357.49 | 239.89 | 597.38 |
| 1972-73 | 368.85 | 252.66 | 621.51 |
| 1973-74 | 346.82 | 236.57 | 583.39 |
| 1974-75 | 251.93 | 196.59 | 448.52 |
| 1975-76 | 250.29 | 195.03 | 445.32 |

NOTE: (a) Data prior to 1969-70 are not strictly comparable with later figures. The current price figures were deflated by the GNE deflator prior to 1960-61 and by the Commonwealth Bureau of Roads road price index after that date.

(b) Urban MITERS are included in the expenditure figures up to 1973-74. Figures up to 1973-74 also include urban roads identified as national roads since 1 July, 1974.

(c) Some figures do not add up to totals due to rounding.

(1) Figures exclude expenditure on urban roads in Commonwealth Territories and unallocated road expenditure.

Sources: (1) Commonwealth Bureau of Roads, Report on Australian Road Systems - 1968, Melbourne, 1969, Table 6.7, p. 32.

(2) Commonwealth Bureau of Roads estimates.

TABLE 2.2 - CAPITAL AND MAINTENANCE EXPENDITURE ON URBAN ARTERIAL AND URBAN LOCAL ROADS, BY STATE: 1969-70 TO 1975-76

($ million, 1974-75 prices)

| State | 1969-70 | 1970-71 | 1971-72 | 1972-73 | 1973-74 | 1974-75 | 1975-76 |
|---|---|---|---|---|---|---|---|
| | | | | Arterial Roads | | | |
| New South Wales | 87.95 | 105.71 | 129.23 | 134.98 | 126.77 | 87.91 | 80.95 |
| Victoria | 110.82 | 106.06 | 114.56 | 113.82 | 111.07 | 95.56 | 100.13 |
| Queensland | 35.31 | 38.57 | 42.89 | 47.69 | 47.64 | 25.33 | 23.40 |
| South Australia | 32.93 | 28.68 | 28.14 | 30.04 | 24.18 | 17.47 | 16.33 |
| Western Australia | 23.82 | 29.40 | 33.90 | 33.39 | 28.31 | 19.49 | 23.66 |
| Tasmania | 4.88 | 7.64 | 8.77 | 8.93 | 8.86 | 6.17 | 5.81 |
| TOTAL | 295.70 | 316.06 | 357.49 | 368.85 | 346.82 | 251.93 | 250.29 |
| | | | | Local Roads | | | |
| New South Wales | 93.68 | 89.92 | 92.34 | 91.97 | 82.62 | 67.61 | 66.70 |
| Victoria | 75.13 | 68.16 | 71.17 | 76.36 | 75.38 | 55.80 | 55.31 |
| Queensland | 29.56 | 25.99 | 26.11 | 33.09 | 30.93 | 33.28 | 33.12 |
| South Australia | 27.52 | 24.60 | 27.54 | 25.90 | 23.98 | 19.23 | 18.65 |
| Western Australia | 22.36 | 17.97 | 16.65 | 18.73 | 16.46 | 12.61 | 12.94 |
| Tasmania | 6.53 | 5.85 | 6.07 | 6.60 | 7.20 | 8.06 | 8.31 |
| TOTAL | 254.78 | 232.50 | 239.89 | 252.66 | 236.57 | 196.59 | 195.03 |

NOTE: (a) Urban MITERS are included in the expenditure figures up to 1973-74. Figures up to 1973-74 also include urban roads identified as national roads since 1 July, 1974.

(b) The sum of the columns may not exactly equal totals shown due to rounding.

Source: Commonwealth Bureau of Roads estimates.

TABLE 2.3 - PUBLIC CAPITAL EXPENDITURE ON URBAN PUBLIC TRANSPORT FOR THE SIX STATE CAPITALS: 1963-64 TO 1974-75

(1974-75 prices)

| Year | Transit (1) ($m) | (%) | Rail ($m) | (%) | Total ($m) |
|---|---|---|---|---|---|
| 1963-64 | 7.0 | 24 | 22.1 | 76 | 29.1 |
| 1964-65 | 10.1 | 29 | 25.3 | 71 | 35.4 |
| 1965-66 | 7.7 | 23 | 26.0 | 77 | 33.7 |
| 1966-67 | 8.1 | 23 | 27.2 | 77 | 35.3 |
| 1967-68 | 11.3 | 23 | 37.3 | 77 | 48.6 |
| 1968-69 | 10.2 | 24 | 33.1 | 76 | 43.3 |
| 1969-70 | 16.5 | 37 | 27.9 | 63 | 44.4 |
| 1970-71 | 15.7 | 32 | 33.6 | 68 | 49.3 |
| 1971-72 | 15.9 | 25 | 48.2 | 75 | 64.1 |
| 1972-73 | 10.2 | 14 | 62.8 | 86 | 73.0 |
| 1973-74 | 7.8 | 9 | 78.1 | 91 | 85.9 |
| 1974-75 | 17.9 (2) | 18 | 82.1 | 82 | 100.0 |

(1) Figures exclude direct capital investment by Commonwealth authorities.
(2) ABS estimate.

Sources: (1) Australian Bureau of Statistics, Public Authority Finance, State and Local Authorities, 1973-74, pp. 17, 19.
(2) Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June, 1972, Table B.8. p. B.10.

Expenditure on urban public transport in areas other than the six State capital cities is not available.

Although a detailed break-up of urban rail capital expenditure in the six State capitals is not available, the NSW Eastern Suburbs Railway in Sydney and the Melbourne Underground Rail Loop have accounted for a considerable proportion of the total since 1969-70. Of the total capital expenditure on urban rail in the six State capitals over the period 1969-70 to 1974-75, about 50 per cent was associated with these two particular projects. Details of these expenditures are shown in Table 2.4.

Urban transit expenditure (public transport other than rail) in the six State capitals since 1963-64 has been characterised by two peaks, the first occuring between 1969 and 1972 and the second in 1974-75. Details of this expenditure by level of government are given in Table 2.5.

The distribution of expenditure by State authorities on new fixed assets in urban transit is shown in Table 2.6. New South Wales and South Australia are shown to be the main contributors to the high level of real expenditure in the years around 1970, while Victoria and Western Australia had sharp increases in expenditure in 1974-75. The latter increases coincided with the provision of Commonwealth assistance to urban public transport under the Urban Public Transport Agreement which was ratified by the States Grants (Urban Public Transport) Act, 1974.

## Total Expenditure on Urban Transport

Available expenditure data for urban arterial and local roads, and for urban railways and publicly owned urban transit, are brought together in Table 2.7. The available data indicates that roads have dominated expenditure on urban transport, but that the road proportion of total expenditure has been slowly declining since 1969-70.

TABLE 2.4 - URBAN RAIL CAPITAL EXPENDITURE: COMPARISON OF TOTAL EXPENDITURE AND EXPENDITURE ON TWO MAJOR URBAN RAIL PROJECTS

(1974-75 prices)

| Year | Total for Six State Capitals ($m) | NSW Eastern Suburbs Railway(1) ($m) | (% of Total) | Melbourne Underground Rail Loop ($m) | (% of Total) |
|---|---|---|---|---|---|
| 1969-70 | 27.9 | 10.1 | 36 | (2) | |
| 1970-71 | 33.6 | 14.9 | 44 | 0.6 | 2 |
| 1971-72 | 48.2 | 17.4 | 36 | 4.7 | 10 |
| 1972-73 | 62.8 | 24.0 | 38 | 13.3 | 21 |
| 1973-74 | 78.1 | 16.7 | 21 | 23.1 | 29 |
| 1974-75 | 82.1 | 17.4 | 21 | 20.5 | 25 |

(1) Expenditure before 1969-70 totalled $14.3 million.
(2) No expenditure was incurred before 1970-71.

Sources: (1) Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June 1972, Table B.8, p. B.10.
(2) Melbourne Underground Rail Loop Authority, Annual Report, various issues.
(3) Public Transport Commission of New South Wales, Annual Report, various issues.
(4) BTE estimates.

TABLE 2.5 - URBAN TRANSIT EXPENDITURE ON NEW FIXED ASSETS BY LEVEL OF GOVERNMENT: 1963-64 TO 1974-75 (1)

($ million, 1974-75 prices)

| Year | State Authorities | Local Authorities (2) | Total for Six Capital Cities | Authorities of the Commonwealth Government |
|---|---|---|---|---|
| 1963-64 | 5.2 | 1.7 | 7.0 | 2.1 |
| 1964-65 | 8.5 | 1.6 | 10.1 | 2.4 |
| 1965-66 | 5.0 | 2.8 | 7.8 | 2.6 |
| 1966-67 | 6.3 | 1.9 | 8.2 | 2.5 |
| 1967-68 | 8.4 | 3.3 | 11.7 | 2.9 |
| 1968-69 | 7.0 | 3.3 | 10.3 | 3.0 |
| 1969-70 | 11.6 | 4.9 | 16.5 | 2.7 |
| 1970-71 | 14.6 | 1.0 | 15.6 | 4.3 |
| 1971-72 | 12.9 | 3.1 | 16.0 | 3.9 |
| 1972-73 | 8.2 | 1.5 | 9.7 | 3.9 |
| 1973-74 | 7.1 | 0.5 | 7.6 | 4.4 |
| 1974-75 (3) | 16.9 | 1.0 | 17.9 | 7.1 |

(1) Figures exclude expenditure on urban rail systems.
(2) Queensland is the only State where local authorities are involved in direct capital expenditure on urban transit systems.
(3) ABS estimates.

Sources: (1) Australian Bureau of Statistics, Public Authority Finance, State and Local Authorities, 1973-74, pp. 17, 19, 117.
(2) Australian Government, Urban and Regional Development 1975-76, 1975-76 Budget Paper No. 9, p. 44.

TABLE 2.6 - URBAN TRANSIT EXPENDITURE ON NEW FIXED ASSETS BY STATE AUTHORITIES (1)

($ million, 1974-75 prices)

| Year | NSW | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| 1963-64 | 0.2 | 1.9 | - | 0.6 | 2.3 | 0.2 | 5.2 |
| 1964-65 | 0.4 | 5.5 | - | - | 2.4 | 0.2 | 8.5 |
| 1965-66 | - | 2.8 | - | - | 1.8 | 0.4 | 5.0 |
| 1966-67 | 1.1 | 2.5 | - | 0.2 | 2.1 | 0.4 | 6.3 |
| 1967-68 | 4.4 | 1.5 | - | - | 2.0 | 0.5 | 8.4 |
| 1968-69 | 3.7 | 0.5 | - | 0.4 | 1.9 | 0.5 | 7.0 |
| 1969-70 | 5.5 | 2.2 | - | 1.7 | 2.2 | - | 11.6 |
| 1970-71 | 6.3 | 1.1 | - | 4.9 | 2.1 | 0.2 | 14.6 |
| 1971-72 | 4.3 | 1.3 | - | 4.6 | 2.4 | 0.3 | 12.9 |
| 1972-73 | 4.0 | 1.4 | - | 0.3 | 2.5 | - | 8.2 |
| 1973-74 | 3.4 | 1.2 | - | 0.1 | 1.6 | 0.4 | 6.7 |
| 1974-75 (2) | 3.7 | 6.6 | - | 0.4 | 3.2 | 1.0 | 14.9 |

(1) Figures exclude expenditure on urban rail systems.
(2) Australian Bureau of Statistics estimates.

Source: Australian Bureau of Statistics, Public Authority Finance, State and Local Authorities, 1973-74, pp. 26-85.

TABLE 2.7 - CAPITAL AND MAINTENANCE EXPENDITURE ON URBAN ROADS AND CAPITAL EXPENDITURE ON URBAN PUBLIC TRANSPORT BY PUBLIC AUTHORITIES: 1958-59 TO 1974-75 [(1)]

(1974-75 prices)

| Year | Roads [(2)] | | | | | | Rail | | Transit [(3)] | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arterial ($m) | (%) | Local ($m) | (%) | Total ($m) | (%) | ($m) | (%) | ($m) | (%) | |
| 1958-59 | | | | | 152.0 | | | | | | |
| 1959-60 | | | | | 179.0 | | | | | | |
| 1960-61 | | | | | | | 32.3 | | | | |
| 1961-62 | | | | | | | 23.2 | | | | |
| 1962-63 | | | | | | | 21.2 | | | | |
| 1963-64 | | | | | 261.0 | 90 | 22.1 | 8 | 7.0 | 2 | 290.1 |
| 1964-65 | | | | | 287.0 | 89 | 25.3 | 8 | 10.1 | 2 | 322.4 |
| 1965-66 | | | | | 302.0 | 90 | 26.0 | 8 | 7.7 | 2 | 335.7 |
| 1966-67 | | | | | | | 27.2 | | 8.1 | | |
| 1967-68 | | | | | | | 37.3 | | 11.3 | | |
| 1968-69 | | | | | | | 33.1 | | 10.2 | | |
| 1969-70 | 295.70 | 50 | 254.78 | 43 | 550.48 | 93 | 27.9 | 4 | 16.5 | 3 | 594.88 |
| 1970-71 | 316.06 | 53 | 232.50 | 39 | 548.56 | 92 | 33.6 | 5 | 15.7 | 3 | 597.86 |
| 1971-72 | 357.49 | 54 | 239.89 | 36 | 597.38 | 90 | 48.2 | 7 | 15.9 | 3 | 661.48 |
| 1972-73 | 368.85 | 53 | 252.66 | 36 | 621.51 | 89 | 62.8 | 9 | 10.2 | 2 | 694.51 |
| 1973-74 | 346.82 | 52 | 236.57 | 35 | 583.39 | 87 | 78.1 | 12 | 7.8 | 1 | 669.29 |
| 1974-75 | 251.93 | 46 | 196.59 | 36 | 448.52 | 82 | 82.1 | 15 | 17.9 | 3 | 548.52 |

NOTE: Urban MITERS are included in expenditure figures up to 1973-74. Figures up to 1973-74 also include urban roads identified as national roads since 1 July, 1974.

(1) Figures exclude expenditure in Commonwealth Territories.
(2) Data prior to 1969-70 are not strictly comparable with later figures. The current price figures were deflated by the GNE deflator prior to 1960-61 and by the Commonwealth Bureau of Roads road price index after that date.
(3) Figures exclude expenditure on urban rail systems.

Sources: Tables 2.1 and 2.3.

TABLE 2.8 - EXPENDITURE BY PUBLIC AUTHORITIES ON URBAN TRANSPORT AND ITS RELATIONSHIP TO GROSS NATIONAL EXPENDITURE: 1958-59 TO 1974-75

| Year | Gross National Expenditure ($m) | Expenditure On Urban Roads as a Proportion of GNE(1) (%) | Expenditure on Urban Public Transport as a Proportion of GNE(2) (%) | Total Expenditure on Urban Transport as a Proportion of GNE (%) |
|---|---|---|---|---|
| 1958-59 | 12,516 | 0.48 | | |
| 1959-60 | 13,870 | 0.53 | | |
| 1960-61 | 15,017 | | | |
| 1961-62 | 14,669 | | | |
| 1962-63 | 16,205 | | | |
| 1963-64 | 17,550 | 0.65 | 0.07 | 0.72 |
| 1964-65 | 20,034 | 0.64 | 0.08 | 0.72 |
| 1965-66 | 21,022 | 0.67 | 0.08 | 0.72 |
| 1966-67 | 22,805 | | 0.08 | |
| 1967-68 | 24,661 | | 0.10 | |
| 1968-69 | 27,437 | | 0.08 | |
| 1969-70 | 29,956 | 0.97 | 0.08 | 1.05 |
| 1970-71 | 32,976 | 0.96 | 0.09 | 1.05 |
| 1971-72 | 36,290 | 1.01 | 0.11 | 1.12 |
| 1972-73 | 40,208 | 1.01 | 0.13 | 1.14 |
| 1973-74 | 50,545 | 0.89 | 0.13 | 1.02 |
| 1974-75 | 59,168 | 0.76 | 0.16 | 0.92 |

NOTE: Data for the period prior to 1969-70 are not strictly compatible with later years due to changes in national accounting procedures and definitional changes in road expenditure categories. Urban MITERS are included in the expenditure figures up to 1973-74. Figures up to 1973-74 also include urban roads identified as national roads since 1 July, 1974.

(1) Excludes Commonwealth Territories.

(2) Excludes direct expenditure by Commonwealth Authorities on urban transit. Includes expenditure by both State and Local Authorities on urban transit and expenditure by State Authorities on urban rail systems in the six state capital cities.

Sources:
(1) Australian Bureau of Statistics, Australian National Accounts, 1973-74, Canberra June 1975.
(2) ABS estimates.
(3) Commonwealth Bureau of Roads, Report on Australian Road Systems-1968, Melbourne, 1969. Table 6.7, p.32.
(4) CBR estimates.
(5) Australian Bureau of Statistics, Public Authority Finance, State and Local Authorities, 1973-74, Canberra, 1976.
(6) Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June, 1972.
(7) BTE estimates.

In order to indicate the relative importance of public authority expenditure on urban roads and urban public transport, the relationship between these expenditures and gross national expenditure (GNE) for the years for which data is available over the period 1958-59 to 1975-76 is shown in Table 2.8. Expenditure on both urban roads and urban public transport expressed as a percentage of GNE has generally increased over the period. Expenditure on urban roads increased from 0.48 per cent in 1958-59 to a high of 1.01 percent in 1972-73, and expenditure on urban public transport increased from 0.07 per cent in 1963-64 to 0.16 per cent in 1974-75. An important feature of the data contained in Table 2.8 is the decline in the proportion of GNE expended on urban roads since 1972-73, the proportion falling to an estimated 0.76 per cent in 1974-75.

While the relationship between urban transport expenditure and GNE helps to place urban transport expenditure in perspective, it should be noted that variations in this relationship over time do not, by themselves, provide useful indications of investment needs.

COMMONWEALTH GRANTS FOR URBAN TRANSPORT

The Commonwealth government currently provides finance for urban transport under the Roads Grants Act, 1974, and the Urban Public Transport Agreement.

Details of Commonwealth grants for urban roads over the period 1969-70 to 1976-77 are given in Table 2.9, along with a comparison of annual Commonwealth grants with total urban road expenditure. These figures indicate a gradual rise and then a sharp decline in Commonwealth grants for urban roads from $148m in 1969-70 to $216.40m in 1973-74 and $104.78m in 1976-77. A break-up of Commonwealth grants for arterial and local roads by State for the period 1969-70 to 1976-77 is given in Table 2.10.

TABLE 2.9 - URBAN ROAD EXPENDITURE FINANCED BY THE COMMONWEALTH GOVERNMENT: 1969-70 TO 1976-77

(1974-75 prices)

| Year | Commonwealth Government Grants for Urban Roads (1) ($m) | Total Expenditure on Urban Roads ($m) | Proportion of Total Expenditure Financed by Commonwealth Government (%) |
|---|---|---|---|
| 1969-70 | 148.33 | 550.48 | 26.9 |
| 1970-71 | 166.67 | 548.56 | 30.4 |
| 1971-72 | 190.91 | 597.38 | 32.0 |
| 1972-73 | 214.24 | 621.51 | 34.5 |
| 1973-74 | 216.40 | 583.39 | 37.1 |
| 1974-75 | 134.02 | 448.52 | 29.9 |
| 1975-76 | 130.66 | 445.32 | 29.3 |
| 1976-77 | 104.78 | | |

NOTE: Urban MITERS are included in the expenditure figures up to 1973-74. Figures up to 1973-74 also include urban roads identified as national roads since 1 July, 1974.

(1) Figures exclude expenditure in Commonwealth Territories.

Sources:
(1) Table 2.2.
(2) Commonwealth Aid Roads Act, 1969.
(3) Roads Grants Act, 1974.
(4) Commonwealth Government, Payments to or for the States and Local Government Authorities 1975-76, 1975-76 Budget Paper No. 7, AGPS, Canberra, 1975.
(5) Commonwealth Government, Payments to or for the States and Local Government Authorities 1976-77, Budget Paper No. 7, AGPS, Canberra, 1976.

TABLE 2.10 - COMMONWEALTH GOVERNMENT GRANTS FOR URBAN ARTERIAL AND URBAN LOCAL ROADS BY STATE: 1969-70 TO 1976-77

($ million, 1974-75 prices)

| Year | NSW | Vic | Qld | S.A. (1) | W.A. (1) | Tas. (1) | All States (1) |
|---|---|---|---|---|---|---|---|
| | | | Arterial Roads | | | | |
| 1969-70 | 49.45 | 40.33 | 25.53 | 14.76 | 14.76 | 3.50 | 148.32 |
| 1970-71 | 56.89 | 44.01 | 27.92 | 16.42 | 16.82 | 4.61 | 166.67 |
| 1971-72 | 63.99 | 49.64 | 31.57 | 18.84 | 19.71 | 7.16 | 190.91 |
| 1972-73 | 71.30 | 55.43 | 35.31 | 21.36 | 22.73 | 8.11 | 214.24 |
| 1973-74 | 71.57 | 55.77 | 35.58 | 21.76 | 23.49 | 8.23 | 216.40 |
| 1974-75 | 46.59 | 35.89 | 16.09 | 7.51 | 18.39 | 4.14 | 128.61 |
| 1975-76 (2) | 38.68 | 37.22 | 14.25 | 7.24 | 19.38 | 3.51 | 120.28 |
| 1976-77 (2) | 29.20 | 30.40 | 10.93 | 5.27 | 15.87 | 2.31 | 93.98 |
| | | | Local Roads | | | | |
| 1974-75 (3) | 1.81 | 1.67 | 0.97 | 0.48 | 0.47 | 0.01 | 5.41 |
| 1975-76 (2) | 3.71 | 2.80 | 1.71 | 0.87 | 0.98 | 0.31 | 10.38 |
| 1976-77 (2) | 3.67 | 3.29 | 1.76 | 0.88 | 0.96 | 0.24 | 10.80 |

NOTE: (a) Some of the allocated grants may have been spent in the six-month period following the end of the financial year.

(b) Figures may not add to total due to rounding.

(1) The figures for 1969-70 to 1973-74 do not include supplementary grants, totalling $52.05 million (equivalent to $86.379 million in 1974-75 prices) which were not allocated according to type of road.

(2) Allocated under the Roads Grants Act, 1974. These figures do not include a preliminary additional grant, aimed at partially offsetting cost escalation, of $35.8 million (equivalent to $28.56 million in 1974-75 prices) which has not yet been allocated according to type of road. In addition, approval has been given to Western Australia to transfer $0.39 million (equivalent to $0.31 million in 1974-75 prices) from its allocation under the National Roads Act 1974; part of this sum may be spent on urban arterial roads.

(3) This is the first year that Commonwealth Grants were given specifically to urban local roads.

Sources: (1) Commonwealth Aid Roads Act, 1969.

(2) Roads Grants Act, 1974.

(3) Commonwealth Government, Payments to or for the States and Local Government Authorities 1975-76, 1975-76 Budget Paper No. 7, AGPS, Canberra 1975.

(4) Commonwealth Government, Payments to or for the States and Local Government Authorities 1976-77, 1976-77 Budget Paper No. 7, AGPS, Canberra 1976.

TABLE 2.11 - ANNUAL ADVANCES TO STATES UNDER STATES GRANTS (URBAN PUBLIC TRANSPORT) ACT, 1974

($ million)

| State | Year | | Total Advanced to 30 June 1976 |
|---|---|---|---|
| | 1974-75 | 1975-76 | |
| New South Wales | 14.763 | 5.693 | 20.456 |
| Victoria | 18.867 | 9.332 | 28.199 |
| Queensland | 2.126 | 8.985 | 11.111 |
| South Australia | 6.084 | 6.757 | 12.841 |
| Western Australia | 2.829 | 0.750 | 3.579 |
| Tasmania | 0.359 | 2.380 | 2.739 |
| TOTAL | 45.028 | 33.897 | 78.925 |

Source: Department of Transport.

Commonwealth grants to the States for urban public transport commenced in 1974-75, in which year finance advanced to the States amounted to $45.3m, of which $12m was a retrospective payment for work carried out on approved projects in 1973-74. A further $34m was advanced to the States in 1975-76. Thus total advances to date are $79m. Details of these advances to the States are contained in Table 2.11.

The distribution of Commonwealth advances for urban public transport by mode is shown in Table 2.12. It is evident that urban rail projects have received the major proportion of these advances (approximately 74 per cent), while urban bus, tram and ferry projects have accounted for approximately 25 per cent of the Commonwealth funds allocated to 30 June, 1976. Furthermore, almost 90 per cent of the $79m in grants which are outstanding on approved projects is also committed to urban rail projects. Commonwealth grants under the Urban Public Transport Agreement that have been approved but were not advanced at 30 June, 1976 are also included in Table 2.12.

TABLE 2.12 - COMMONWEALTH GOVERNMENT ADVANCES AND APPROVED GRANTS TO THE STATES UNDER STATES GRANTS (URBAN PUBLIC TRANSPORT) ACT, 1974 BY MODE AS AT 30 JUNE, 1976

($ million)

| State | Train | Bus | Tram | Ferry | Other (1) | Total |
|---|---|---|---|---|---|---|
| | | Advances Made to 30 June 1976 | | | | |
| New South Wales | 18.933 | 0.279 | - | 1.244 | - | 20.456 |
| Victoria | 24.189 | 0.540 | 3.377 | - | 0.093 | 28.199 |
| Queensland | 9.490 | 0.754 | - | - | 0.867 | 11.111 |
| South Australia | 6.226 | 6.311 | 0.304 | - | - | 12.841 |
| Western Australia | 0.034 | 3.358 | - | 0.187 | - | 3.579 |
| Tasmania | - | 2.739 | - | - | - | 2.739 |
| TOTAL | 58.872 | 13.981 | 3.681 | 1.431 | 0.960 | 78.925 |
| | | Grants approved but not advanced at 30 June 1976 | | | | |
| New South Wales | 36.495 | 0.795 | - | 0.209 | 0.168 | 37.667 |
| Victoria | 16.732 | 0.100 | 1.688 | - | 0.240 | 18.760 |
| Queensland | 12.497 | 0.526 | - | - | 0.900 | 13.923 |
| South Australia | 5.694 | 0.588 | 0.300 | - | - | 6.582 |
| Western Australia | 0.011 | 1.715 | - | 0.110 | - | 1.836 |
| Tasmania | - | 0.327 | - | - | - | 0.327 |
| TOTAL | 71.429 | 4.051 | 1.988 | 0.319 | 1.308 | 79.095 |

(1) Includes grants for passenger interchanges.

Source: Department of Transport.

# CHAPTER 3 - SUPPLY AND DEMAND IN URBAN TRANSPORT

## THE URBAN TRANSPORT TASK

### Description of the Task

The urban transport task is difficult to describe adequately because of the large number of dimensions related to its measurement. These dimensions include trip purpose, trip length, geographical orientation of the trip, time of day and travel mode. Nevertheless, an examination of the broad patterns of urban travel is a useful prelude to detailed analysis of demand for urban transport and the resources required to meet this demand.

The dominance of private road transport in the total urban transport scene is indisputable. The private car is clearly the most important mode for passenger travel in urban areas even though the public transport modes perform important parts of the total passenger task. Data limitations restrict direct comparisons between the total private car and public transport modes, but Table 3.1 provides relevant information from the most recent of the major urban transportation studies.

Table 3.1 indicates that the public transport task was in the vicinity of one-third of the total urban passenger task in Sydney in 1971. These statistics understate the current dominance of car travel because it has been growing faster than public transport travel over the period since 1971. Further, the relative dominance of car travel is almost certainly greater in the other major cities than in Sydney(1). Road is the only significant mode of intra-urban freight transport.

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(1) Evidence for this for work and school travel is given in: Australian Bureau of Statistics, Journey to Work and School Survey, August, 1974. In Sydney in 1974, 29.7 per cent of work trips and 36.9 per cent of trips for educational purposes were by public transport. These percentages were higher than for the other capital cities and compare with aggregate percentages for the six State capitals of 24.3 per cent for work travel and 27.1 per cent for school travel.

TABLE 3.1 - PASSENGER TRAVEL BY MODE, SYDNEY, 1971

| | Ferry | Rail | Bus | Total public transport | Car |
|---|---|---|---|---|---|
| Daily Trips ('000) | 36 | 562 | 793 | 1391 | 3548 |
| Median Journey length (km) | 10.3 | 15.0 | 4.7 | 7.1 | 5.8 |

Source: Sydney Area Transportation Study, Vol. 1, 1974.

TABLE 3.2 - MOTOR VEHICLE USAGE BY AREA OF OPERATION, AUSTRALIA, 1971

('000 million vehicle-km)

| | Capital city urban | Provin-cial urban | Other areas of State or Territory | Other States or Territories | Total |
|---|---|---|---|---|---|
| Cars and Station wagons | 35.5 | 5.3 | 20.6 | 2.6 | 64.0 |
| Light commercial type vehicles and trucks | 6.9 | 1.1 | 7.7 | 0.7 | 16.4 |

NOTE: The area-of-operation classification relates to the vehicles on register in a particular State or Territory. Classification of usage outside the State or Territory of registration into urban and non-urban is not available.

Source: Australian Bureau of Statistics, Survey of Motor Vehicle Usage, 1971.

The importance of the urban component of the total Australian private road transport task and the relation between the freight and passenger tasks in terms of vehicle-kilometres can be seen from Table 3.2. The statistics indicate that a little over half of this task was performed in capital cities or provincial urban areas. Of this task, 75 per cent is performed on arterial roads which comprise 20 per cent of total road length in urban areas(1). Far more vehicle-kms were travelled by cars and station wagons in urban areas than by commercial vehicles. However, vehicle-kms do not provide an adequate measure either of the relative resources used or of the relative value of the transport tasks.

Returning briefly to the public transport passenger task in the major cities, Table 3.3 shows that there are distinct differences in modal proportions between cities. This is to be expected because of differences in historical development patterns and differences in density and topography between cities. Even though such differences do exist, there appears to be a positive relation between size of city and the importance of rail in the urban transport system. This is consistent with the view that the cost effectiveness of rail transport improves in comparison with other mass transit modes as traffic volumes increase. This does not necessarily mean that as population grows the emphasis in public transport should be towards rail.

Insight into the roles of the various urban transport modes can be obtained by identifying some major sub-markets within the overall travel market.

One of the most important characteristics of urban travel is the peakiness of demand. This is illustrated by Figure 3.1 which shows the distribution of person journeys by time of day for work, school and other trips in Sydney in 1971. It can be seen that the morning school and work peaks coincide and this exacerbates the urban transport problem.

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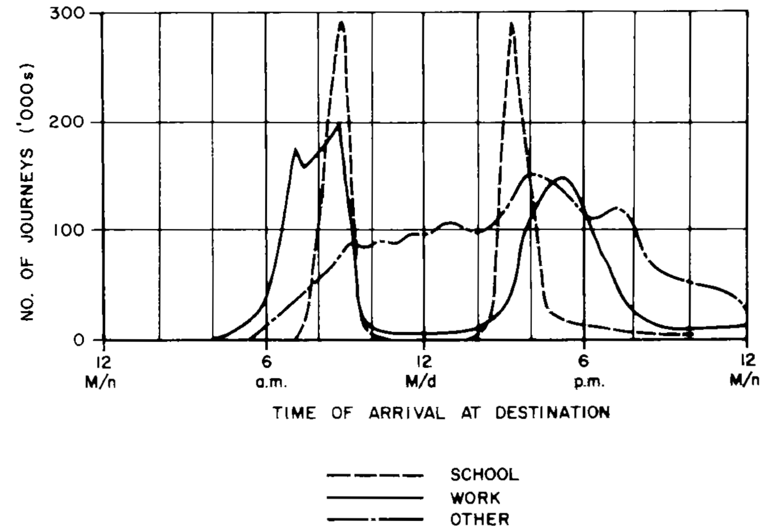
(1) Commonwealth Bureau of Roads (1975), <u>op. cit.</u>, p. 113.

TABLE 3.3 - URBAN PUBLIC TRANSPORT IN THE SIX STATE CAPITALS, 1974-75

(passenger journeys in millions)

| | Govt. bus | Govt. tram & trolley bus | Private bus | Total road-based public transport | Rail | Ferry | Total |
|---|---|---|---|---|---|---|---|
| Sydney | 175.9 | - | 113.8 | 289.7 | 167.9 | 11.0 | 468.6 |
| Melbourne | 22.7 | 111.1 | 63.0 | 196.8 | 112.8 | - | 309.6 |
| Brisbane | 49.1 | - | 14.8 | 63.9 | 34.8 | 1.9 | 100.6 |
| Adelaide | 57.0 | 1.3 | 1.4 | 59.7 | 12.0 | - | 71.7 |
| Perth | 58.7 | - | - | 58.7 | 10.0 | 0.4 | 69.1 |
| Hobart | 14.9 | - | 0.5 (1) | 15.4 | 0.3 (2) | 3.3 (3) | 19.0 |

(1) Estimated by Tasmanian Transport Commission.
(2) Operations ceased December 1974.
(3) Estimated by Tasmanian Transport Commission from revenue collected. Figures reflect the introduction of commuter ferry operations following the collapse of the Tasman Bridge in January 1975.




SOURCE: SYDNEY AREA TRANSPORTATION STUDY

FIGURE 3·1

DISTRIBUTION OF PERSON JOURNEYS BY TIME OF DAY, BY JOURNEY PURPOSE SYDNEY, 1971

The public transport modes face a much more peaked demand than car travel, partly because public transport caters for work and school trips to a much greater extent than private car. This is shown, again using Sydney data, in Table 3.4.

TABLE 3.4 - IMPORTANCE OF WORK AND SCHOOL PURPOSE FOR BUS, TRAIN AND CAR TRAVEL, SYDNEY, 1971

(Percentage of modal trips by purpose)

| | Work | School | Other |
|---|---|---|---|
| Bus | 35 | 30 | 35 |
| Train | 64 | 15 | 21 |
| Car | 33 | 5 | 62 |

Source: Basic data from Sydney Area Transportation Study.

Another area of specialisation of public transport is in CBD-oriented travel. In Sydney in 1971, nearly 30 per cent of public transport trips were CBD-oriented compared with only 5 per cent of car trips. The percentage of rail travel centred on the CBD was double that of bus travel.

It is clear that one of the important roles of public transport is to carry large numbers of people along high density corridors to destinations characterised by a high concentration of activities. This is related to a low requirement for land at terminals and to decreasing costs as volume increases. The limited flexibility of public transport reduces its viability in more dispersed travel markets.

In addition to being a highly efficient means of transport in some instances, public transport has an important objective of providing a basic transport service to the group of people either permanently or temporarily without reasonable access to other means of transport. This group includes those people in households with low incomes and low car ownership characteristics. It also includes persons without a driver's licence either because of age or disability. Part of the community demand for a basic public transport system also stems from a desire for a contingency transport service.

The vital role of public transport in school travel has been referred to above. Statistics for all State capital cities indicate that in 1974, 27 per cent of all trips to school, university and other educational institutions were by public transport and were predominantly by bus[(1)]. Walking or travelling as car passengers were the other major means of transport.

Turning to other trip purposes, the component of the total Sydney public transport task that would appear to have the most need from an equity point of view, according to SATS data, is the non-CBD bus task. Only 20 per cent of these travellers possess a licence and come from households owning at least one car. They contrast strongly with CBD public transport users for whom the corresponding figure is 50 per cent.

## Trends in Demand

This section examines historical trends in urban transport usage and seeks to identify the factors affecting demand and estimate the strength of their influence. Some of these factors can be used as instruments of transport policy (for example fares and service levels) while others are determined independently of the transport system (population and income levels for example).

Public transport patronage has generally declined over the past fifteen years. Figure 3.2 shows this trend for the six State capital cities as measured by the number of trips by each mode. The rate of decline in total public transport patronage has averaged about 1.4 per cent per annum. The trends differ from city to city[(2)], but only in Perth has there been positive growth in patronage over the long term.

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(1) Australian Bureau of Statistics, Journey to Work and School op. cit.

(2) Brisbane rail patronage has been growing steadily even though total public transport patronage in that city has shown a downward trend.

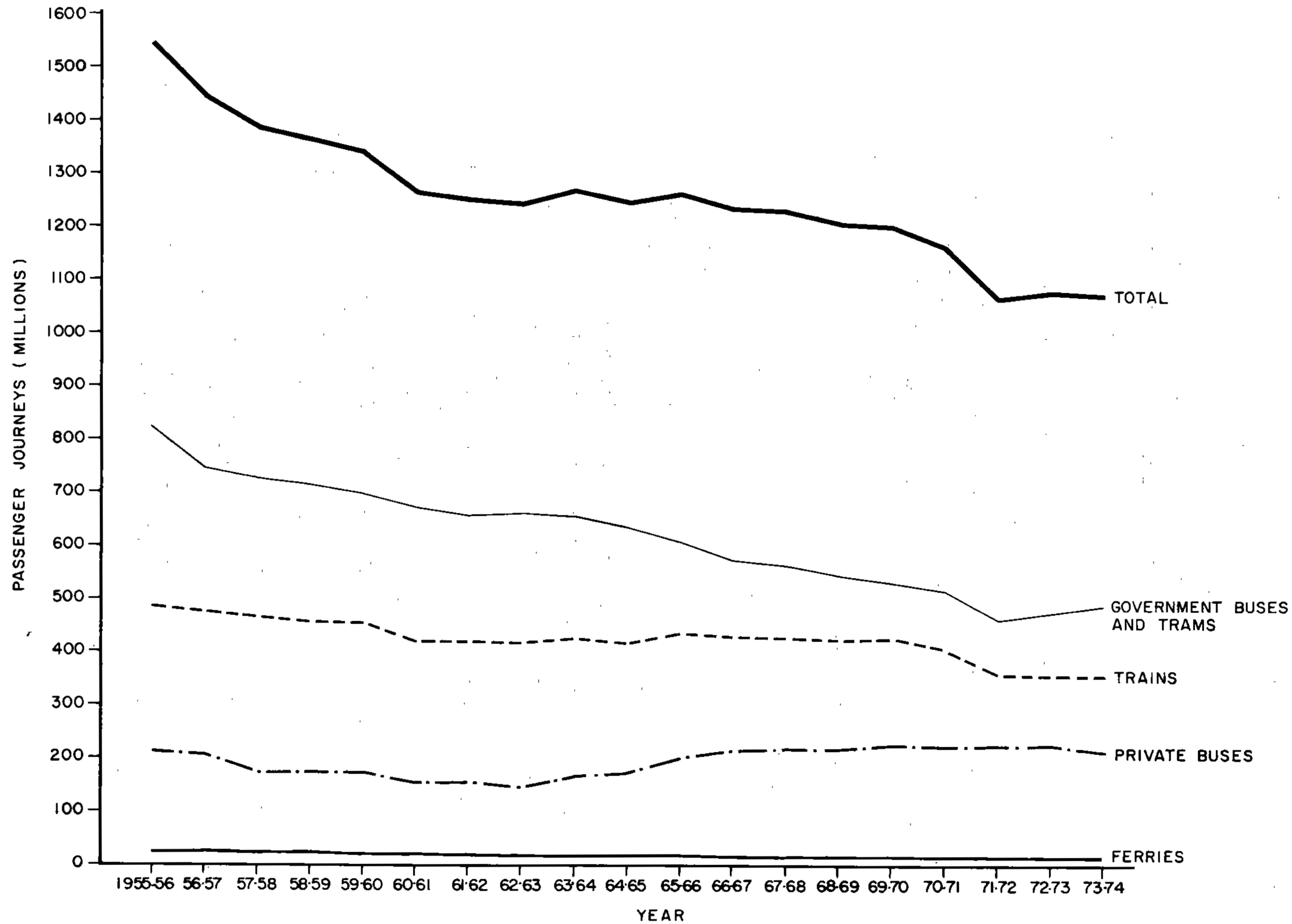


FIGURE 3·2

URBAN PUBLIC TRANSPORT

Trend data on private motor vehicle transport is very limited. The basic sources are two motor vehicle usage surveys carried out in December 1963 and September 1971 by the Australian Bureau of Statistics. Only the latter survey distinguishes urban from non-urban vehicle usage and comparison between the two years is therefore restricted to total usage throughout Australia.

Travel by car and station wagon, measured by vehicle kilometres per annum, has been growing rapidly and doubled between 1963 and 1971. However, there has been a fall in the growth rate of the number of cars and station wagons on register from 7 per cent per annum in the early 1960's to 5.5 per cent per annum in the early 1970's. This suggests that the rate of growth in vehicle kilometres could be declining.

Distance travelled by light commercial vehicles and trucks has also grown rapidly over the period 1963 to 1971. This growth has been at an average rate of about 5 per cent per annum.

There is limited survey information on trends in the sub-markets of the urban travel market such as peak travel. However, there are indirect indicators from trends in the location of activities. This information is presented later in support of conclusions about growth in urban transport demand.

## Explanation of Demand Trends

In general the assumption is made in this report that the underlying relationships between urban travel demand and the factors determining that demand are reasonably uniform across the major Australian cities. That is, demand is postulated to respond to changes in, say, income or fare levels in an approximately similar way in Perth or Brisbane or Sydney. This does not imply similar forecasts for all cities because the determining factors may be expected to change in different ways. This will be true of population, for example.

TABLE 3.5 - MOTOR VEHICLE USAGE, 1963 AND 1971

| | | 1963 | 1971 | Average annual growth p.a.(%) |
|---|---|---|---|---|
| Population (m) | | 11.1 | 12.9 | 2.0 |
| station wagons | Vehicles per head | 0.224 | 0.310 | 4.2 |
| | Vehicle-km ('000m) | 32.8 | 64.7 | 8.8 |
| Light commercial type vehicles and trucks | Vehicles per head | 0.074 | 0.073 | -0.2 |
| | Km per vehicles ('000) | 13.7 | 17.5 | 3.2 |
| | Vehicle-km ('000m) | 11.2 | 16.5 | 5.0 |
| All vehicles | Vehicle-km ('000m) | 44.0 | 81.2 | 7.9 |

Source: Australian Bureau of Statistics, Survey of Motor Vehicle Usage, 1963 and 1971.

Taking the private travel market first, the growth in private motor vehicle usage can be analysed by splitting vehicle-km growth into three components; population, vehicles per head, and km per vehicle. This categorisation is shown in Table 3.5 for passenger car travel (cars and station wagons) and road freight transport (light commercial-type vehicles and trucks).

The demand for freight transport is generated by general economic activity. The close link between them is supported by the observation that the increase in truck vehicle-km was slightly below the GNP growth rate.

The growth in car travel was much greater than freight, and the figures in Table 3.5 indicate that growth in the number of cars per head was the major contributor. This component can be analysed in more detail using annual data.

Car ownership per head in Australia has grown from 0.197 in 1960 to 0.372 in 1975. Econometric studies(1) show that changes in ownership of cars per head over time can be explained by changes in real per capita income and in real car prices. Results of these studies indicate that most of the growth in cars per head over the period between the mid 1950's and mid 1970's was due to growth in real per capita income (which averaged 3.3 per cent per annum over the period). The fall in real car prices (which averaged about 1.7 per cent per annum) was the other major explanator of the growth in car ownership.

The analyses support the hypothesis that income and price elasticities are falling as car ownership levels increase. The suggestion of a falling income elasticity resulting in a falling growth rate in cars per head is consistent with the view that the market is approaching saturation. This is also consistent with international evidence where comparisons of trends in cars per head provide cross-sectional evidence of logistic growth. In the

(1) Reported in Annex A.

TABLE 3.6 - IMPACT OF CHANGES IN FARES AND INCOME ON PUBLIC TRANSPORT DEMAND

| | Elasticity | | Contribution to decline 1965-66 to 1974-75 (% p.a.) | |
|---|---|---|---|---|
| | Bus | Rail | Bus | Rail |
| Fares | -0.35 | -0.37 | +1.3 | +0.6 |
| Income/head | -0.40 | -0.20 | +1.3 | +0.7 |

TABLE 3.7 - CHANGES IN EMPLOYMENT AND POPULATION AT INCREASING DISTANCES FROM THE CITY CENTRE: SYDNEY, 1961 TO 1971

(Average rates of change, % p.a.)

| | Central Area | Intermediate Area | Outer Area | Total |
|---|---|---|---|---|
| Employment | 1.4 | 4.9 | 9.6 | 4.4 |
| Population | -0.6 | 0.8 | 3.8 | 1.9 |

Source: Sydney Area Transportation Study, Sydney, January 1974, Vol. 1.

decade from 1960 to 1970, cars per head increased by 156 per cent from 0.068 to 0.106 in Western Europe, by 55 per cent from 0.195 to 0.303 in Australia, and by 27 per cent from 0.341 to 0.434 in U.S.A.(1)

Data inadequacies prevent detailed analysis of the growth in average annual distances travelled by cars. It is probably generated by increasing income levels and again is likely to be subject to saturation.

The decline in urban public transport patronage is in marked contrast to the private transport trend. BTE studies of time series data identify fares and income levels as important factors responsible for this decline.(2) Estimates of the elasticities with respect to fares and income per head (both in real terms) for the State capital cities as a whole are shown in Table 3.6. The corresponding contributions to the patronage decline in terms of average annual growth rates over the ten years to 1974-75 are also shown.

Fares over the ten year period to 1974-75 have been rising (in real terms) at an average rate of 3.7 per cent per annum for bus and 1.7 per cent per annum for rail. These high rates to some extent reflect the labour intensive nature of the industries and the limited productivity gains that are possible. The relatively low fare elasticity has cushioned the adverse effects of these rises on demand.

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(1) A.H. Tulpule, An Analysis of Some World Transport Statistics, Transport and Road Research Laboratory Report No. 662, Crowthorne, Berkshire, 1974.

(2) Refer to Annex A. The econometric model for bus demand estimated a car ownership elasticity rather than an income elasticity. However an estimate of the underlying income elasticity can be obtained by mutliplying the income elasticity of demand for car ownership (about 0.7 for the decade 1965-75 from Annex A) by the car ownership elasticity of demand for bus travel (0.57 from Annex A).

Income can influence public transport demand through several channels,[1] but the dominant effect is via car ownership levels. Increasing per capita car ownership reduces the size of the potential travel market captive to public transport.

The roles of population growth and urban development in influencing travel demand are very important but difficult to determine in precise terms. In the case of private transport it has been assumed above that the population elasticity of demand was unity. However, it is likely that population growth has had a smaller effect on public transport travel than it has had on private vehicle travel. This follows from the general CBD orientation of public transport and the predominantly non-CBD orientation of car travel in association with the trends in urban development towards extensive patterns of land use.[2]

The growth of activities and employment in CBDs in recent years has been very low, especially when compared with growth in outer suburban areas. This is illustrated for Sydney in Table 3.7. Figures for Melbourne also indicate slower growth of employment and population in central areas.

The implication of this finding is that the market in which public transport has a comparative advantage has been relatively static, and most of the growth has been occurring in the market better served by car travel. This is reflected in the trends in demand for the two modes.

## Demand in Major Sub-Markets

Since peak loads present the greatest problems in urban transport it is important to look at trends, not just in total demand, but also in the distribution of demand over time and space. Appropriate data is scarce but some inferences can be drawn.

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(1) Further discussion is contained in Annex A.
(2) Changing population and urban development patterns are linked with changing service levels provided by public transport. The interrelationships are discussed in more detail in Annex A.

First, the consequences of the relative dispersal of population and employment away from central city areas on the geographical pattern of growth in private vahicle transport are clear. The less congested outer urban areas are those in which growth in motor vehicle usage is greatest.

The relative growth rates for different trip purposes have implications for the distribution of travel. Table 3.8 shows that travel for purposes other than for work or school is the fastest growing component of passenger travel. It is also the component currently placing the least burden on the transport system as it occurs mainly during off-peak periods.

Further analysis of Melbourne survey data, shown in Table 3.9, reveals that the growth in trips for purposes other than for work or school was in car-owning households. Non car-owning households made slightly fewer trips in 1972 than 1964.

Turning to work trips, the Australian Bureau of Statistics Journey to Work Surveys provide an indication of the modal share between 1970 and 1974. Car trips grew at about 5 per cent per annum. Work trips by public transport declined at an average rate of more than 3 per cent per annum (which is a higher rate than for the total public transport task).

## RESOURCES IN URBAN TRANSPORT

The previous section examined the urban transport task in terms of the historical demand for particular modes. This examination only covers one part of the urban transport picture. The resources employed in the performance of this task makes up the other part.

This section examines the supply of urban transport services in terms of capital employed, the operating results of the various authorities and the utilisation of resources employed.

TABLE 3.8 - HOME BASED TRIP PRODUCTION RATES: MELBOURNE

(week day trips per household)

| | 1964 | 1972 |
|---|---|---|
| Work and school | 2.68 | 2.66 |
| Other | 1.76 | 3.14 |

Sources: Survey for Melbourne Transportation Study, 1964.
Survey by Melbourne Transportation Committee, 1972.

TABLE 3.9 - HOME BASED TRIP PRODUCTION RATES: MELBOURNE, 1964 AND 1972

(week day trips per household)

| Cars per household | Shopping 1964 | Shopping 1972 | Social 1964 | Social 1972 | Other 1964 | Other 1972 |
|---|---|---|---|---|---|---|
| 0 | .29 | .24 | .13 | .11 | .34 | .32 |
| 1 | .50 | .86 | .36 | .62 | .78 | 1.17 |
| 2 | .86 | 1.41 | .65 | .85 | 1.34 | 1.95 |
| 3+ | .98 | 1.54 | .75 | 1.40 | 1.67 | 2.17 |

Sources: Survey for Melbourne Transportation Study, 1964.
Survey by Melbourne Transportation Committee, 1972.

Description of Resource Use

The resources employed in carrying out the urban transport task include both capital and current resources. The trends in capital expenditure on rail, government operated urban transit, arterial roads and local roads in urban areas during recent years were discussed in Chapter 2. Historical data on capital investment in privately operated transit systems in urban areas are not available. They do, however, perform a significant part of the public transport task[(1)] and so an estimate of the order of magnitude of the annual capital expenditure on privately operated route buses in urban areas has been made.

Assuming an average 15 year bus replacement cycle for all private operators, approximately 6.7 per cent of these buses would need to be replaced annually to maintain a static fleet age distribution. If each replacement route bus costs around $40,000 in 1974-75 prices, the annual capital expenditure by private bus operators in urban areas based on these assumptions and the information that there were 3,390 private buses being used on route services in urban areas in March 1975[(2)] would be around $9.5 million.[(3)]

Capital expenditure is only one part, albeit an important one, of the total resource use picture. Current expenditure associated with operating the systems and the revenues received by those systems are also important as they have implications for the overall resource balance and the financial position of the operators of each system.

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(1) See Figure 3.2 for example.

(2) This compares with 4,946 buses being operated on route services by government operators at the same point in time. The information is derived from Rendel and Partners, "Review of Privately Owned Bus and Ferry Service in Urban Areas in Australia", Volume II - Appendices.

(3) This could be expected to be an over estimate of the actual investment figure because of wide use of second-hand vehicles and because fleet age distribution statistics indicate that private operators adopt a somewhat larger replacement cycle than 15 years.

TABLE 3.10 - URBAN PUBLIC TRANSPORT BUS AND TRAM SERVICES OPERATED BY PUBLIC AUTHORITIES: REPORTED OPERATING RESULT

($ million)

| | Capital City [1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Sydney [2] | Melbourne | Brisbane | Adelaide | Perth | Hobart | Total |
| 1965-66 | -4.9 | -1.5 | -0.9 | -0.2 | -1.3 | -0.6 | -9.4 |
| 1966-67 | -4.6 | -1.0 | -0.9 | -0.1 | -0.6 | -0.7 | -7.9 |
| 1967-68 | -5.6 | -1.5 | -1.0 | -0.1 | -0.6 | -0.7 | -9.5 |
| 1968-69 | -4.7 | -1.8 | -1.5 | -(3) | -0.9 | -0.7 | -9.6 |
| 1969-70 | -4.9 | -1.8 | -2.1 | -(3) | -0.9 | -1.0 | -10.7 |
| 1970-71 | -6.4 | -3.4 | -1.1 | -0.5 | -1.8 | -1.4 | -14.6 |
| 1971-72 | -7.8 | -2.4 | -1.1 | -0.6 | -3.2 | -1.3 | -16.4 |
| 1972-73 | -12.5 | -5.1 | -1.6 | -1.4 | -4.6 | -1.7 | -27.3 |
| 1973-74 | -23.0 | -11.6 | -2.2 | -2.2 | -5.8 | -2.5 | -47.3 |
| 1974-75 | -32.8 | -21.5 | -3.7 | -5.9 | -8.4 | -4.0 | -76.3 |

NOTE: Minus sign (-) denotes loss or deficit.

(1) Surplus/deficit estimates for Melbourne, Brisbane and Adelaide include bus and tram.

(2) Includes subsidy for concession fares. In 1974-75 this subsidy amounted to $4.17m.

(3) Less than $50,000.

Source: Annual Reports of various Public Bus and Tram Authorities.

Details of the reported operating results of urban bus and tram services operated by public authorities in the State capital cities over the period 1965-66 to 1974-75 are summarised in Table 3.10. The dramatic increase in the level of reported deficit for all State capital cities in recent years is evident. In total, these systems showed a deficit of $76.3m in 1974-75.

The passenger revenue for government operated bus and tram services in the six State capital cities over the period 1965-66 to 1974-75 are shown in Table 3.11. The average annual growth rates in revenue for bus services over the period were: Sydney 5.9 per cent, Melbourne 4.8 per cent, Brisbane 19.7 per cent(1), Adelaide 12.2 per cent, Perth 6.4 per cent and Hobart 2.5 per cent.

The passenger revenues received by the State capital city rail systems for the period 1965-66 to 1974-75 are shown in Table 3.12. Revenues for all systems except Hobart have grown over the period. The average annual growth rates for the other systems were: Sydney 7.8 per cent, Melbourne 3.7 per cent, Brisbane 9 per cent, Adelaide 4.1 per cent and Perth 7.8 per cent.

The costs associated with urban rail operations are not published as a matter of course by all railway operating authorities. It is therefore not possible to build up a complete picture of the operating results of urban rail services over time. The reported deficit of Sydney and Newcastle urban rail operation in 1972-73 was $10.9 million and in 1973-74 was $19.6 million.(2) Deficits of $4.81 million, $5.98 million, $7.56 million and $9.12 million for the years 1972-73 to 1975-76 respectively have been reported

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(1) This high growth rate is partially explained by the replacement of tram services by bus services in 1968-69.

(2) Public Transport Commission of New South Wales, Annual Report, 1974.

TABLE 3.11 - URBAN PUBLIC TRANSPORT BUS AND TRAM SERVICES OPERATED BY PUBLIC AUTHORITIES: PASSENGER REVENUE

($ million)

| Year | State Capital City | | | | | | | | Six Capitals |
|---|---|---|---|---|---|---|---|---|---|
| | Sydney (1) | Melbourne | | Brisbane | | Adelaide (2) | Perth (1) | Hobart (1) | |
| | | Bus | Tram | Bus | Tram (3) | | | | |
| 1965-66 | 19.9 | 2.9 | 14.7 | 2.8 | 4.8 | 6.0 | 5.9 | 2.2 | 59.2 |
| 1966-67 | 21.5 | 3.3 | 15.9 | 3.2 | 5.0 | 6.3 | 6.6 | 2.4 | 64.2 |
| 1967-68 | 21.7 | 3.4 | 15.6 | 3.5 | 4.5 | 6.2 | 7.6 | 2.5 | 65.0 |
| 1968-69 | 24.5 | 3.5 | 15.9 | 4.7 | 2.4 | 6.5 | 8.0 | 2.5 | 68.0 |
| 1969-70 | 26.1 | 3.6 | 16.7 | 7.8 | | 6.7 | 8.2 | 2.3 | 71.4 |
| 1970-71 | 27.0 | 3.7 | 16.6 | 9.1 | | 6.9 | 8.4 | 2.3 | 74.0 |
| 1971-72 | 28.8 | 4.1 | 19.0 | 9.6 | | 7.0 | 8.6 | 2.6 | 79.7 |
| 1972-73 | 30.3 | 4.3 | 19.8 | 9.5 | | 7.3 | 8.5 | 2.6 | 82.3 |
| 1973-74 | 30.9 | 4.5 | 20.5 | 11.3 | | 9.9 | 10.2 | 2.7 | 90.0 |
| 1974-75 | 33.8 | 4.5 | 20.9 | 12.6 | | 13.4 | 12.0 | 2.9 | 100.1 |

(1) Figures are for bus only.
(2) Figures are for bus and tram combined.
(3) Brisbane ceased Tram operations in 1968-69.

Sources: (1) Australian Bureau of Statistics, Transport and Communication, (Various issues).
(2) Annual Reports of State Bus and Tram Authorities.

TABLE 3.12 - URBAN PUBLIC TRANSPORT RAIL SERVICES OPERATED BY PUBLIC AUTHORITIES: PASSENGER REVENUE

($ million)

| Year | State Capital City | | | | | | Six Capitals |
|---|---|---|---|---|---|---|---|
| | Sydney | Melbourne | Brisbane | Adelaide | Perth | Hobart (1) | |
| 1965-66 | 25.84 | 20.25 | 1.97 | 1.79 | 1.02 | 0.08 | 50.95 |
| 1966-67 | 28.32 | 22.22 | 2.24 | 1.91 | 1.14 | 0.08 | 55.91 |
| 1967-68 | 29.11 | 22.51 | 2.46 | 1.90 | 1.21 | 0.08 | 57.27 |
| 1968-69 | 31.37 | 22.98 | 2.69 | 1.96 | 1.27 | 0.07 | 60.34 |
| 1969-70 | 33.15 | 24.17 | 2.77 | 2.00 | 1.44 | 0.07 | 63.60 |
| 1970-71 | 33.55 | 23.99 | 2.91 | 2.05 | 1.54 | 0.06 | 64.10 |
| 1971-72 | 45.72 | 25.77 | 3.47 | 2.15 | 1.59 | 0.06 | 79.76 |
| 1972-73 | 45.88 | 27.17 | 2.81 | 2.28 | 1.69 | 0.07 | 80.90 |
| 1973-74 | 47.90 | 27.70 | 4.07 | 2.42 | 2.00 | 0.07 | 84.16 |
| 1974-75 | n.a. | 28.37 | 4.40 | 2.73 | n.a. | 0.07 | n.a. |

(1) Operations ceased in December 1974.

Source: (1) Australian Bureau of Statistics, Rail, Bus and Air Transport, various issues.
(2) Australian Bureau of Statistics, Transport and Communications, various issues.
(3) Annual Reports of the various State Public Transport Operating Authorities.

for urban rail operations in Western Australia[1]. These data show that the deficits for these operations have increased in absolute magnitude over time. The implied deficits per passenger carried have also increased.

Similar information has not been published for the other systems, but Queensland Railways have indicated to BTE that they estimate that urban passenger rail operations in Brisbane in 1974-75 recorded a deficit of $14.5 million.

## Urban Transport Utilisation

Economic efficiency requires that resources are allocated in such a way that there is no other allocation possible which would make at least one person better off without making anyone else worse off. Economic efficiency also requires that existing resources are used in such a way that the greatest possible benefit is obtained from the limited capacity available.

In order to achieve economic efficiency in the provision of transport facilities and services in urban areas, it is necessary to ensure that new resources are allocated to those areas where net benefits are greatest, and that the greatest possible benefit is obtained from the existing infrastructure. It is, therefore, useful to consider the total costs of performing the transportation task by different modes in different circumstances, and to examine some of the implications from changing existing operating procedures.

Urban Corridor Cost Studies: Variations in land use within a conurbation lead to different transport tasks in different parts of the urban area. That is, different travel corridors are typified by vastly different traffic densities and traffic

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(1) Director General of Transport for Western Australia, Annual Report, 1975-76. The figures presented on p. 23 of that report have been adjusted to current prices using the miscellaneous group component of the CPI for Perth.

A time profile of daily demand was developed for use in the study using Sydney and Melbourne data, and the results of overseas studies. The distribution of trips throughout the day used in the analysis was as follows:

| Time Slot | 6-7am | 7-9am | 9am-4pm | 4-6pm | 6-10pm |
|---|---|---|---|---|---|
| Percentage of Daily Trips (%) | 2 | 30 | 27 | 32 | 9 |

Three methods of trip collection/distribution were considered at the low population density residential end of the corridor. These were route bus, park and ride, and kiss and ride. The three public transport modes considered for the line haul stage of the trip were electric rail, route bus and express bus. The distribution task at the high density end of the corridor was considered to be handled in the same way for each alternative.

The objective of the study was to compare the costs of performing the alternative transportation tasks by the different modes. Costs included in the study were vehicle operating costs that is, system costs (excluding road and rail infrastructure capital costs) and user time costs. Other social costs such as congestion, noise and pollution costs, although important, were not quantified for this exercise. The cost estimates employed are given in Annex B.

The overall results of the study are illustrated in Figure 3.3.[1] The diagram shows that the car is the lowest cost mode of travel in the short low volume corridor. Although if allowances were made for collection/distribution costs at the high density end of the corridor, the taxi would be the same cost as the car for the short corridor. For the medium length corridor the private car is the least cost mode. For the longer highest volume corridor, the results indicate a cost advantage for rail and express bus over the other modes.

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(1) These results assume a modal split in collection/distribution at the residential end of the corridor of route bus 50 per cent, kiss and ride 25 per cent, park and ride 25 per cent.

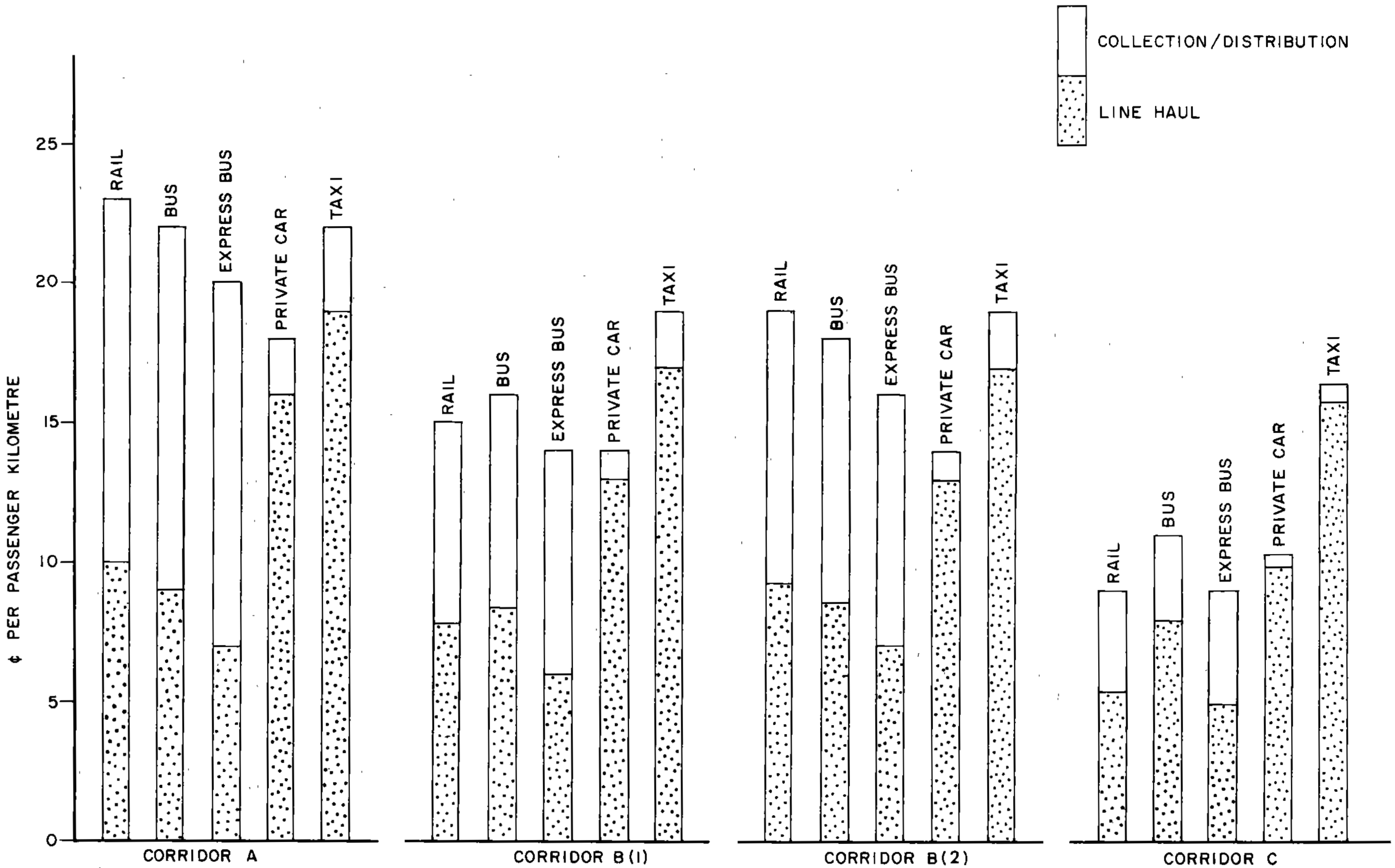


**FIGURE 3·3**
**COST PER PASSENGER KILOMETRE**

compositions. This has major implications for the way the transport system is developed since alternative systems are available to satisfy these differing demands. For example, public transport modes such as bus and rail are best suited to high traffic density corridors, while the private vehicle and para-transit systems are well suited to lower density corridors. The results of a comparative cost analysis for different modes for typical travel corridors found in the Australian capital cities are reported in this section.(1)

The travel corridors examined in this report were defined as a chain of residential suburbs of equal population density extending from a dense trip generation or attraction area such as a CBD. All passenger journeys in the corridor were assumed to have one trip end in the suburban area and one in the dense trip generation or attraction area.

Four corridors, defined in terms of length and passenger demand characteristics, were selected for examination. These were delineated as being representative of travel corridors in the capital cities having travel demand levels in excess of 10,000 travellers in the corridor per day. The characteristics of these corridors are described in Table 3.13.

The transport task in these corridors was defined to comprise a collection/distribution task in the residential areas, a collection/distribution task in the dense trip generation or attraction area, and a line haul task connecting the two. The private vehicle and taxis were considered to be travel alternatives for the total trip. The other travel alternatives were multimodal.

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(1) A detailed report of the analyses conducted is presented in Annex B.

TABLE 3.13 - CHARACTERISTICS OF STUDY CORRIDORS

| Corridor Identifier | Length (km) | Passengers per day ('000) | Passenger kilometres per day ('000) |
|---|---|---|---|
| A | 4 | 10 | 30 |
| B(1) | 10 | 10 | 60 |
| B(2) | 10 | 25 | 150 |
| C | 30 | 100 | 1500 |

The results of the study with respect to just the collection/ distribution task at the residential end of the corridor suggest that the route bus is the lowest generalised cost transport system for corridors A, B(1) and C. For corridor B(2), 'park and ride' is the lowest cost system. These results are quite sensitive to the assumptions employed, especially in respect of treatment of time costs, whether marginal or average motor vehicle operating costs are employed, the level of parking charges and the population density of the area.

For the line-haul task only, rail and express bus were superior in the longer more densely trafficked corridor, while bus was less costly in the lighter traffic density corridor situation.

The modal cost comparisons reported above do not include a cost component for infrastructure capital investment. That is, the conclusions drawn relate to utilisation of existing infrastructure on the assumption that historical capital investment is sunk. To make valid modal comparisons in situations where capital investment is required for extension of infrastructural capacity for one mode or another, capital costs would need to be included in the analyses.

Inproving Urban Transport Utilisation: Clearly, the capacity and utilisation of urban transport systems are affected by the way in which they are operated. In some instances it may be possible to improve the utilisation of existing transport systems by implementing appropriate changes in operating procedures. Such changes can produce substantial benefits in situations where significant congestion occurs. Further, in some instances they may have the effect of reducing or deferring the need for capital investment in additional infrastructure.

In recent years a number of studies and demonstration projects relating to urban transport operating procedures have been undertaken. The majority of these have been concerned with relieving traffic congestion on major arterial roads in urban areas. Measures such as peak load pricing, use of transit lanes, car pooling incentives, traffic limitation techniques and improved traffic signalling techniques are all examples. A detailed discussion of the likely effects of implementing these types of changes is contained in the latest report by the CBR on roads in Australia[1]. A brief review is given of the effectiveness of two specific transport operating measures that have been adopted in urban areas overseas and of the effects of some recent changes in operating procedures for particular urban transport undertakings in Australia.

One of the more common innovations undertaken overseas has been the use of reserve traffic lanes for buses. The objective of providing these lanes has generally been to reduce the average travel time of commuters, and/or to relieve peak hour road congestion by encouraging commuters to divert from private to public transport. Promotional experiments in cities such as Amsterdam, Marseilles and Toulouse have achieved substantial increases in patronage and substantial savings in travel time. However, the proportion of new users diverted from private car travel has been shown to vary quite markedly for particular routes. Promotional experiments such as these have demonstrated that reserved bus lanes have a bigger impact when coupled with higher frequency and/or express services. It has also been demonstrated that innovations such as special traffic lights for buses and right-of-way to buses pulling away from a stop can result in savings in bus travel times.

The implementation of innovations such as reserve traffic lanes can result in substantial benefits to bus users or other exempt traffic via reduced travel times. These measures will, however, impose delays on other vehicles. It is therefore necessary to evaluate proposals prior to implementation.

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(1) Commonwealth Bureau of Roads (1975), op. cit., pp. 126-135.

As mentioned earlier, the majority of changes in urban transport operating procedures have been primarily concerned with relieving peak hour traffic congestion. One method of tackling the peak demand problem is the implementation of an area licensing scheme, such as that introduced in Singapore. Under this scheme, private car travellers pay a premium to travel in congested areas in the morning peak demand period. In an attempt to encourage car pooling, private cars with at least four occupants are exempted from this charge. Indications are that the Singapore experiment has reduced travel times by as much as 25 per cent during the morning peak. In addition, regular bus patronage has increased by 10-15 per cent. Attempts to promote a park-and-ride scheme have, however, had less success. Nevertheless, the Singapore scheme represents a significant attempt to tackle the peak demand problem through the price mechanism. Quite clearly, the problems and circumstances differ between cities and the solutions to specific problems need to be tailored to the circumstances.

Experimental changes in Australian urban transport operating procedures have become more prevalent in recent years, partly in response to the assistance given by the Commonwealth Government for research projects on roads and urban public transport. This assistance is provided through the Transport (Planning and Research) Act, 1974. Under this Act, $26m for assistance on a two-to-one basis for research projects on roads and urban public transport has been provided in the triennium 1974-75 to 1976-77. The objectives of the Act are to promote an integrated approach to transport planning and research, to encourage new initiatives, to make results generally available, to identify projects and where possible avoid duplication, and to ensure that proper consideration of alternative options precedes major investment proposals.

Projects approved under this Act have been mainly concerned with technical improvements to the infrastructure, for example, studies of road pavement and bridge design measures. However, there are some important studies which are concerned with finding more efficient operating practices for urban transport. Nearly all

States are presently undertaking studies in traffic management techniques for their particular urban areas. These are basically before and after type studies to assess changes in traffic patterns following various experiments in pricing and/or regulation of urban transport.

Pricing initiatives being examined include a zonal fare system for Sydney and an area subscription scheme for Perth. The zonal fare system study being carried out by the New South Wales Department of Motor Transport is directed towards determining guidelines for a zonal fare system where multi-modal transport is involved. The object of the study is to develop a fare structure on a zonal basis in order to attract more passengers to public transport. The area subscription scheme for Perth is one of a number of policy options being considered in stage one of a comprehensive study to limit traffic into and through central Perth.

Research results reported earlier indicate that the urban travel market is price responsive to the extent that a one per cent across the board fare decrease in a particular city could be expected to result in average increases in bus and rail patronages of 0.35 per cent. Adjustments of this order of magnitude may not occur immediately after the fare change, but may take up to a year to be fully observed. Further, it is possible that countervailing forces could act to dampen the magnitude of such responses to price changes. These considerations are important in examining the outcome of the recent pricing initiatives taken by the New South Wales government.

While the effects of the 20 per cent public transport fare reductions in this State have not been published, information made available to BTE indicates that a very small increase in public transport patronage has so far been observed in Sydney. Certainly the response to date would be inconsistent with the levels of responsiveness indicated by price elasticities given above. However, it could be that Sydney people have not been fully adjusted to the new fare levels as yet. It may be that the stated fare elasticities are too high for Sydney. Finally, other factors could be dampening the demand response expected from the fare decline. For example, if the level of individual service declined as a result of demand generation, which would occur if additional capacity was not provided in an already congested situation, demand supression could result in a lower than expected response to the fare decline.

Although there is some uncertainty about the exact response one might have expected to occur in the Sydney case, one can be reasonably sure that the Public Transport Commission will incur greater deficits from its urban transport operations as a direct result of the fare decrease. Because the overall demand elasticity for urban public transport is quite low, an across the board fare decrease is not a cost effective method of increasing urban public transport utilisation. Fare cuts are generally only cost effective in this regard if applied in particularly fare responsive sub-markets of the urban travel market.

A number of experiments and studies on regulatory changes for urban transport have been initiated in recent years. One particular study recently completed by the New South Wales Department of Transport evaluated the introduction of a transit lane on the Spit Bridge, Sydney in late 1974. The study concluded that the transit lane (available to buses, taxis, motorcycles and vehicles with three or more occupants) had benefited not only bus operations but also other traffic. A significant decline was observable in the overall person time spent on the route and the approaches to the route between a period immediately prior to the introduction of the lane and the following 12 months. The number of car-pools also increased substantially over the same period. The success of the transit lane is implied by the fact that a questionnaire survey of users of the Spit Bridge showed only a 25 per cent opposition to the transit lane. On the basis of these results the report recommended that transit lane operations should be extended to other suitable routes.

A number of other studies on changes in urban transport operating procedures are currently being undertaken with financial assistance from the commonwealth government.

Projects being sponsored in Victoria include an operations research and patronage study and an investigation into traffic engineering characteristics with the aim of improving the flow of street public transport vehicles. Improved bus fleet operational efficiency is the objective of several projects being undertaken in Queensland. It is hoped that one of these studies will serve as a basis for implementation of bus priority treatments. On a broader scale, a continuing study in South Australia is examining methods for increasing the capacity and operational safety of existing right of way by traffic management techniques such as priority roads, reversible lanes, and clearways.

One feature of the projects concerned with efficient operating practices for urban transport is the relatively small amount of resources committed to them. Of the $26million in Commonwealth assistance for research projects on roads and urban public transport provided for the triennium 1974-75 to 1976-77, it is estimated that approximately $1million is associated with this type of project. The amount compares with estimated Commonwealth assistance in excess of $450million for capital expenditure on urban roads and urban public transport over the same period. Given that the potential benefits from implementation of the findings of studies on improved operating practices are extremely high in relation to the study costs, more relative effort on these projects would appear to be warranted.

## RESOURCE USE IMPLICATIONS

In this chapter, the demand for and supply of urban transport services have been examined. This examination has revealed several factors which must be considered when developing future capital expenditure programs.

It is apparent that the annual rate of growth in demand for road travel has historically been very high but is now slackening. At the same time the demand for travel by public transport has been steadily declining.

On the supply side, two factors should be considered: capital expenditure and operating procedures.

Capital expenditure on roads appears to have reflected the noted trends in demand. On the other hand, capital expenditure on urban public transport in recent years has not followed the trends in demand, but has increased dramatically. This reflects a conscious government attempt to improve the level of service provided. A result of this policy is that additional benefits are being conferred on those members of the community that are public transport users. In this context it is important to note that several different markets are served by public transport in urban areas. The public interest could well be served by adopting different policies in different sub-markets. For example, fare levels for CBD oriented commuters could be increased relative to those for off-peak travellers.

In regard to operating procedures, there is potential for substantial benefits from relatively low cost innovations. These innovations should be given full consideration when determining the magnitude of future capital expenditure programs. There is scope for improving the utilisation of the existing transport system in all areas, and these opportunities should be examined along with new capital investment proposals in formulating urban transport development programs.

# CHAPTER 4 - FUTURE RESOURCE USE IN URBAN TRANSPORT

## FORECASTS OF URBAN TRAVEL DEMAND

Forecasts of urban transport demand are made using the relationships described earlier between demand and its determinants. Relevant determinants have been identified as income per head, public transport fares, car costs, operating and investment policies and finally population and urban structure. The first task in making demand forecasts is to forecast the future behaviour of these determining factors.

Per capita real income levels in Australia have grown at an average rate of 3.3 per cent per annum since 1955-56. It is expected that this growth rate will continue for the next decade or so.

Although public transport fare levels are a policy variable, in the past they have increased at average rates of between one and three per cent per annum in real terms. These increases have probably been largely in response to cost increases. A continuation of this trend would seem to be a reasonable expectation for the immediate future.

Car prices have been declining in real terms over the last decade, but the rate of decline has been decreasing and it is assumed that they will remain steady in the future. Real operating costs have shown a similar downward trend but these are expected to rise during the next decade as Australian petrol prices gradually adjust to import parity levels.

Trends in the above factors are expected to be relatively uniform across urban areas.

Population growth is likely to vary significantly from city to city. It is also unlikely that past trends in population growth will continue. Detailed population projections have been made and are provided in Annex C. On average, the population growth in major Australian cities is expected to fall from 2.1 per cent per annum between 1966 and 1974 to 1.4 per cent per annum between 1974 and 1981. The growth rate is expected to continue to decline beyond 1981.

The current trend in urban development of low growth in employment in centralised locations within urban areas is expected to continue. The pressure for dispersal from CBDs may even increase if government policies are pursued which reduce the subsidy to peak CBD travel. Restrictions on car travel both to and within CBDs will tend to add to this pressure. There is also the possibility that governments will relocate significant numbers of their own employees away from CBDs. Some such relocations are already underway. Quite clearly, these and other structural changes in urban form will have an impact on future travel patterns in urban areas. Forecasting urban travel demand using the causal relationships reported upon previously will reflect such changes to the extent that similar changes have occurred in the past.

Growth in per capita car ownership is predicted to fall from the average rate of 3.8 per cent per annum between 1970 and 1975 to about 2 per cent per annum in the subsequent period to 1981. This rate of growth would result in an increase in the average per capita car ownership from 0.37 cars and station wagons in 1975 to 0.42 in 1981.

The average growth rate in vehicle kilometres travelled by cars and station wagons is forecast to slacken by about 2.5 per cent per annum in the next 5 years compared with the last five years. This is a direct result of the predicted decline in rate of population growth and per capita car ownership.[1]

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(1) It should be recognised that the impact of population changes is complicated by the changing age distribution.

Urban road freight transport has historically grown more slowly than passenger car travel. However, a much smaller reduction in its growth rate is anticipated. The size of this task is linked with commodity production and consumption levels. The forecast reduction in the growth in this task is associated with reduced population growth causing slight reductions in the rates of growth in domestic consumption and perhaps also in domestic production.

The major factors tending to depress demand for public transport in urban areas are expected to continue to apply in the immediate future, but not necessarily as strongly as they have in the past. Reduced growth in car ownership levels should gradually reduce the impact of this factor. There is also potential for partially offsetting the depressing effect of rising average fares by changing the fare structure to encourage more responsive parts of the market. Restrictions on car use and increases in the cost of car use for particular travel purposes may also have an impact. Improved marketing of urban public transport could also be expected to have some positive impact on patronage.

Reduced population growth rates are expected to have a weaker dampening effect on the rate of growth in public transport demand than on the rate of growth in the demand for car travel in urban areas. This expectation results from the different markets served by the public and private transport modes. Public transport is oriented towards CBD travel which is less responsive to changes in the rate of growth in population than are the non-CBD oriented travel markets.

Overall, the rate of decline in public transport patronage observed over the past twenty years or so is expected to moderate in the forseeable future.

## IMPLICATIONS FOR INVESTMENT

The above discussion sets out in broad terms the environment against which future investment requirements need to be assessed. Quite clearly however, these broad trends in demand will not apply across all components of the urban transport travel market. For example, while the overall public transport task is not expected to grow, positive growth rates are expected in some specific sub-markets. This means that while new investment might be inappropriate for some parts of the urban transport system, substantial new investment will be warranted in others.

Private road transport is relatively efficient compared with public transport for the dispersed and relatively low density cross-town transport task. The demand for this type of travel is expected to increase linearly by about 5 or 6 per cent of current demand levels annually. This is due mainly to exogenous factors such as population and income growth. This will create a continuing need for further investment in roads to service what is essentially a circumferential oriented traffic task. In addition to investment generated by growth, there is a large backlog of projects necessary to correct current deficiencies in the quality of these roads.

The public transport modes tend to be more cost effective than the private car for the bulk of the passenger transport task in the longer and higher traffic density CBD-oriented corridors. The historic rate of decline in this task is expected to moderate over the next decade. The investment program for this sector of public transport should be designed to improve efficiency and to overcome deficiencies in the existing system.

## Government Operated Urban Transport Systems

The objective of this section is to derive a program of expenditure on new urban public transport projects for government operated urban public transport systems which are economically justified. The program takes cognisance of work already in hand.

In previous evaluations by BTE[1] the procedure adopted has been to take a list of projects formally proposed by the various State governments and to evaluate each project in detail to determine benefits and costs. This approach requires that projects be completely defined and that they have reached a planning stage where detailed cost estimates can be provided. In most instances State planning authorities have not developed detailed plans for projects intended to be undertaken in the period 1977-78 to 1979-80 and so this approach needed modification. The approach adopted is described in detail in Annex D.

There are two main features of the modified approach. Firstly, the BTE undertook an examination of government operated urban public transport systems to identify problem areas and to define projects to overcome them. Secondly, the economic merits of these projects were based upon the results of previous BTE evaluations of a wide range of similar projects.

The starting point for identification of public transport improvement projects was to examine, firstly, the programs submitted by the States for Commonwealth government support during the period 1972 to 1975, and, secondly, the projects being undertaken by the States without Commonwealth government support. From this base

(1) Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June 1972. A Review of Public Transport Investment Proposals for Australian Capital Cities, 1973-74, Canberra, August 1973. A Review of Public Transport Investment Proposals for Australian Capital Cities, 1974-75, Canberra, April 1975.

it was possible to identify many projects which follow logically from those already under way or planned in detail. Extension of rail electrification, provision of additional services, provision of busways, replacement and addition of rolling stock, provision of passenger interchanges, bus priority schemes, etc. can be foreshadowed with some degree of confidence from existing projects.

In addition, much of the current urban public transport planning being undertaken by State authorities is based upon the results and recommendations of major transport studies[(1)]. Using these studies and the known lines of development adopted by State planning authorities, it was possible to identify a series of projects likely to be undertaken towards the end of the present decade.

Once a list of likely projects had been drawn up the next step was to make estimates of the costs involved. The usual process of establishing preliminary engineering designs as a basis for estimation was not possible because of time constraints and so order-of-cost estimates were made on the basis of cost estimates for previous similar projects.

At the completion of this stage, the list of projects developed and their cost estimates were discussed informally with State authorities to ensure that they were in reasonable accord with State planning objectives. The economic merit of each of the

(1) Sydney Area Transportation Study, May 1974.
The Metropolitan Transportation Committee, Melbourne Transportation Study, Volume 3: The Transportation Plan, December 1969.
Wilbur Smith and Associates, South-East Queensland Brisbane Region Public Transport Study, April 1970.
Associates Inc., Report on Metropolitan Adelaide Transportation Study, June 1968.
Perth Regional Transport Study 1970, January 1971.
Wilbur Smith & Associates, Perth Central City Railway Feasibility Study, 1974.

TABLE 4.1 - ECONOMICALLY WARRANTED CAPITAL INVESTMENT FOR STATE CAPITAL CITY PUBLIC TRANSPORT PROJECTS: 1977-78 TO 1979-80 (1) (2)

($ million, 1974-75 prices)

| Mode | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| Rail | 331.7 | 172.4 | 119.5 | 89.6 | 6.7 | - | 719.9 |
| Bus | 95.7 | 21.1 | 56.9 | 7.8 | 83.3 | 8.5 | 273.3 |
| Tram | - | 25.2 | - | 1.6 | - | - | 26.8 |
| Ferry | 8.2 | - | 2.1 | - | - | - | 10.3 |
| Misc. | 18.8 | - | - | 5.3 | - | - | 24.1 |
| TOTAL | 454.4 | 218.7 | 178.5 | 104.3 | 90.0 | 8.5 | 1054.4 |

(1) Table includes projects with benefit-cost ratios greater than one for a discount rate of 10 per cent.

(2) Comprises total capital needed for investment in economically warranted projects that could be commenced in the period 1977-78 to 1979-80.

TABLE 4.2 - CAPITAL NEEDED IN THE PERIOD 1977-78 TO 1979-80 FOR INVESTMENT IN ECONOMICALLY WARRANTED PROJECTS THAT COULD BE COMMENCED IN THAT PERIOD (1)

($million, 1974-75 prices)

| Mode | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| Rail | 208.5 | 103.2 | 56.8 | 49.7 | 6.7 | - | 424.8 |
| Bus | 73.2 | 13.9 | 41.3 | 5.4 | 25.9 | 4.9 | 164.6 |
| Tram | - | 17.3 | - | 1.6 | - | - | 18.9 |
| Ferry | 8.2 | - | 1.1 | - | 0.02 | - | 9.3 |
| Misc. | 10.8 | - | - | 1.0 | - | - | 11.8 |
| TOTAL | 300.7 | 134.4 | 99.2 | 57.6 | 32.6 | 4.9 | 629.5 |

(1) Table includes projects with benefit-cost ratios greater than one for a discount rate of 10 per cent.

projects was estimated by comparing them with similar projects which had been previously evaluated by the BTE. Annex D lists the projects considered and describes the evaluation procedure and assumptions employed.

Benefit-cost ratios were employed in assessing the economic merit of projects. Projects with a benefit-cost ratio of greater than one using a 10 per cent discount rate were regarded as economically warranted. Table 4.1 summarises capital expenditure needs by mode for each State capital city for projects which were found to be economically warranted using the above criterion and which could be expected to be commenced in the period 1977-78 to 1979-80. The table includes expenditure which it is expected would be incurred after 1979-80. The expenditure which could be expected to be incurred wholly within the triennium 1977-78 to 1979-80 is shown in Table 4.2.

In order to determine the robustness of the investment program presented in Tables 4.1 and 4.2 two sensitivity tests were performed. Firstly, the impact on the investment program of excluding various classes of benefits from the analysis was determined. Secondly, because there is a body of opinion which suggests that the appropriate discount rate to be used in the evaluation of public sector investment projects is somewhat higher than 10 per cent, the impact on the investment program of increasing the discount rate was examined.

The evaluations leading to the capital investment needs reported in Tables 4.1 and 4.2 include all benefits that would accrue to public transport operators through operating cost savings; to existing public transport passengers mainly through travel and waiting time savings; to passengers that would undertake travel by public transport as a direct result of the investment and would not have undertaken that journey before the investment was undertaken (called generated patronage); to passengers that would have used private motor cars before the investment was undertaken (called converted patronage) and to remaining road

TABLE 4.3 - DISTRIBUTION OF BENEFITS FOR A SAMPLE OF URBAN PUBLIC TRANSPORT PROJECTS

| Benefit Type | Operator | Existing User | Generated | Converted | Remaining Road User |
|---|---|---|---|---|---|
| Percentage of overall benefits(%) | 23 | 40 | 6 | 23 | 8 |

TABLE 4.4 - EFFECT ON URBAN PUBLIC TRANSPORT CAPITAL INVESTMENT OF EXCLUDING SOME CATEGORIES OF BENEFITS(1)

($million, 1974-75 prices)

| Benefits Included | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| All Benefits | 301 | 134 | 99 | 58 | 33 | 5 | 630 |
| Existing User and Operator Benefits | 175 | 78 | 58 | 33 | 19 | 3 | 366 |
| Operator benefits | 57 | 25 | 19 | 11 | 6 | 1 | 119 |

(1) Includes projects that yield benefit-cost ratios greater than one using a 10 per cent discount rate and only relates to expenditure that could be expected to be incurred on these projects during the triennium 1977-78 to 1979-80.

users that would benefit from lower road congestion because of the investment. The distribution of these benefits amongst these benefit categories for a sample of projects previously appraised by the BTE is shown in Table 4.3.

It is clear from the figures shown in Table 4.3 that much of the justification for improving public transport in urban areas has stemmed from estimates of increased patronage. Since increases in patronage as large as expected have not been observed following several recent public transport upgrading measures[1], there must be some doubt as to the true value that travellers attach to non-monetary benefits associated with improvements in service levels. Accordingly, it was decided to examine the impact of deleting these benefits on the investment programs shown in Tables 4.1 and 4.2. Further, because of measurement problems associated with the quantification of non-traded benefits, especially travel time savings, the impact on the investment program of excluding these benefits was also examined. The results of these investigations are reported in Table 4.4.

It can be seen that while expenditure of $630 million over the period 1977-78 to 1979-80 is economically warranted when all benefits are included, only 58.1 per cent is warranted on the basis of benefits to the operator and existing public transport users alone, and 19.0 per cent is warranted on the basis of benefits to the operator alone. It can thus be concluded that between 50 and 75 per cent of the investment program is sensitive to the value attached to intangible benefits. This reinforces the view that it would be desirable to undertake a more rigorous evaluation of the projects used to develop the program when they have been planned and costed in detail.

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(1) Victorian Railways, Glen Waverley Model Project Comparison of Results of "Before" and "After" Studies, Development and Planning Division, September, 1975.
Victorian Railways, The Glen Waverley Model Line Project - Report on the "Before" and "After" Studies, prepared by P.G. Pak-Poy and Assoc, June 1976.
NSW Department of Motor Transport, Evaluation of Transit Lanes, 1976.

TABLE 4.5 - EFFECT ON THREE YEAR WARRANTED INVESTMENT EXPENDITURE FOR URBAN PUBLIC TRANSPORT OF INCREASING THE DISCOUNT RATE TO 15 PER CENT(1)

($ million, 1974-75 prices)

| | N.S.W. | Vic | Qld | S.A. | W.A. | Tas | Total |
|---|---|---|---|---|---|---|---|
| Rail | 68.7 | 38.9 | 45.0 | 17.1 | 1.0 | - | 170.7 |
| Bus | 43.3 | - | 15.2 | 4.0 | 21.5 | - | 84.1 |
| Train | - | 5.8 | - | 1.3 | - | - | 7.1 |
| Ferry | - | - | - | - | 0.02 | - | 0.02 |
| Miscellaneous | 7.8 | - | - | 1.0 | - | - | 8.8 |
| TOTAL | 119.8 | 44.8 | 60.2 | 23.4 | 22.5 | - | 270.7 |

(1) Includes projects that yield benefit-cost ratios greater than one for a discount rate of 15 per cent and only relates to expenditure that could be expected to be incurred on those projects during the triennium 1977-78 to 1979-80.

TABLE 4.6 - WARRANTED PROGRAM FOR CONSTRUCTION EXPENDITURE FOR URBAN ROADS 1976-77 TO 1980-81

($ million, 1974-75 prices)

| | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | ACT | Total |
|---|---|---|---|---|---|---|---|---|
| Arterial Roads | 680.8 | 813.0 | 202.0 | 166.1 | 297.6 | 54.0 | 31.2 | 2244.7 |
| Local Roads | 188.6 | 109.3 | 81.7 | 36.4 | 47.9 | 9.2 | 5.2 | 478.3 |
| MITORS | 56.2 | 50.0 | 44.8 | 18.2 | 28.8 | 14.2 | 3.9 | 216.1 |
| TOTAL | 925.6 | 972.3 | 328.5 | 220.7 | 374.3 | 77.4 | 40.3 | 2939.1 |

Source: Commonwealth Bureau of Roads, Report on Roads in Australia 1975, Chapter 7, Table 7.24, p. 143.

The impact on the investment program of increasing the discount rate to 15 per cent was also investigated and the results are summarised in Table 4.5[1]. This table shows that warranted investment expenditure over the triennium 1977-78 to 1979-80 is decreased by 57 per cent by increasing the discount rate from 10 to 15 per cent. Greater than 57 per cent reductions occur in rail rolling stock replacement and track works (other than electrification) in bus and tram rolling stock replacement works, and in all ferry works.

The investment programs presented above are for new projects only. These will also be substantial expenditure after June 1977 on projects that are currently underway and not yet completed. It is estimated that $105 million was spent on such projects in 1975-76 and that $130 million will be expended in 1976-77. A further $25 million, in 1974-75 prices, is estimated to be required for these projects in the period 1977-78 to 1979-80. This is comprised of $100 million on projects partially funded by the Commonwealth government and $115 million on projects wholly funded by the States.

Taking account of expenditure on both existing projects and on new projects, economically warranted investment needs for the period 1977-78 to 1979-80 amounts to about $845 million.

Privately Operated Urban Public Transport Systems

The magnitude of the investment that will be required in privately operated public transport in urban areas of Australia has not been thoroughly investigated in this report.

However, the average annual investment in vehicle replacement was estimated earlier to be about $9.5 million. This implies an investment of about $28.5 million for the three year period 1977-78 to 1979-80.

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(1) For more detailed discussion of results see Annex D.

The CBR has developed economically warranted investment programs for urban roads for the period 1976-77 to 1980-81[1]. The programs and a detailed description of their derivation are contained in the Bureau's recent Report on Roads in Australia 1975. These programs for the construction of arterial and local roads and for minor improvements in transport operations and safety (MITORS) are shown, by State, Table 4.6[2].

The program for urban arterial roads is the outcome of assessment procedures in which benefit-cost analysis plays a key role[3].

The criterion for project selection is that the benefit-cost ratio must be at least one using a discount rate for future costs and benefits of 10 per cent.

The ratio of the present value of total discounted net benefits to total discounted construction expenditure on urban arterial roads is 2.5[4]. The most important category of benefits is commercial time saving which accounts for 46 per cent of total net benefits. The other major categories are savings in vehicle operating costs (23 per cent) accident cost savings (16 per cent) and private travel time savings (13 per cent).

Estimates of various indirect costs and benefits associated with the investment program were included in the evaluations. The exclusion of the social costs of disruption and benefits from generated traffic have a relatively small impact on the

(1) BTE has not undertaken an independent analysis of road investment needs for the purposes of this study.
(2) The CBR reported their program in 1973-74 prices. BTE have updated these to 1974-75 prices using the road price index developed by CBR.
(3) Bayley and Both, "Evaluation Procedures for Urban Arterial Road Projects", Australian Road Research Board Proceedings, Vol. 8, 1976.
(4) These estimates are derived from Commonwealth Bureau of Roads (1975), op. cit., Table 7.26, p. 144.

savings are also of minor significance for the program.[1] This information is interesting because of the uncertainty generally associated with the valuation of these factors.

The sensitivity of the warranted program to changes in the discount rate used to evaluate projects is indicated in Table 4.7 and is discussed in the next section.

## DISCUSSION OF THE INVESTMENT PROGRAMS

### Relationship between the Urban Roads and Urban Public Transport Programs

This section examines the assumptions used in deriving the estimates of economically warranted capital investment needs of roads and public transport in urban areas and compares the responsiveness of the estimates to alternative assumptions. A related issue of considerable importance which is discussed here is the interaction between, and the complementarity of, the programs.

Both programs are sensitive to the discount rate used in deriving them. If the rate is raised from 10 per cent to 15 per cent, both programs are reduced by a little over 50 per cent.[2] Many urban transport projects are very large and the "lumpiness" inherent in the investment programs could be partly responsible for the sensitivity to discount rate increases.

A cut-off benefit-cost ratio of greater than one has been the criterion for project selection for both the arterial roads and public transport warranted investment programs. However, this

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(1) CBR have provided information which suggests that the exclusion of disruption costs and generated traffic benefits would increase the warranted program by about 6 per cent while the exclusion of private travel time savings would reduce the warranted program by 2 per cent.

(2) Results reported in Tables 4.5 and 4.7.

TABLE 4.7 - RELATION BETWEEN THE WARRANTED INVESTMENT IN URBAN ARTERIALS AND THE DISCOUNT RATE

| Discount Rate (per cent) | Warranted Investment ($ million, 1974-75 prices) | Relationship between Programs (per cent) |
|---|---|---|
| 7 | 3366 | 150 |
| 10 | 2244 | 100 |
| 15 | 1054 | 47 |

Sources: (1) Commonwealth Bureau of Roads, Report on Roads in Australia 1975, Melbourne, 1975.
(2) Supplementary information provided to BTE by the Commonwealth Bureau of Roads.

TABLE 4.8 - HOUSEHOLD CHARACTERISTICS OF TRAVELLERS, SYDNEY, 1971

| Mode used by Traveller | Average household income ($ per annum) | Percentage of Travel Group with a licence and from Households with: | | Percentage of Travel Group without a licence |
|---|---|---|---|---|
| | | one car (%) | two or more cars (%) | (%) |
| Car | 6943 | 44 | 38 | 17 |
| Public Transport | 6205 | 24 | 11 | 58 |
| Off-peak rail | 6205 | 28 | 12 | 53 |
| Off-peak bus | 5685 | 17 | 7 | 69 |
| Peak CBD rail | 7217 | 38 | 22 | 39 |
| Peak CBD bus | 7007 | 31 | 15 | 43 |

NOTE: (1) Peak trips are thos ending during the periods 7.00am to 8.59am and 4.00pm to 5.59pm.
(2) School trips have been excluded.

Source: Basic data from SATS.

criterion is not always the most appropriate. When net benefits from investment increase over calendar time, the rate of return can be improved in some instances by delaying the project after the time at which the benefit-cost ratio has become equal to one. Under these circumstances the optimal approach is to choose the timing of the investment in order to maximize its net present value(1). The effect of applying this criterion would be to reduce the size of the programs, but empirical estimates of the extent of such reductions have not been made.

At various places in the report it has been suggested that distinct roles for private and public transport can be identified where competitive interaction between them is limited. The programs that have been developed can be regarded as largely complementary because of their emphasis towards fulfilling these roles, with a large part of the road investment program directed towards circumferential routes around the urban area to cater for a predominantly private transport task and public transport investment concentrated towards the peak radial task.

This is not to suggest that road investment should be restricted to circumferential routes only, or that there is no interaction between road and public transport investment. In Adelaide for example, it has been estimated that as a result of proposals to improve bus transport through the provision of new, heavier and larger buses, and extension and relocation of routes through the local street system, there is a need for over $7 million (1974 prices) to be spent on urban local roadworks.(2)

A comparison of the types of benefits flowing from the two programs throws additional light on the complementary nature of the programs as well as providing an indication on the relative

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(1) Marglin, S.A., Approaches to Dynamic Investment Planning, Amsterdam, Nth. Holland, 1963.
Georgi, H., Cost-Benefit Analysis and Public Investment in Transport: A Survey, London, Butterworths, 1973.

(2) Information provided by the Department of Highways and Local Government of South Australia.

robustness of the programs. In excess of 80 per cent of benefits from the arterial roads program can be classed as direct resource cost savings,(1) and most of these accrue to commercial users. On the other hand, less than a quarter of the benefits from the public transport program are direct resource cost savings (accruing to the operating authority). The great majority of benefits are private travel time savings accruing to existing public transport travellers and similar benefits accruing to travellers attracted to public transport (a significant proportion of whom are assumed to come from congested radial arterial roads).

The valuation of benefits associated with private travel time savings and converted and generated travel requires assumptions about the values of travel time savings and about the values of demand elasticities. The variance in the results of empirical studies and the diversity of behaviour across the urban travel spectrum means that considerable uncertainty attaches to the value of benefits derived using these parameters.

The sensitivity tests applied earlier to the programs show that changes in these assumptions have very little effect on the roads program but a quite massive effect on public transport investment. The results reported in Table 4.4 show that if the benefits from conversion and generation fail to materialise, the public transport warranted program would fall by nearly 50 per cent. If only direct resource (operating) savings are included that program falls by nearly 70 per cent. These results certainly suggest that there is a need to closely examine levels of travel generation that are adopted in evaluating investment proposals prior to making large increases in current levels of investment in urban public transport.

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(1) Resource costs are defined to include wages, vehicle operating costs and accident costs.

## The Impact of Operating Procedures on the Investment Programs

Reference has been made above to the scope for generating benefits from improved pricing and regulatory policies relating to the use of roads and public transport facilities. In addition to their direct influence on community welfare, the efficiency of transport system operations also affects the need for and the viability of new investment projects.

Pollution and congestion are particularly important considerations in this regard, as the costs born by transport users are most likely much less than the total social cost. In general, corrective pricing policies would be expected to reduce the benefits to be derived from new investment by reducing both the size of the task and the resource costs per unit of task.(1) However it does not necessarily follow that the application of these policies will reduce the warranted investment programs.

Innovations in operating procedures will most likely be directed predominantly at the peak radial passenger task and could include CBD area licences, priority bus measures and peak/off-peak fare differentials for public transport. A balanced approach would involve raising the price of peak travel to the CBD, that is, raising the perceived costs of both the private car and public transport components of this task. However, since it is generally accepted that the externalities associated with car use are greater than those associated with public transport use, the perceived cost ratio may be expected to move in favour of public transport, thus tending to increase its proportion of the CBD task.

The impact of these policies on warranted road expenditure would most likely be very small because they mainly apply to inner areas where further road investment may not be warranted

(1) Reducing the resource costs per unit of travel through improved pricing reduces the scope for further reductions through new investment.

because of very high construction and disruption costs. The direction of their effect on public transport investment is uncertain. The higher cost of travel to the CBD in the peak could divert travel to other times and destinations, although these responses may occur only over a fairly long time period and their strength will depend on other concurrent changes such as the introduction of flexible working hours and variations in land use patterns. On the other hand, a relatively greater increase in the cost of car travel compared with public transport will tend to divert travellers to public transport. Since these changes work in opposite directions, the net effect of the changes is uncertain.

## Equity Considerations

The criterion used for developing the warranted programs has been economic efficiency. A further criterion relevant to expenditure decisions is the distribution of benefits between different groups of users.

As mentioned, the largest proportion of the assessed benefits from road upgradings accrue to commercial users in the first instance, but will potentially be available to the whole community through reductions in commodity prices.

An analysis of data from the Sydney area has provided an indication of the characteristics of various groups of passenger travellers for that city in the year 1971. A summary of this analysis is shown in Table 4.8. Peak CBD-oriented public transport trips were made by people from households with above average incomes. On the other hand, off-peak public transport users came from households with below average incomes and had very low levels of accessibility to car travel.

Given the high capital expenditure required for upgrading rail (which is generally more centrally orientated than bus) and the importance of congestion relief in generating benefits, a relatively high proportion of the benefits from the public transport program accrues to peak CBD users. Thus using data in Table 4.8 as a guide, the major beneficiaries of public transport investment are in a relatively good position to contribute towards its cost. This is consistent with the arguments relating to efficiency pricing outlined earlier. Furthermore higher CBD peak fares (in combination with restrictions on car use) would assist in reducing the operating deficits of the operating authorities.

## IMPLICATIONS OF RESOURCE RATIONING FOR THE INVESTMENT PROGRAMS

The investment programs presented above would not constitute feasible expenditure programs for the three year period examined because of various constraints associated with the financing and implementation of the programs. A very large part of the programs consist of backlog projects which are economically viable now, but in practice could only be implemented over a number of years and many would extend beyond June 1980.

The CBR has undertaken detailed analyses of the physical capacity of the road construction industry and of the feasible sources of finance available at all levels of government in all States. The Bureau showed that physical resource availability was not a constraint on undertaking the warranted program, so that financial considerations became decisive in arriving at the final recommended program for all road classes. The five year CBR recommended program for urban road construction for each State is shown in Table 4.9 and for each year in Table 4.10. This program is 66 per cent of the warranted program for total construction expenditure and 63 per cent of the urban arterial roads component.

In contrast to recent trends in expenditure on urban roads the recommended program contained in Table 4.10 shows the rate of real expenditure increasing fairly rapidly at about 7.5 per cent per annum over the five year period 1976-77 to 1980-81. At the

TABLE 4.9 - RECOMMENDED PROGRAM FOR CONSTRUCTION EXPENDITURE FOR URBAN ROADS BY STATE: 1976-77 TO 1980-81

($ million, 1974-75 prices)

| | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | ACT | Total |
|---|---|---|---|---|---|---|---|---|
| Arterial Roads | 439.1 | 542.3 | 125.2 | 91.9 | 147.4 | 33.2 | 26.9 | 1406.0 |
| Local roads | 174.0 | 121.1 | 53.9 | 22.4 | 36.8 | 5.7 | - | 413.9 |
| MITORS | 38.5 | 27.7 | 19.5 | 17.4 | 13.2 | 5.9 | - | 122.2 |
| TOTAL | 651.6 | 691.1 | 198.6 | 131.7 | 197.4 | 44.8 | 26.9 | 1942.1 |

Source: Commonwealth Bureau of Roads, Report on Roads in Australia, 1975, Table 7.24, p. 142.

TABLE 4.10 - RECOMMENDED PROGRAM FOR CONSTRUCTION EXPENDITURE FOR URBAN ROADS BY YEAR: 1976-77 TO 1980-81

($ million, 1974-75 prices)

| | Year ended 30 June | | | | | Total |
|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | |
| Arterial roads | 234.2 | 255.8 | 275.3 | 304.9 | 335.8 | 1406.0 |
| Local roads | 79.1 | 80.8 | 82.3 | 84.6 | 87.1 | 413.9 |
| MITORS | 18.2 | 21.4 | 24.4 | 27.6 | 30.6 | 122.2 |
| TOTAL | 331.5 | 358.0 | 382.0 | 417.1 | 453.5 | 1942.1 |

same time the rate of growth in demand is predicted to slacken significantly as indicated earlier in this chapter. The program clearly represents a concerted attempt to reduce the backlog of investment and its implementation should lead to substantial service improvements.

The economically warranted level of investment for public transport in the State capital cities for the period 1977-78 to 1979-80 was estimated by BTE to be in the order of $845 million. This is comprised of the $630 million for expenditure on new projects and $215 million on projects already underway and is equivalent to $282 million per year. This level of spending would be an extremely large increase over historic levels, but it is anticipated that the detailed planning investigations associated with new projects would be a severe constraint which will reduce the practical spending level well below these figures. Furthermore, the pressure on State financial resources of a very rapid expansion in investment on urban public transport must be recognised.

The BTE has not investigated these and other factors affecting capital expenditure on urban public transport in the detail necessary to quantify their impact on the level of capital spending on urban public transport over the period 1977-78 to 1979-80. The BTE does not, therefore, recommend a particular program of capital expenditure for urban transport over the period. However, capital investment needs can be put into historical perspective by projecting observed trends in capital spending into the future. Preliminary results of a study of capital formation in transport have been used for this purpose(1).

Trends in historical capital-output ratios have been extrapolated and combined with the demand forecasts reported above to project future asset stocks. These capital stock projections, together

(1) Bureau of Transport Economics, Capital Formation in Transport with Projections to 1981, forthcoming.

TABLE 4.11 - HISTORIC AND PROJECTED STATE CAPITAL CITY URBAN PUBLIC TRANSPORT ASSET STOCKS(1)

| Mode and Item | Year Ended 30 June | | | | | |
|---|---|---|---|---|---|---|
| | 1956 | 1961 | 1966 | 1971 | 1976(1) | 1981(2) |
| **Rail Infrastructure** | | | | | | |
| . Output (m. passenger journeys) | 488 | 434 | 427 | 410 | 320 | 320 |
| . Capital(3) ($m, 1971-72 prices) | 385 | 459 | 548 | 660 | 657 | 830 |
| . Capital - Output Ratio | .7889 | 1.0576 | 1.2834 | 1.6098 | 2.0546 | 2.595 |
| **Rail Vehicles** | | | | | | |
| . Output (m. passenger journeys) | 488 | 434 | 427 | 410 | 320 | 320 |
| . Capital ($m, 1971-72 prices) | 81 | 90 | 107 | 127 | 122 | 150 |
| . Capital - Output Ratio | .1660 | .2074 | .2506 | .3098 | .3806 | .4677 |
| **Government Bus and Tram** | | | | | | |
| . Output (m. passenger journeys) | 854 | 676 | 610 | 519 | 439 | 439 |
| . Capital ($m, 1971-72 prices) | 83 | 81 | 63 | 61 | 53 | 55 |
| . Capital - Output Ratio | .0972 | .1198 | .1033 | .1175 | .1211 | .1263 |

(1) Preliminary results - final estimates to be published in Bureau of Transport Economics, Capital Formation in Transport with Projections to 1981.

(2) Capital stocks for 1976 and 1981 derived by extrapolating trends in capital-output ratios and projecting output to remain static at expected 1975-76 levels.

(3) All capital stocks measured in constant 1971-72 prices using the retail price index.

with the estimates from which they have been derived are given in Table 4.11 for each of the elements of the urban public transport system. The difference between the asset stocks of any two years provides an estimate of net investment in the intervening time period. Annual net investment can be derived by interpolation and the replacement investment required to maintain each year's capital stock calculated using the depreciation schedules used to generate the capital stock estimates. The resulting capital investment projections for the two five-year periods 1971-72 to 1975-76 and 1976-77 to 1980-81 are given in Table 4.12.

These projections provide estimates of real capital expenditure that would be required to accommodate the projected output assuming no change in past trends regarding service levels (including quality of service) and relative prices amongst different modes. The methodology reflects secular shifts in the substitution of labour for capital, but does not reflect changes in capital utilisation or allow for marked shifts in technology or other factors which would radically alter the relationship between capital and output. It is implicit that historic depreciation profiles are appropriate in the future. Finally, the estimates embody the assumption that financial constraints on future capital investment for urban public transport are similar to those that applied in the past.

A test of the accuracy of this projection method is provided by a comparison of projected gross capital formation during the period 1971-72 to 1975-76 with the actual capital expenditure during the same period. Public authority capital expenditure on public transport in the six State capital cities in that period has been estimated to total $428 million in 1974-75 prices.(1) The equivalent figure derived from Table 4.12 is $232 million. This estimate is 46 per cent lower than actual.

(1) Table 2.3 provides data for the period 1971-72 to 1974-75. BTE has estimated that the appropriate figure for 1975-76 is $105 million.

TABLE 4.12 - PROJECTED GROSS CAPITAL FORMATION IN STATE CAPITAL CITY URBAN PUBLIC TRANSPORT: 1971-72 TO 1980-81 (1)

($ million, 1974-75 prices)

| Time Period | Expenditure by Mode | | |
|---|---|---|---|
| | Rail | | Government Bus & Tram |
| | Infrastructure | Vehicles | |
| 1971-72 to 1975-76 | 162 | 25 | 45 |
| 1976-77 to 1980-81 | 407 | 70 | 52 |

(1) Preliminary estimates - final estimates to be published in Bureau of Transport Economics, Capital Formation in Transport with Projections to 1981. See also Table 4.13.

TABLE 4.13 - ALTERNATIVE CAPITAL INVESTMENT NEEDS PROJECTIONS FOR PUBLIC TRANSPORT IN THE STATE CAPITAL CITIES: 1977-78 TO 1979-80

($ million, 1974-75 prices)

| Method of Estimation | Expenditure Level | |
|---|---|---|
| | Triennium 1977-78 to 1979-80 | Average Annual |
| Benefit-Cost Analysis (1) | | |
| . Employing a 10% discount rate | | |
| - including all benefit categories | 845 | 282 |
| - including operator and existing user benefits only | 581 | 194 |
| Capital-Output Ratio Method (2) | | |
| . Constant Task | 317 | 106 |
| . One per cent per annum growth in task | 361 | 120 |
| Historic Expenditure Projection (3) | | |
| | 505 | 168 |

(1) Includes projected expenditure on existing projects plus economically warranted expenditure on new projects.
(2) Triennium expenditure assumed to be three-fifths of projected 1976-77 to 1980-81 expenditure.
(3) Estimated by extrapolating the constant growth rate trend derived from the capital expenditure series for the period 1971-72 to 1976-77.

The failure of the capital-output ratio approach to adequately project actual levels of capital expenditures during this period may be explained by a breakdown of the assumptions implicit in the capital-output ratio method. An examination of the trends in capital expenditure reveal a change in spending patterns starting about 1971-72. In the eight year period prior to this date, there was a fairly clear trend for real capital investment expenditure to grow at a constant rate of 7 per cent per annum. In the period beginning 1971-72, the trend in real capital expenditure shows an annual rate of growth of 13.6 per cent. That is, there would appear to have been a change in investment patterns that could be expected to radically alter the relationship between capital and output that had existed prior to about 1971-72. In particular, the marked increase in capital expenditure on urban public transport over the period 1971-72 to 1975-76 in the face of declining urban public transport patronage would have led to a marked improvement in the level and quality of service provided.

Projections of gross capital formation for public transport in the State capital cities over the period 1976-77 to 1980-81 based on maintaining estimated 1975-76 demand levels throughout the period are shown in Table 4.12. The projections give total public authority capital requirements over the five year period as $529 million in 1974-75 prices. This would increase to $602 million in 1974-75 prices if demand for public transport were to grow at 1 per cent per annum over the period 1976-77 to 1980-81. Adopting the forecast that urban public transport demand will remain at estimated 1975-76 levels over the five year period 1976-77 to 1980-81, capital investment needs for the three year period 1977-78 to 1979-80 would be about $317 million in 1974-75 prices (1). This compares with $505 million in 1974-75 prices over the same period if the average growth trend in spending that has been observed since 1971-72 were to be continued into the future.

(1) Allocated between years of the five year period using average annual investment.

Although the different methods of projecting capital investment needs for urban public transport produce quite different results, as indicated in Table 4.13, it is possible to interpret some of these differences and draw some conclusions about the appropriate level of investment.

First, it is concluded that the capital investment projections derived from the capital-output ratio method would represent minimum investment needs over the period. The demand forecasts presented earlier in this report and used to derive these forecasts embody expectation that the declining trend in the urban public transport task will be arrested and that the task will tend to remain fairly static. This is perhaps a pessimistic view in the light of present government and public transport authority attitudes which are expected to result in the adoption of transport policies designed to increase public transport patronage. Therefore, the output forecasts embodied in the calculations of future capital needs may be lower than those that would be expected to result from these policies.

Further, it is likely that at least some of the measures employed to implement such policies will be directed towards improving the level and quality of service provided by the public transport system. The capital required to do this would not be reflected in forecasts of capital needs derived by the capital-output ratio method because that method incorporates the assumption that historic trends in quality of service will continue into the future. As has already been observed, this projection method did not predict the very large growth in real capital expenditure that was observed in the period commencing in 1971-72.

Second, it is concluded that the capital investment projections for the triennium 1977-78 to 1979-80 which were derived using benefit-cost analysis would represent a maximum program of capital expenditure over the period. The program of $845 million in 1974-75 prices which was derived using a 10 per cent discount rate allows for the possibility that these changes will result in quite large increases in public transport patronage. Recent experience, reported upon earlier in this report, indicates that estimates of demand responsiveness to changes in the level and quality of public transport services that have been used by the BTE to evaluate public transport investment proposals may be somewhat optimistic. This would result in over-estimation of the benefit streams in the project evaluations and hence, to an overestimation of the capital investment that can be economically warranted.

Excluding those benefits that would be generated by new public transport patronage from the individual project appraisals used in deriving the investment program would result in a warranted investment program of $581 million in 1974-75 prices over the period 1977-78 to 1979-80. To allow for over-estimation of demand generation as a result of capital investment in urban public transport, a mid-point interpolation between the investment levels derived counting all benefits on the one hand and excluding all benefits attributable to traffic generation on the other has been employed. The result of this interpolation is to yield an economically warranted level of investment of about $713 million in 1974-75 prices. This level of spending would result in significant improvements in the level and quality of public transport services which are justified largely by the benefits bestowed upon existing users in terms of travel time and comfort improvements.

The overall conclusion that can be drawn from this discussion is that capital investment on public transport in the State capital cities of around $713 million in 1974-75 prices over the period 1977-78 to 1979-80 could be justified. However, since this would mean a considerable increase in the recent rate of growth in capital expenditure on public transport in those cities, a lower level of spending would seem to be appropriate. A level somewhat higher than the $505 million implied by recent expenditure trends would reinforce the recent trend for capital investment to be directed towards substantial improvments in the quality and level of service provided by public transport.

Should further capital rationing be necessary, the information provided in Annex D can be used to allocate capital to new projects to ensure that the marginal return on investments in each State is approximately equalised. The method of doing this is described in Annex E.

The urban public transport investment needs discussed above relate only to publicly operated systems in the State capital cities. The capital investment needs of public transport systems in other urban areas, or those privately operated public transport systems in the capital cities, have not been thoroughly investigated in this report. However, it is expected that capital investment of around $28.5 million in 1974-75 prices would constitute an upper bound for private bus operator investment in route buses in urban areas.

# ANNEX A

# URBAN TRANSPORT DEMAND

## DEMAND FOR CAR OWNERSHIP

The number of cars and station wagons (hereinafter called cars) is a key determinant of demand for road usage. It is therefore important to identify the factors affecting car ownership per capita and to measure the strength of their influence.

### Recent Australian Studies of Motor Vehicle Demand

There have been several time series studies of Australian demand for cars. Generally their purpose has been to explain the demand for new vehicles rather than the level of car ownership per capita. Two recent studies are considered below, and their conclusions with respect to the price and income elasticities are reported.

The first study, by Swan[(1)], postulates a relationship for the demand for the stock of services provided by cars. The stock of services was calculated using the age distribution of cars obtained from motor vehicle census data and annual vehicle registration figures.

The desired stock of car services per head of population was hypothesised to be a linear function of per capita income and the price of services. The stock at any particular time was allowed to vary from the desired stock because of the lag in the adjustment from previous stock levels in response to income or price changes. An expression for the capitalized (market) price of a car was used to derive a 'rental' price variable for cars of each vintage. Published second-hand car prices were used to derive the

(1) Swan, P., "A Model of Demand and Forecasts of Annual Sales of Automobiles in Australia, 1949-1980", paper presented to the Australasian Conference of Econometricians, Monash University, 1971.

vintage. Published second-hand car prices were used to derive the vehicle capital prices for each year. The income measure used was personal disposable income per head deflated by the Consumer Price Index (CPI).

Several equations were estimated for the period 1948 to 1966. The regression results showed wide variation for different hypotheses. In one of his preferred equations the value of the long run income elasticity of demand for car services per capita was 1.63 and the corresponding price elasticity was -0.34. About 73 per cent of the desired adjustment of stock is achieved within a year. This equation contains a time trend variable. If the time trend is removed the income and price elasticities become 2.56 and -0.58 respectively and 52 per cent of the adjustment is estimated to occur within one year.

Filmer and Talbot[1] employ a similar approach to Swan. As with Swan's study, the basis of these studies was the relationship between the present value of the future services offered by a car and its capitalized price. The differences arise in the detailed specification of the services and rental variables and in the range of independent variables tested. For example, maintenance and operation costs are put directly into the vehicle rental prices. Also an index of quality is incorporated in the derivation of the stock of vehicle services.

The model employed a linear model for the desired level of stocks of services per capita as a function of the rental price deflated by the CPI, gross national product at constant prices, and a proxy for the current economic conditions (ratio of the level of registered unemployed to the level of registered vacancies). As in Swan's model, lagged adjustment of stock levels was allowed.

(1) Filmer, R., and S. Talbot, "Demand for Passenger Motor Vehicles", paper presented to ANU Economics Seminar, July, 1974.

The model was estimated for annual data over the period 1950 to 1972. The long run price elasticity was reported as -0.87 and the long run income elasticity 2.12, both measured at the variable means. At 1972 the elasticities were estimated to be -0.40 and 1.88 respectively. The model implied that 40 per cent of the adjustment to a new desired stock level occurred within one year.

There are a number of reasons why further studies to investigate movements in the number of motor vehicles per head directly were thought to be warranted.

The price and income elasticities reported in the above studies relate to the stock of services provided by cars. The direct application of these elasticities for forecasting car ownership will probably result in biased predictions. Since people are able to choose between different bundles of car services by choosing cars of different size or quality, they may be expected to respond to increases in income or decreases in price by purchasing larger and better quality cars as well as more cars. Hence we could expect both the income and price elasticities for car services to be greater than those for the stock of cars.

Car ownership per head has been increasing for many years in Australia. However, it is suggested that it must eventually reach a ceiling level. On the basis of an analysis of possible levels of car ownership per capita for Australia, Tulpule(1) estimated saturation levels of between 0.30 to 0.61 and preferred an ultimate level of 0.5. As at December 1975, car ownership per capita in Australia was 0.37 (0.47 in the A.C.T.) hence some tendency towards saturation of car ownership may well be appearing. This would be causing demand elasticities for the stock of

(1) Tulpule, A.H., "Estimating Future Car Ownership in Australia", paper prepared for the New Zealand Roading Symposium, Wellington, N.Z., August 1975.

cars to be falling. However the elasticities of car services are unlikely to be affected to the same extent because of the continued scope for improvements in the quality of cars.

A further point is that the Swan model uses data to 1966 and the Filmer and Talbot model uses data up to 1972-73. Thus the variability that has occurred since 1972-73 has not been analysed. Finally, the low adjustment coefficients obtained, implying long lags in adjustment of actual to desired demand, are viewed with some concern.

## The Models

The first three models considered in the BTE studies of the demand for car ownership per capita were specified on the assumption that complete adjustment of actual demand to desired demand occurred within one year. Following the Swan, and Filmer and Talbot studies, the desired demand for the stock of car services was hypothesised to be a function of prices and incomes. The performance of a linear equation, as was used in the above mentioned studies, was compared with two alternative functional forms. The three forms tested are represented in equations (A.1) to (A.3) below:

$$CO = a + b.\ RP + c.\ Y, \qquad \ldots\ldots (A.1)$$

$$CO = a\ .\ RP^{b}.\ Y^{c}, \qquad \ldots\ldots (A.2)$$

$$\text{i.e., } \log CO = \log a + b\ .\ \log RP + c\ .\ \log Y,$$

$$CO = a + b\ .\ \log RP + c\ .\ \log Y, \qquad \ldots\ldots (A.3)$$

where CO = car ownership per capita,
RP = new and used car price index deflated by the CPI,
Y = household income per capita deflated by the CPI.

In the linear relationship, equation (A.1), the change in demand for a given change in an explanatory variable is constant; the elasticity however, will vary with both demand and the level of the explanatory variable. Equation (A.2) is a constant elasticity model, the elasticities obtained directly from the coefficients of the independent variables. Equation (A.3) can be described as a linear-log model. It requires that a fixed percentage change in income (or price) results in a fixed absolute change in per capita demand. The price and income elasticities in this model both decrease as car ownership increases which is consistent with a gradual move towards saturation in car ownership.

The fourth model tested in BTE studies was a lagged adjustment model. Lagged adjustments of actual demand to desired demand are common in studies of demand for durable goods. It is hypothesised that the amount of adjustment within one year is proportional to the difference between the desired level at the end of the year and the actual level at the beginning of the year. A similar hypothesis was employed in the earlier mentioned studies. The functional form of the model is expressed mathematically as follows:

$$CO_t - CO_{t-1} = d \,.(CO_t^* - CO_{t-1}), \qquad \ldots\ldots \text{(A.4)}$$

where $CO_t$ is car ownership in year t,

$CO_t^*$ is the desired car ownership level based on income and prices,

d represents the proportion of the adjustment of desired to actual demand that occurs in each period.

Assuming that the desired demand for car ownership is described by equation (A.3), then the estimating equation is represented by

$$CO_t = a + (1 - d)\ CO_{t-1} + b.d.\log Y_t + c.d.\log RP_t .. \quad \text{(A.5)}$$

TABLE A.1 - AUSTRALIAN AUTOMOBILE DEMAND REGRESSION COEFFICIENTS

| Equation No. | Dependent Variable | Independent Variables | | | | | $R^2$ | D.W. |
|---|---|---|---|---|---|---|---|---|
| | | Y | Log Y | RP | Log RP | $CO_{-1}$ | | |
| (A.1) | CO | .100<br>(9.17) | | -.00199<br>(-7.51) | | | .992 | 0.91 |
| (A.2) | CO | | .183<br>(9.14) | | -.174<br>(-5.65) | | .994 | 1.20 |
| (A.3) | log CO | | .46<br>(4.95) | | -1.06<br>(-2.38) | .992 | 1.00 | |
| (A.5) | CO | | .059<br>(3.48) | | -.041<br>(-2.09) | .725<br>(8.34) | .999 | |

<u>NOTE</u>: t values are indicated in parentheses below the corresponding coefficient.

## Estimation Results

The above relationships were estimated using annual data for the period 1960-61 to 1974-75. Data for an implicit index for new and used motor vehicle prices has been derived from data published by the Australian Bureau of Statistics (ABS) in Australian National Accounts, 1974-75. From the same source, annual figures for current household income have been obtained. These series were deflated by the CPI for the six State capitals. Australian registrations of cars and station wagons were obtained from the ABS publication Transport and Communication for the years 1960-61 to 1972-73. For years after 1972-73, data on motor vehicle registrations were obtained from the ABS publication Motor Vehicle Registrations. Finally mean Australian population estimates for the period were obtained from various issues of the ABS publication Quarterly Review of Australian Statistics.

The results of estimation are given in Table A.1. Considering the first three equations in which there is no allowance for lagged adjustment, the price and income coefficients have the correct signs and are significant for all three formulations. The inclusion of the car operating cost index was not significant in these models and was deleted from further analysis.

The linear model, equation (A.1), revealed a falling price elasticity over time and a relatively constant income elasticity. The price elasticity was -0.47 and the income elasticity 0.63 in 1974-75. For the linear-log model, equation (A.3), the income and price elasticities were 0.80 and -0.76 respectively in 1964-65, and they fell to 0.52 and -0.49 respectively in 1974-75.

When a lagged dependent variable was included, the estimated rate of adjustment, d, was surprisingly slow for all the models tested. Thus in the estimation of equation (A.5) $d = 0.27$, which meant that only 27 per cent of the adjustment occurs within one year. This is difficult to accept on intuitive grounds.

Furthermore, lagged car ownership is strongly correlated with both income and price and this reduces confidence in the estimate of d from a statistical point of view.

It is observed that the long run price and income elasticities implied by the partial adjustment model in the year 1975 are -0.41 and 0.57 respectively which are similar to the elasticities calculated from the corresponding model with no lagged dependent variable, equation (A.3). Thus the problem of determining precisely the rate of adjustment does not necessarily hinder the ability to make forecasts over the relatively long run.

## Conclusion

While all the studies reported above have shown real car prices and per capita incomes to be important determinants of per capita car ownership, there is considerable variance in the estimates of the size of the coefficients. This stems in part from the difficulty of coping with a changing degree of responsiveness over time as car ownership levels increase towards saturation level.

The price elasticities from the BTE studies are reasonably close to the estimates from the earlier studies. However the BTE estimates of the income elasticity are significantly lower. This is probably due, at least partly, to the use of car numbers instead of car services as the dependent variable. It would also be consistent with the examination of a more recent time period and the expectation of reduced responsiveness to income increases as ownership levels grow.

## Forecasts

Historically price reductions have played a fairly important role in the growth of car ownership levels (particularly according to the BTE results), although they are not expected to be as significant in the future. Per capita incomes, however, will continue their upward trend and for forecasting purposes the income coefficient is therefore the crucial one.

If, using as a basis the linear-log regressions, the increase in car ownership per annum is 0.002 units for every percentage point of income growth, and assuming incomes grow at 3.3 per cent per annum, then car ownership will grow to 0.412 in 1981. This could perhaps be regarded as a lower limit given the possibility of further car price reductions (in real terms) and the generally slightly higher projections that would be obtained from the other models. A figure of 0.42 by 1981 is therefore adopted which implies an average annual growth in per capita car ownership of 2 per cent between 1975 and 1981.

## ANALYSIS OF URBAN PUBLIC TRANSPORT DEMAND IN AUSTRALIA

This section reports the results of econometric analyses carried out by BTE of the demand for public transport in the Australian State capital cities using time series data.

### The Model

Traditional economic theory postulates that an individual's demand for a good is a function of the price of that good, the price of all other goods, income and tastes. Any causal interaction between goods should be included via the attributes of the complementary or competitive goods. One could theoretically model individual behaviour. However, since only broad indicators of demand are required for this exercise, considerable aggregation has been employed. This results in losses in information. Firstly, much of the variability in individual variables is lost (incomes, services offered, etc) and, secondly, the aggregation takes place over markets that may display differing growth rates and responses to modal determinants, (for example, peak and off-peak markets, demand on various routes, etc). The results nevertheless provide useful information on average responses across cities.

The dependant variable used to measure demand in this study is trips per head of population of potential trip makers. Normally with such a specification, population would not be included as an explanatory variable, which would imply a population elasticity of unity. This may not be a realistic assumption since population growth has been accompanied by a relative dispersal of trip origins and destinations. This has made it increasingly difficult for the public transport modes to maintain a constant level of accessibility or service because of the inflexibility of public transport and the need for substantial corridor flows for economic viability, particularly in the case of rail. Thus, population growth, together with the changing urban structure, has not only increased the number of potential trip-makers, but has also led to decreasing public transport accessibility levels (reflected in a fall in vehicle-km per head). The net effect has been an increase in demand which is less than proportional to the increase in population. This has been accounted for in the model specification by the inclusion of appropriate service variables.

The price of using a transport mode can be considered as a 'generalised' price, embodying both the level of service provided by the mode and the 'out of pocket' cost. While the latter component is easily accounted for by the inclusion of a variable measuring average fare levels, the level of service provided has a number of different dimensions including frequency of service, coverage or accessibility, speed, reliability, and comfort. The impacts of the last three attributes are particularly difficult to measure using time series analysis, largely because of difficulties with obtaining estimates of the attribute levels. If these factors are either not very important determinants of demand or have not been changing much over time they have had little impact on demand trends and their omission is not serious from the point of view of providing an explanation of these trends.

The first two attributes of level of service, frequency and coverage, taken together, can be measured, albeit imperfectly, by vehicle-kilometres per head of population. Rather more satisfactory would be to separate out the two components by using vehicle-km per route-km as a measure of frequency, and route-km per head as a measure of coverage. Unfortunately, measures of route-kms were not available and so this latter refinement was not pursued.

Income influences public transport demand in three ways. The first and most important channel is through its effect on car ownership. This is a negative effect. Income growth generates car ownership growth which reduces the demand for public transport by increasing the service level of the alternative mode. The second effect of increasing income levels, which is also a negative effect, comes about in situations where people have a choice between public transport and car, because people raise the value they place on such attributes as convenience and comfort for which car generally has an advantage over public transport. Finally, increasing incomes have an independent trip generating effect on public transport.

A range of functional forms to specify the relationship between these variables are possible. However, if past trends in the explanatory factors continue a linear function would predict negative demand some time in the future, a hypothesis that is difficult to support.

A priori, it seems reasonable to expect that similar fare changes (in proportional or absolute terms) across different cities, could be expected to result in similar proportional reductions in demand. This observation suggests that "pooling" of data from the various cities and the estimation of a single regression for all cities may be appropriate.

While it is realised that adjustment lags do occur with respect to changes in fares, income and service levels (due to habit, imperfect knowledge, delays in vehicle purchase decisions, etc) it is considered that these effects have substantially worked themselves through when annual observations are used.

Estimation

Data series for public transport patronage and bus-km and train engine-km (used in the service variables) for the capital cities for those modes operated by public authorities were obtained from various issues of the ABS publications Transport and Communication and Rail, Bus and Air Transport. Some correction to rail patronage estimates was required for years prior to 1973-74 when the basis of estimating the number of trips made by holders of 'workers weekly' tickets was changed from 12 trips/week to 10 trips/week. Some private bus patronage figures are published in Transport and Communication and Rail, Bus and Air Transport bulletins but BTE estimates were also employed.

State and capital city population estimates were obtained from various issues of the ABS publication Population and Vital Statistics.

Indices for bus and rail fares, and a cost of motoring index (including cost of petrol and oil) for each city were provided by the ABS. State personal disposable income was obtained from Australian National Accounts, 1974-75 and ownership of cars and station wagons from various issues of Transport and Communication and Motor Vehicle Registrations.

Per capita income and car ownership levels in the cities were assumed to be the same as the State-wide levels. The per capita incomes and fares and motoring cost indices were deflated by the CPI for each city.

Initially, regressions for bus and rail demand were run on data aggregated over all the State capital cities over the period 1959-60 to 1973-74. The bus equations include government and private buses, trolley buses and trams. Different functional forms and different sets of variables were tested and the alternative specifications narrowed down to a few. Separate equations were then run for the individual cities and further testing was done. The tests were evaluated on the basis of the signs and statistical significances of the coefficients, and to a lesser extent the $R^2$ and Durbin-Watson statistics for the equations.

The following general conclusions were drawn from the investigations:

- car operating costs were rarely significant;
- when the fares and incomes variables were expressed in real terms (deflated by CPI) their significance was greater than when included in current terms;
- per capita demand equations were more satisfactory on statistical grounds than total demand equations;
- when the variables were included in log terms, the significance of the coefficients of the explanatory variables was improved;
- serial correlation was a problem, and although this does not bias the coefficient estimates, it may sometimes cause the 't' statistics to be biased.

Collinearity between variables was troublesome and it was impossible to separate out the influences of car ownership and income. From a statistical point of view, the car ownership variable generally performed better in bus demand equations and the income variable was more satisfactory in rail demand equations. This is in line with the observation that rail is more CBD and peak oriented than bus and its demand less dominated by car ownership constraints.

TABLE A.2 - PUBLIC TRANSPORT DEMAND ELASTICITIES: AUSTRALIAN STATE CAPITAL CITIES (1)

**Bus Demand**

| City | Bus Fares | Car Ownership | Bus Service |
|---|---|---|---|
| Sydney | .034 (.23) | -.40 (-2.66) | 1.11 (2.95) |
| Melbourne | -.37 (-3.94) | -.72 (-6.79) | .49 (2.90) |
| Brisbane | -.49 (-2.60) | -.71 (-3.64) | .67 (2.13) |
| Adelaide | -.48 (-3.77) | -.57 (-4.25) | .54 (4.97) |
| Perth | -.14 (-.98) | -.46 (-5.27) | .86 (10.24) |
| Hobart | -.14 (.69) | -.82 (-7.21) | .34 (2.16) |
| Aggregate Aust(2) | -.29 (-4.62) | -.41 (-6.10) | 1.0 (4.76) |

**Rail Demand**

| City | Rail Fares | Income | Rail Service |
|---|---|---|---|
| Sydney | -.47 (-3.64) | .31 (.95) | 1.04 (3.19) |
| Melbourne | .25 (1.09) | -1.05 (-3.97) | .97 (2.80) |
| Brisbane | .03 (.12) | .61 (4.25) | 1.07 (4.31) |
| Adelaide | -.48 (-3.49) | -.43 (-4.16) | .73 (6.34) |
| Perth | -.83 (-3.78) | .56 (1.67) | 1.26 (3.55) |
| Hobart | -.22 (-1.71) | -2.53 (-14.5) | .44 (4.52) |
| Aggregate Aust.(2) | -.35 (-1.42) | -.41 (-2.44) | .21 (.49) |

NOTE: 't' values are given in parentheses below the respective elasticity.

(1) Elasticities are obtained directly from the regression coefficients.

(2) Public transport fares were used in these regressions.

It was decided that, overall, the best specification of the bus and rail demand equations were:

$$\log \frac{BD}{P} = a - b.\log RBF - c.\ \log CO + d.\ \log \frac{BK}{P};$$

$$\log \frac{RD}{P} = a - b.\ \log RRF - c.\ \log CO + d.\ \log \frac{RK}{P};$$

where BD = urban bus demand,
RD = urban rail demand,
RBF = bus fares in real terms,
RRF = real rail fares,
CO = car and station wagon ownership per head,
Y = real gross domestic product per head,
BK = urban bus-km,
RK = rail train engine-km,
P = total population of State capital cities.

The results of estimating these equations are shown in Table A.2.

Overall, there was a large amount of variability between cities but certain reasonably consistent features were evident. The direct fare coefficients usually have the correct negative sign. Furthermore those with the correct sign are usually significantly different from zero at the 95 per cent confidence level. The car ownership coefficients in the bus demand equations all have the correct sign and are significant. The rail income elasticities were less satisfactory. The income elasticity for Brisbane rail, which has growing patronage, was positive and significant which is contrary to expectations. Income has probably picked up the influence of other factors on patronage.

The other major explanatory variable was service level as measured by vehicle-km per capita. Service was invariably a strongly significant variable with the correct (positive) sign. Its significance in the rail demand equations for the individual capital cities contrasts with its behaviour in the aggregate Australian rail demand equation. There is, however, a reason for scepticism about whether an accurate estimation of the impact of service on demand is being obtained, over and above the service measurement problems discussed earlier. While fare levels have probably been determined by exogenous forces, for example cost increases or specific policy decisions, service levels have probably been rather more responsive to demand. This responsiveness of service to demand may be preventing unique identification of the effect of service on demand in the estimated relationships.

Given an assumption of similar response to fares, service and income or car ownership between cities, an efficient estimation procedure is to pool the cross-section and time series data and run a single regression for each mode. A typical observation is the number of bus (or train) passengers in a particular year and a particular city, together with the corresponding values of the independent variables. This approach increases the degrees of freedom by providing many more observations, and the variation of the independent variables both between cities and over time would normally reduce collinearity problems.

From the individual city equations it is plain that the key factors determining the demand for Brisbane rail have not been identified, and Brisbane data was omitted from the rail regression. To allow for variations between cities, a dummy variable was included for each city allowing the constant term to take different values for each city. The coefficients of the variables are constrained to be the same for all cities. The following equations were estimated over the period 1955-56 to 1973-74.

$$\log \frac{BD}{P} = \underset{(5.97)}{1.64} - \underset{(-4.63)}{0.35} \log RBF - \underset{(10.23)}{0.57} \log CO + \underset{(7.74)}{0.63} \log \frac{BK}{P}$$

$$+\underset{(0.48)}{0.010}SYD.D + \underset{(1.71)}{0.043}MEL.D - \underset{(-9.52)}{0.224}ADEL.D - \underset{(-12.02)}{0.453}PER.D - \underset{(-4.36)}{0.103}HOB.D;$$

$R^2 = .953,$

$$\log \frac{RD}{P} = \underset{(6.5)}{1.93} - \underset{(-2.61)}{0.37} \log RRF - \underset{(-1.65)}{0.20} \log Y + \underset{(10.20)}{1.10} \log \frac{RK}{P}$$

$$+ \underset{(5.30)}{0.947}\ SYD.D + \underset{(4.50)}{0.675}\ MEL.D - \underset{(-1.20)}{0.144}\ ADEL.D - \underset{(-0.26)}{0.025}\ PER.D;\ R^2=.991,$$

where the dummy variables are defined as:

SYD.D = 1 when data for Sydney is used, and zero otherwise,

MEL.D = 1 when data for Melbourne is used, and zero otherwise,

ADEL.D = 1 when data for Adelaide is used, and zero otherwise,

PER.D = 1 when data for Perth is used, and zero otherwise,

HOB.D = 1 when data for Hobart is used, and zero otherwise,

and other variables are defined as previously.

The bus demand equation is very satisfactory with the fares, service and car ownership variables all strongly significant. The fare elasticity is a bit higher than the average of the individual cities; and the service and car ownership elasticities are very close to the averages of the cities. The fare and service elasticities are reasonably consistent with other time series estimates(1).

The fare and service elasticities in the rail equation are significant and are fairly close in magnitude to the average of the individual cities. The coefficient for income is not significantly different from zero at the 95 per cent level of confidence, although it is at the 90 per cent level.

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(1) An example of a recent overseas study is P. Mullen, "Estimating the Demand for Urban Bus Travel", Transportation, 4, 1975, pp. 231-252. He estimated equations for twelve UK cities using fares, vehicle miles and a time trend as the explanatory variables. The fare elasticities ranged from -0.17 to -0.45 with a mean of -0.31, and the service elasticities from +0.52 to +1.19 with a mean of +0.62.

## Conclusion

The econometric investigations of urban rail and bus demand have revealed fares, service and income or car ownership as important explanatory factors. Further research is needed for a fuller understanding of the relationships, and a more detailed analysis of the role of service should have high priority. It is essential to bear in mind that the measure of service used for this time series analysis, vehicle-km per head, is a very incomplete measure. Nevertheless it has probably accounted for the major trends in service over the period analysed. The downward trend in this measure resulted from population growth and dispersion, with vehicle-km failing to respond significantly, particularly for the rail mode.

Despite reservations, the pooled regressions probably represent a reasonable basis for selecting broad demand elasticities pertinent to public transport in Australia's major cities. Using these elasticities in conjunction with the growth rates of the explanatory variables, deductions can be drawn about the relative contributions of the several factors towards the trends in per capita demand. The faster growth of bus fares than rail fares and the higher car ownership elasticity of demand for bus travel compared with the income elasticity for rail has resulted in these factors causing a greater decline in bus than in rail travel. On the other hand a higher service elasticity for rail was estimated, and a greater downward trend in the service measure occurred for rail, and this factor was therefore responsible for a much greater decline in rail patronage than bus patronage.

# ANNEX B

## MODE COST STUDY

The study(1) reported in this Annex is an endeavour to determine the least costly modes for a range of travel volumes and other conditions that can be expected in urban corridors of Australian cities.(2) The generalised corridor model employed in the analysis assumes that each trip undertaken has one trip end in a typical outer urban area and the other trip end in a high density trip attractor.

A corridor is defined to comprise a chain of low-population density suburbs extending from outer areas of the city to a high density travel attractor such as a CBD or major suburban shopping centre. The volume of travel along such corridors was assumed to increase linearly as the high density attractor was approached. Schematic diagrams of the generalised corridor model are given in Figures B.1 and B.2.

The task of the transport system in the corridor was assumed to have three components:

- a collection/distribution task at the low density or residential end of the journey
- a line-haul task linking the residential areas and the high-density travel generator/attractor
- a collection/distribution task at the high-density end of the journey.

Three different methods of trip collection/distribution were considered at the low density end of the journey:

- route bus
- private car
    - park and ride
    - kiss and ride

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(1) The basic work of this Annex was undertaken by Mr R. Bullock acting as a consultant to the BTE.

(2) A similar study has been carried out for urban corridors in the U.S. by Meyer J.R., Kain J.F., and M. Wohl, The Urban Transportation Problem, Harvard University Press, Cambridge, Massachusetts, 1965.

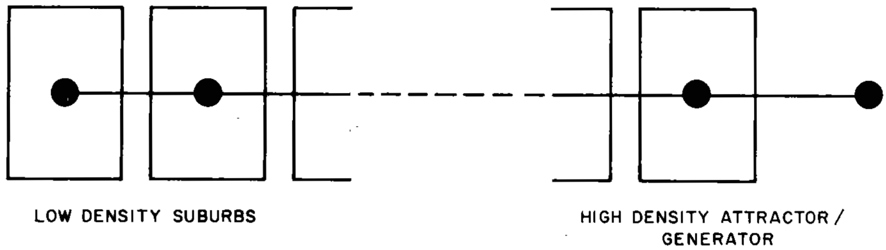


FIGURE B·1
SCHEMATIC DIAGRAM OF TRANSPORT CORRIDOR

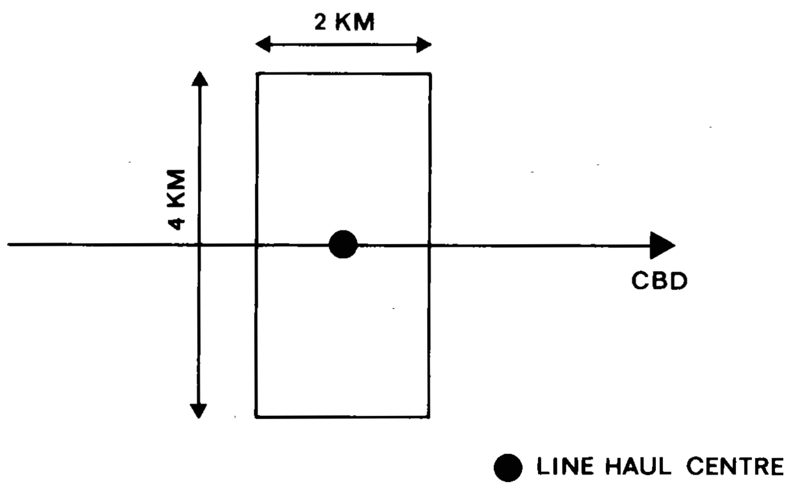


FIGURE B·2
SCHEMATIC REPRESENTATION OF SUBURB

Five transport modes were considered for the line-haul stage:

- electric rail
- route Bus
- express bus
- private car
- taxi.

The distribution task at the high density end of the corridor was considered to be the same for all trips.

## CORRIDOR SPECIFICATION AND TRAVEL DEMAND

Four corridors, defined in terms of length and passenger demand were selected for examination. These were delineated as being representative of travel corridors in Australian cities having traffic volume levels of at least 10,000 movements per day. The major characteristics of these corridors are described in Table B.1.

TABLE B.1 - CORRIDORS SELECTED FOR STUDY

| Corridor | Length (km) | Passenger Movements per Day ('000) | Line-Haul Passenger Kilometres per Day ('000) |
|---|---|---|---|
| A | 4 | 10 | 30 |
| B(1) | 10 | 25 | 150 |
| B(2) | 10 | 10 | 60 |
| C | 30 | 100 | 1,500 |

The level of passenger movements in each corridor shown in Table B.1 derive from the construct of the general corridor model and the structured parameters (such as suburb size, suburb population and trip generation rates) used to define it. For example, the corridors referred to above are assumed to comprise standard urban units which straddle the corridor axis and measure 2 km in length along that axis and 4 km in breadth.

Seventy-five per cent of the area of the standard urban units are assumed to be zoned residential and the basic population density of these areas is taken to be 37 people per hectare. This population density is an average of the residential densities shown in Table B.2. For corridors B(2) and C population densities of 15 and 48 people per hectare were assumed respectively. The population of the standard urban unit is therefore 22,000. This population would form about 6,500 households.

TABLE B.2 - TYPICAL SUBURBAN RESIDENTIAL DENSITIES[1]

| City | Suburb | Persons per Residential Hectare | Date |
|---|---|---|---|
| Adelaide | Brighton | 44 | 1965 |
| | Tee Tree Gully | 32 | 1965 |
| Geelong | Corio | 37 | 1970 |
| Melbourne | Malvern | 49 | 1969 |
| Perth | Midland | 32 | 1969 |
| | Scarborough | 35 | 1966 |
| Sydney | Blacktown | 47 | 1971 |
| | Sutherland | 37 | 1971 |

(1) Residential density is defined as the ratio of the residential population divided by the area of land zoned for residential purposes plus internal and a percentage of abutting roads, community halls, schools and like purposes of residential areas.

Sources: References given in Appendix B.1.

An aggregate trip generation rate for two-way travel along the corridor of about 1 trip per household each day is employed for all suburbs in corridors A, B(1) and C.[1] This implies that each suburb would generate around 6,500 two way trips per day

(1) This figure was based on data from the Melbourne Transportation Study, 1964.

which result in, in round terms, 10, 25 and 100 thousand trips per day for corridors A, B(1) and C respectively. A lower trip generation rate was employed for corridor B(2) to test the sensitivity of trip generation rates on alternative corridor transportation systems.

Daily Demand Profile

Daily demand was divided into five periods: the early morning off-peak (6am-7am), the morning peak (7am - 9am), the between peak period (9am-4pm), the evening peak (4pm - 6pm), and the evening off-peak (6pm-10pm). Inbound and outbound travel demands were also separated. The demand profile used in subsequent analyses is shown in Table B.3. It was based on observed demand profiles for rail and bus services in Sydney and Melbourne as shown in Table B.4.

TABLE B.3 - DAILY DEMAND PROFILE

| Period | % Total Trips | % To CBD |
|---|---|---|
| 6 - 7am | 2 | 58 |
| 7 - 9am | 30 | 96 |
| 9 - 4pm | 27 | 54 |
| 4 - 6pm | 32 | 15 |
| 6 - 10pm | 9 | 24 |

TABLE B.4 - DAILY DEMAND PROFILE FOR VARIOUS URBAN PUBLIC TRANSPORT SERVICES

(% of total traffic)

| | Rail | | Bus | % Inbound |
|---|---|---|---|---|
| | Sydney 1971 | Melbourne 1969 | Melbourne 1964 | Melbourne Rail |
| 6 - 7am | 2 | 3 | 3 | 58 |
| 7 - 9am | 30 | 29 | 30 | 96 |
| 9 - 4pm | 25 | 24 | 27 | 54 |
| 4 - 6pm | 34 | 36 | 32 | 15 |
| 6 - 10pm | 9 | 8 | 8 | 24 |

Sources: (1) NSW PTC and VR barrier counts.
(2) Melbourne Transportation Study, 1964.

Applying the daily demand profile shown in Table B.3 to total corridor passenger flows gives the line-haul passenger flow profile shown in Table B.5. Applying the daily demand profile to passenger flows by suburb gives the collection/distribution passenger task by time of day. Corridor A and B(1), B(2) and C,are shown in Table B.6.

TABLE B.5 - LINE-HAUL PASSENGER MOVEMENTS (1)

| Period | Corridor | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | | B(1) | | B(2) | | C | |
| | to CBD | from CBD | to CBD | from CBD | to CBD | from CBD | to CBD | from CBD |
| 6- 7am | 116 | 84 | 290 | 210 | 116 | 84 | 1,160 | 840 |
| 7- 9am | 2,880 | 120 | 7,200 | 300 | 2,880 | 120 | 28,800 | 1,200 |
| 9- 4pm | 1,458 | 1,242 | 3,645 | 3,105 | 1,458 | 1,242 | 14,580 | 12,420 |
| 4- 6pm | 480 | 2,720 | 1,200 | 6,800 | 480 | 2,720 | 4,800 | 27,200 |
| 6-10pm | 210 | 684 | 540 | 1,710 | 210 | 684 | 2,160 | 6,840 |

(1) Discrepancies in totals caused by rounding errors.

TABLE B.6 - SUBURBAN COLLECTION AND DISTRIBUTION PASSENGER TASK CORRIDORS (1)

| Period | Average Passengers Per Hour | | | | | |
|---|---|---|---|---|---|---|
| | Corridors A & B | | Corridor B(2) | | Corridor C | |
| | to CBD | from CBD | to CBD | from CBD | to CBD | from CBD |
| 6 - 7am | 58 | 42 | 23 | 17 | 75 | 55 |
| 7 - 9am | 720 | 30 | 288 | 12 | 936 | 39 |
| 9 - 4pm | 104 | 89 | 42 | 36 | 135 | 115 |
| 4 - 6pm | 120 | 680 | 48 | 272 | 156 | 884 |
| 6 -10pm | 27 | 86 | 11 | 34 | 35 | 112 |

(1) Discrepancies in totals caused by rounding errors.

TRANSPORT SYSTEM CHARACTERISTICS

Collection/Distribution Systems

Route Bus: Each bus route is assumed to start at a corner of the suburb and continue directly to the relevant line-haul interchange at the suburb's centre. The average route length is therefore 2.2 km. A passenger catchment area of one kilometre about the bus route is assumed. Each route therefore serves an area of 2.2 sq. km, and four routes are required to completely service each suburb.

Employing the assumption that demands throughout the length of each route are uniform. The use of 50 seater buses would require provision of the levels of service shown in Table B.7.

TABLE B.7 - ROUTE BUS DEMAND AND SERVICES

| Period | Average Hourly Demand To CBD | Average Hourly Demand From CBD | Service Frequency (buses/hour) |
|---|---|---|---|
| CORRIDOR A, B(1) | | | |
| 6 - 7am | 15 | 11 | 2 |
| 7 - 9am | 180 | 8 | 4 (1) |
| 9 - 4pm | 26 | 22 | 2 |
| 4 - 6pm | 30 | 170 | 4 |
| 6 - 10pm | 9 | 22 | 2 |
| CORRIDOR B(2) | | | |
| 6 - 7am | 6 | 4 | 2 |
| 7 - 9am | 72 | 3 | 2 |
| 9 - 4pm | 10 | 9 | 2 |
| 4 - 6pm | 12 | 68 | 2 |
| 6 - 10pm | 4 | 9 | 2 |
| CORRIDOR C | | | |
| 6 - 7am | 20 | 14 | 2 |
| 7 - 9am | 234 | 10 | 5 |
| 9 - 4pm | 34 | 29 | 2 |
| 4 - 6pm | 39 | 221 | 5 |
| 6 - 10pm | 12 | 29 | 2 |

(1) Allows for overloading during mid peak.

Given an operating speed of 11 km/hr and a scheduled delay of 3 minutes at the terminus, the following buses are required per peak period per suburb:

| CORRIDOR | NO OF BUSES PER PEAK |
|---|---|
| A | 8 |
| B(1) | 8 |
| B(2) | 4 |
| C | 10 |

Using an average walking distance of 250 metres and an average transfer time of 3 minutes results in an average door to terminal journey time of 5 minutes.

Park and Ride: Users of this mode would drive their cars to public transport collection points, see Figure B.1, where they would be parked until the return journey that evening. An average journey time of 5 minutes from the user's house to the collection point is assumed.

Vehicles used for park and ride are engaged for an estimated 2,000 hours annually in that activity. The activity is therefore considered to be the major use of such vehicles and their use is costed assuming a total annual distance travelled per vehicle of 8,000 km.

Kiss and Ride: Users of this mode are deposited by private vehicle at public transport collection points by drivers who have the vehicle available for other uses during the day. Commuting would thus be a marginal use of the vehicle. Vehicles engaged in this activity are costed assuming a total annual distance travelled per vehicle of 16,000 kilometres. The driver's time was considered to be an operating cost of the motor vehicle and added to the proportion of total vehicle operating and maintenance costs assigned to kiss and ride vehicle usage to obtain total costs for this mode.

## Line-Haul System

**Electric Rail**: Passenger trains are assumed to have an operating speed of 35 km/hr. This is similar to that of the Sydney suburban system which has stations spaced at an average distance of 1.7km.

Table B.8 shows the journey times, theoretical cycle times (allowing 5 minute turn-arounds) and possible number of round trips performed by each train during 2 hour peak periods.

TABLE B.8 - OPERATING CHARACTERISTICS FOR RAIL

| Characteristic | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Length (km) | 4 | 10 | 10 | 30 |
| Journey time (hr) | 0.11 | 0.29 | 0.29 | 0.86 |
| Cycle time (hr) | 0.38 | 0.74 | 0.74 | 1.88 |
| Train trips during peak | 5.3 | 2.7 | 2.7 | 1.1 |

Using the projected corridor passenger demands shown in Table B.5, two-car train sets for corridors A and B(2), four-car sets for corridor B and eight-car and four-car sets during peak and off-peak periods respectively for corridor C, the service frequencies shown in Table B.9 are obtained.

TABLE B.9 - RAIL SERVICE FREQUENCIES

| Period | Train frequencies/hr | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| 6 - 7am | 2 | 2 | 3 | 3 |
| 7 - 9am | 3 | 4 | 4 | 8 |
| 9 - 4pm | 2 | 2 | 2 | 4 |
| 4 - 6pm | 4 | 4 | 4 | 7 |
| 6 - 10pm | 2 | 2 | 2 | 2 |

The off-peak services shown in Table B.9 provide more train capacity and more frequent train services than demand alone warrants, since a minimum service frequency of two trains per hour is assumed.

Peak rolling-stock requirements are derived by combining Tables B.8 and B.9. For example, the numbers of two-car sets required during peak periods are 2, 8, 3 and 72 for corridors A, B(1), B(2) and C respectively. The number of train kms travelled daily by each type of train set is shown in Table B.10.

TABLE B.10 - DAILY DISTANCE TRAVELLED BY RAIL VEHICLES

(train kms)

| Train Type | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| 2-car sets | 320 | - | 800 | - |
| 4-car sets | - | 880 | - | 2520 |
| 8-car sets | - | - | - | 2400 |

Bus: BTE research indicates that line-haul route buses operate at an average of around 20 km/hr. Such average speeds are maintained in peak periods by offsetting congestion effects through running semi-express services. Express buses are assumed to operate at 40 km/hr.

Table B.11 shows trip times, calculated cycle times and the number of round trips performed during peak periods for both route and express buses. A turn-around delay time of 15 per cent of the trip-time was used in these calculations.

Projected service frequencies using 50-seat buses and the passenger demand levels shown in Table B.5 are shown in Table B.12.

TABLE B.11 - OPERATING CHARACTERISTICS FOR BUSES

| | Route bus | | | | Express bus | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B(1) | B(2) | C | A | B(1) | B(2) | C |
| One way journey time(hr) | .20 | .50 | .50 | 1.50 | .13 | .31 | .31 | .94 |
| Cycle time(hr) | .46 | 1.15 | 1.15 | 3.45 | .29 | .72 | .72 | 2.16 |
| Trips in peak | 4.3 | 1.7 | 1.7 | 0.58 | 6.96 | 2.78 | 2.78 | 0.93 |

TABLE B.12 - BUS FREQUENCIES BY CORRIDOR

| Period | Bus frequency(1) (buses/hr) | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| 6 - 7am | 2 | 5 | 2 | 20 |
| 7 - 9am | 24 | 60 | 24 | 240 |
| 9 - 4pm | 4 | 9 | 4 | 35 |
| 4 - 6pm | 23 | 57 | 23 | 227 |
| 6 - 10pm | 3 | 8 | 3 | 29 |

(1) 120 per cent load factors are assumed during peak periods.

In calculating peak rolling stock requirements it is assumed that, because of traffic density and the consequent opportunity to run part-way services, peak vehicle requirements and daily vehicle distance travelled can be reduced by 15 per cent in corridors B(1) and B(2), and 30 per cent in corridor C. Employing this assumption and the data given in Tables B.11 and B.12 gives peak vehicle numbers required. These numbers, together with the distance travelled by buses in each corridor are shown in Table B.13.

Private Motor Vehicle: Private motor vehicles used for the line-haul task are assumed to travel at an average speed of 35 km/hr during that phase of the journey and are parked at the high density attractor at the same average distance from the final destination as is the line-haul terminus.

TABLE B.13 - BUS VEHICLES NEEDED AND DAILY BUS KILOMETRES

| | Route bus | | | | Express bus | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B(1) | B(2) | C | A | B(1) | B(2) | C |
| Peak vehicles needed | 11 | 60 | 24 | 579 | 7 | 37 | 15 | 361 |
| Vehicle-km | | | | | | | | |
| -peak | 752 | 3978 | 1598 | 39228 | 752 | 3978 | 1598 | 39228 |
| -off-peak | 336 | 2000 | 840 | 22860 | 336 | 2000 | 840 | 22860 |
| -total | 1088 | 5928 | 2438 | 62088 | 1088 | 5928 | 2438 | 62088 |

DERIVATION OF COSTS

The three types of costs included in the analysis of alternative corridor transport systems are operating costs, user costs and the costs of any externalities imposed by transport users on the rest of the community.

Two main groups of operating costs were considered; variable costs, such as labour and fuel costs, and fixed costs, such as interest and depreciation.

Resource costs are considered as the basis for comparison. Therefore all costs are exclusive of fuel excise duty and sales tax. However, production taxes on crude oil and customs tariffs on imported transport equipment have been retained. The treatment of licence, registration and insurance fees are discussed case by case.

Depreciation is used to measure the annual cost of asset depletion and is calculated on a time-basis, that is, all vehicles have an operating life measured in years. Interest charges are calculated at 10 per cent of the half-life asset values.

Four aspects of user cost are identified: vehicle access time, waiting and transfer time, in-vehicle time, and other (comfort, safety, etc). While the first three of these are faily readily quantifiable, the last is not and was ignored.

Externalities are the costs imposed by transport users upon the remainder of the community. There are many costs that can be included under this heading, but most are difficult, if not impossible, to quantify.

The principal externalities that need to be given consideration are congestion imposed on other road users, noise and pollution imposed on residents and, in the case of new road or rail construction, disamenity costs imposed upon the community during construction and severance upon construction. Of these, only the first can be adequately assessed and only in certain situations at the present time. For this reason, although external costs are discussed in this report, no attempt is made to value them.

Route Bus Operation Costs

Table B.14 sets out operating costs for five public bus operators and two groups of private bus operators for 1972-73. The figures shown are not strictly comparable because accounting methods and operating procedures vary considerably between operators. The data for the public bus operators are taken from their 1972-73 Annual Reports. Data for the first group of private bus operators are derived from the Australian Department of Transport[1], and the second from the Victorian Transport Regulations Board.

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(1) Rendel & Partners in Association with Price Waterhouse Associates Pty Ltd., "Private Bus and Ferry Operations in Australia," a report prepared for the Australian Department of Transport.

TABLE B.14 - OPERATING STATISTICS AND COSTS FOR URBAN BUS OPERATIONS: 1972-73

| Operator (1) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Bus Fleet (No.) | 776 | 402 (2) | 240 | 195 | 610 (3) | 437 | 1055 |
| Average daily demand for buses(4) (No.) | 657 | 339 | 203 | 174 | 494 | n.a. | n.a. |
| Average Annual Distance per bus ('000 km) | 54.2 | 49.6 | 59.8 | 35.9 | 40.7 | 39.6 | 43.5 |
| Staff (no.) - drivers | 1175 | 702 | n.a. | n.a. | 824 | n.a. | n.a. |
| - other | 700 | 510 | n.a. | n.a. | 724 | n.a. | n.a. |
| - total | 1875 | 1112 | 4285 (5) | 446 | 1548 | n.a. | n.a. |
| Drivers/bus | 1.8 | 1.9 | n.a. | n.a. | 1.7 | n.a. | n.a. |
| Average operating speed (km/hr) | 23 | 18 | 18 | n.a. | n.a. | n.a. | n.a. |
| Bus km(million) | 37.7 | 17.5 | 11.9 | 6.2 | 20.1 | 17.3 | 45.9 |
| Variable Operating Costs (c/bus km) | | | | | | | |
| Traffic-salaries & wages of drivers, etc. | 19.0 | 27.4 | 28.5 | 28.6 | 36.2 | 15.8 | 12.5 |
| Fuel & oil | 2.2 | 2.4 | 2.3 | 3.1 | 3.0 | 3.5 | 2.8 |
| Maintenance | 6.7 | 8.5 | 11.9 | 8.6 | 5.6 | 2.3 | 4.9 |
| Administration ($/bus in fleet) | 3.9 | 3.1 | 3.2 | 7.3 | 3.5 | 2.2 | 5.8 |
| Total variable costs | 31.8 | 41.4 | 45.9 | 47.6 | 48.3 | 23.8 | 26.0 |
| Fixed Operating Costs ($/year) | | | | | | | |
| Licence, reg. & insurance | 232 | 704 | 90 | - | - | 572 | 541 |
| Depreciation & interest | 1673 | 1681 | 3475 | 1165 | 3610 | 1316 | 1221 |
| Other costs | 441 | 188 | 320 | - | 220 | - | - |
| Total fixed costs | 2346 | 2573 | 3885 | 1165 | 3830 | 1888 | 1762 |

NOTES: (1) 1 - Metropolitan (Perth) Passenger Transit Trust.
2 - Municipal Tramway Trust - Adelaide.
3 - Melbourne & Metropolitan Tramways Board.
4 - Municipal Tramway Trust - Hobart.
5 - Brisbane City Council.
6 - The Australian Department of Transport "Private Bus and Ferry Operations in Australia", Rendel and Partners in Association with Price Waterhouse Associates Pty. Ltd.
7 - Victorian Private bus under the control of the Transport Regulation Board.

TABLE B.14 - CONTINUED

NOTES:
(2) Includes 26 trams.
(3) Includes 37 buses in store.
(4) ANZ City Transit Conference 1972-73.
(5) Includes tramway staff.

Sources:
(1) 1972-73 Annual Reports of various Public Transport Authorities.
(2) Rendal & Partners in Association with Price Waterhouse Associates Pty.Ltd., "Private Bus and Ferry Operations in Australia", a report prepared for the Australian Department of Transport.
(3) Victorian Transport Regulation Board, Annual Report, 1972-73.

Comments on operating costs

The data presented in Table B.14 must be treated with considerable caution as the various undertakings operate different types and sizes of bus, have different crewing, organisational and maintenance policies, and the accounts from which the data were derived are not mutually consistent in their treatment of all items.

The two sets of figures for private bus operations almost certainly understate the labour cost of the private bus proprietor and his family. This could result in lower traffic, maintenance and administration charges. On the other hand, the private bus operator may incur higher fuel costs than the public operator.

The variable operating costs for the Perth system are the lowest of the public systems examined. It is not possible to tell from the data available whether this is due to inherent operating advantages, for example, higher operating speeds, or because of the achievement of a higher level of efficiency in administering that system.

The variable operating costs for the Adelaide bus system are used in subsequent analyses as these are closest to the average of the seven sets of data shown in Table B.14. These costs were increased by 51 per cent however, to bring them into line with 1974-75 prices[1]. That is the average variable cost per km used in the analysis is increased from 41.4 cents to 62 cents. Fuel excise duty of 4.9 cents/litre used must be subtracted from this cost to convert to resource costs. A reduction of 1.4 cents/km is therefore necessary.

Since the bulk of variable operating costs (41 cents/km at 1974-75 prices) are traffic operation costs (drivers, wages, fuel etc), which are largely independent of the size of bus used, it is unlikely that changes in this operating parameter will have a significant impact on variable bus operating costs. However, as bus crews are paid on an hourly basis, any increase in speeds of travel would be reflected in lower cost per bus kilometre through the greater distance travelled per labour-hour travelled. Faster operations would therefore be most likely to reduce operating costs. Therefore, assuming that traffic costs vary inversely with operating speed and that any variation in fuel, maintenance and administration costs is minimal enough to be neglected, the likely impact on variable operating costs of varying bus operating speeds is as illustrated in Table B.15.

TABLE B.15 - SENSITIVITY OF VARIABLE OPERATING COSTS TO CHANGES IN BUS SPEED

| Operating speed (km/hr) | Traffic costs (c/km) | Other variable operating costs (c/km) | Total variable operating costs (c/km) |
|---|---|---|---|
| 12 | 62 | 21 | 83 |
| 18 | 41 | 21 | 62 |
| 25 | 30 | 21 | 51 |
| 35 | 21 | 21 | 42 |

(1) MMTB data on bus operating costs was used to derive this inflator.

Turning now to fixed operating costs, road maintenance is allowed for in the costing exercise by including licencing and registration costs. Insurance is included as a lump sum payment to cover accident costs. (Where organisations self-insure for vehicle damage, the cost of repairs appears as 'repairs and maintenance' instead of 'insurance'). It is difficult to obtain reasonable estimates of the individual components of these charges from published accounts. Further, comparisons between operators can be misleading because State regulations differ resulting in different levels of charges and premiums from State to State. However, a lump sum of $700/bus in service, in 1972-73 prices, is used in the analysis. This is the approximate charge per bus for these items in Adelaide as is shown in Table B.14. In 1974-75 prices, this is equivalent to about $1,060.

The capital cost of buses varies almost directly with bus size as shown in Table B.16. A retail purchase price of $33,000 in 1974-75 prices for 50 seat buses is used in the costing analysis. From this value import duty of $3,000 is deducted to convert retail costs to resource costs. This cost is annualised assuming a bus life of 15 years and annual interest rates of 10 per cent giving annual depreciation and interest charges of $2,000 and $1,500 respectively.

TABLE B.16 - BUS CAPITAL COSTS

| Bus seating capacity | Price ('000) | Annual Charges | | Total |
|---|---|---|---|---|
| | | Depreciation | Interest | |
| 20 | 12 | 800 | 600 | 1400 |
| 30 | 16 | 1070 | 800 | 1870 |
| 40 | 20 | 1330 | 1000 | 2330 |
| 50 | 33 | 2000 | 1500 | 3500 |

Source: Purchase prices adapted from the Australian Department of Transport, "Private Bus and Ferry Operations in Australia", Rendel & Partners in Association with Price Waterhouse Pty., Ltd., and other information available to BTE.

## Rail Operating Costs

The base data on variable operating costs for rail are shown in Table B.17. The two sets of costs given relate to NSW PTC urban operations in 1971-72 and estimates costs used in a State electrification study undertaken by BTE in 1973-74. Quite clearly there are significant differences between the two sets of data. A synthetic set of operating costs was therefore developed for the purposes of this exercise.

TABLE B.17 - RAIL OPERATING COSTS: 1973-74 PRICES

| | NSW PTC (1) (c/km) | State (2) (c/km) |
|---|---|---|
| Drivers wages | 29.2 | 19.9 |
| Guards, etc. | 23.4 | 32.9 |
| Station staff & administration | 98.1 | - |
| General administration | 44.8 (3) | 29.2 |
| Fuel and power (4) | 24.8 | 33.7 |
| Maintenance of rolling stock (4) | 49.8 | 112.7 |
| Maintenance of way & works (4) | 21.1 (3) | - (5) |
| Total | 291.1 | 228.4 |

(1) NSW PTC costs for 1971-72 inflated by 27.6 per cent to convert to 1973-74 prices - 1971-72 costs obtained from SAPT.
(2) Estimates of cost in an electrification study conducted by BTE.
(3) Total system cost.
(4) 4-car train sets assumed in calculations.
(5) Expressed as a cost/track km.

The costs of drivers wages, guards, etc., for the NSW PTC are similar for each data set. The NSW PTC cost is therefore employed.

Station staff were estimated to cost $14/hour/station in 1973-74 prices based on an allowance for three station staff per station per day.

The NSW PTC costs for general administration and fuel and power were used in the cost analyses.

On average, the rolling stock of the NSW PTC is older than the equipment assumed for purposes of capital stock evaluation, and thus maintenance costs for the NSW PTC would be too high. A rolling stock maintenance cost of 35¢/km in 1973-74 prices is thus adopted.

Annual NSW PTC permanent way maintenance, per track kilometre costs about $4,250 for track, $1,200 for signals and $760 for electrification, that is, a total cost of $6,210 per route kilometre. The estimates used in the electrification study were $6,100, $700 and $2,200 respectively, a total of $9,000. As the two sets of figures are reasonably comparable, the NSW PTC figure for maintenance of way and works was adopted in this study.

Since the operating costs given above are all in 1973-74 prices, an inflation factor of 20 per cent is employed to convert them to 1974-75 prices for comparative purposes. The synthesised costs are shown in Table B.18. These costs are assumed to relate to typical rolling stock for the NSW PTC which have a seating capacity of 100 persons per car, or 200 in the peak 'crush'

TABLE B.18 - RAIL OPERATING COSTS: 1974-75 PRICES

| | Unit Cost (c/km) |
|---|---|
| Drivers, guards, etc. | 63.2 |
| Station staff, etc. (1) | - |
| General administration | 54.0 |
| Fuel | 29.8 |
| Maintenance of rolling stock | 42.0 |
| Maintenance of way and works | 25.3 |
| Total | 214.3 |

(1) A cost of $17/hour/station is used in subsequent analyses.

The costs presented so far exclude the costs of vehicle and track. Information available to the BTE indicates that a 2-car trailer set costs about $500,000 in 1974-75 prices. Such a set would have an estimated life of 30 years and would thus incur an annual depreciation charge of $16,700 and interest charges of $25,000 per annum employing the same method of calculation outlined above.

Track capital costs are estimated assuming that a double track in undulating country with only minor bridgework would be required. Costs are developed using the 1973 SAPT rail construction costs inflated by 40 per cent to convert them to 1974-75 prices. A 50 year life for trackwork is assumed in determining an annual cost. The annual track capital costs are given in Table B.19.

TABLE B.19 - ANNUAL TRACK CAPITAL COSTS

| | Cost/route km[1] ($m) |
|---|---|
| Earthworks | 0.2 |
| Bridgework | 0.2 |
| Trackwork | 0.2 |
| Electrification | 0.5 |
| Signalling - lineside | 0.3 |
| - stations | 0.2 |
| Total | 1.6 |
| Stations | 0.6 |

(1) 1972-73 prices inflated by 40 per cent to give 1974-75 prices.
Source: (1) Based on rail construction costs by Sydney Airport Planning Team (S.A.P.T.), 1973.

## Private Motor Vehicle Operating Costs

Two major sources are used to derive motor vehicle operating costs: the Road User Cost Manual[1] (RUCM) and various issues of Royal Auto[2]. The costs quoted are those for a medium-sized car, defined as having an engine capacity over 2,000 c.c. and costing up to $5,000 in 1975 prices. This which would include current models such as Falcon 500, Torana, Holden Belmont and Toyota Crown.

The costs for medium sedans from the two sources are given in Table B.20. The RUCM costs as published are for the year 1966-67 whereas the Royal Auto costs are for February 1975. The RUCM costs have been updated to February 1975 by:

(1) Australian Road Research Board, Road User Cost Manual, Special Report No. 9, 1973.
(2) Royal Automobile Club of Victoria, Royal Auto, May 1975, June 1975, July 1975.

(i) allowing for an increase in fuel cost from 9 cents/litre to 13.2 cents/litre over the period;

(ii) increasing the cost of repairs and maintenance and tyres and tubes by the 97 per cent that ABS data indicates that car maintenance costs increased by between 1966-67 and 1973-74; and

(iii) further increasing the cost of repairs and maintenance and tyres and tubes by 20 per cent to convert them to February 1975 prices, the date of the RACV costs.

TABLE B.20 - OPERATING COST FOR MEDIUM-SIZED CARS

(cents/km)

| | RACV(1) | RUCM | |
|---|---|---|---|
| | Feb 1975 | 1966-67 | Feb 1975 (estimated) |
| Petrol (@ 13.2¢/litre) | 1.9 | 1.3 | 1.9 |
| Oil | 0.1 | 0.1 | 0.1 |
| Repairs & maintenance) Tyres and tubes ) | 3.0 | 1.2 | 2.9 |
| Total | 5.0 | 2.6 | 4.9 |

(1) Based on 16,000 km and 3rd year of operation.

Sources: (1) Royal Automobile Club of Victoria, Royal Auto, July 1975.
(2) Currie, G.R.B., "A Survey of Private Vehicle Operating Costs in Australia", Road Research, Volume 4, March 1970.
(3) BTE estimates.

The RACV studies of vehicle operating costs show that maintenance costs increase with vehicle age. The RACV reported costs for the first three years of vehicle usage and since the average age of vehicles 'on-the-road' was estimated to be 5.8 years in 1971(1), the costs applicable to the third year of vehicle operation are used herein. These costs are reported in Table B.20.

(1) Australian Bureau of Statistics, Survey of Motor Vehicle Usage, op. cit.

Fixed vehicle operating costs are incurred irrespective of the distance travelled by the vehicle. Whether or not they should be included in any study depends upon the objectives of that analysis. The aim of this study is to compare the motor car as a commuter mode with public transport modes and the attribution of fixed costs to commuting and other vehicle uses is dependent upon the mode of vehicle usage. It is assumed that total fixed costs for vehicles in 'kiss-and-ride' usage are averaged over 16,000 km of annual vehicle utilisation, whereas those for vehicles in 'park-and-ride' usage are averaged over 8,000 km of annual vehicle utilisation.

Fixed costs are reasonably straightforward to determine except for depreciation. The Road User Cost Manual[1] employs a 22½ per cent diminishing balance rate of depreciation. This rate is also used by the RACV and is supported to some extent by the Industries Assistance Commission[2] which suggests rates of 22.5 percent, 17.0 per cent and 18.5 per cent for small, medium and large cars respectively. The effects of inflation appear to have been neglected in each of these analyses. Assuming a purchase price, including sales tax, for medium sized vehicles of $4,150 in 1974-75 prices, the annual depreciation for a vehicle of average age, that is, a vehicle in its fifth year of operation, is $337.

Other fixed costs include:

(i) vehicle registration and licence fees as a proxy for road maintenance costs;
(ii) third party insurance as a proxy for the external costs of accidents;
(iii) comprehensive insurance as a proxy for the internal costs of accidents;
(iv) road service organisation membership fees as a proxy for the costs of breakdown services.

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(1) Australian Road Research Board, Road User Cost Manual, op. cit.
(2) Industries Assistance Commission, The Australian Market for Passenger Motor Vehicles, June 1974.

Total fixed operating costs for medium sized vehicles are shown in Table B.21.

TABLE B.21 - FIXED COSTS FOR MEDIUM-SIZED CARS: VICTORIA 1974-75

| | ($) |
|---|---|
| Registration | 44 |
| Compulsory Third Party | 91 |
| Comp. insurance (no claim bonus assumed) | 128 |
| RACV membership | 18 |
| Driving Licence | 6 |
| Depreciation (22½% of 1500) | 337 |
| Total | 624 |

The costs quoted above are inclusive of excise duty on fuel, sales tax on materials such as spare parts and tyres of 15 per cent and sales tax of 27 per cent on vehicle purchase price. The resource costs for private vehicles in 'kiss-and-ride' and 'park-and-ride' usage obtain by deleting such transfer payments are shown in Table B.22.

TABLE B.22 - TOTAL OPERATING COSTS FOR MEDIUM-SIZED CARS: VICTORIA 1975 (1)

(cents/km)

| | Vehicle Usage | |
|---|---|---|
| | Kiss and Ride | Park and Ride |
| Variable costs | 4.0 | 4.0 |
| Fixed costs | 3.4 | 6.8 |
| Total costs | 7.4 | 10.8 |

(1) Exclusive of excise duty on fuel and sales taxes.

## Taxi Costs

The taxi costs employed in subsequent analyses are the fares charged by taxi operators. This cost includes vehicle operating costs, including driver costs, and the returns on capital employed by taxi owners. The costs incurred by owner/drivers of taxis in the ACT in 1975, exclusive of their returns to capital, are shown in Table B.23. The user charges employed in the analyses are shown in Table B.24,which are an Australian average taxi fare.

TABLE B.23 - ANNUAL COSTS OF OWNER/DRIVERS OF TAXIS: ACT 1975

| Standing Costs | $ | Variable Costs | $ |
|---|---|---|---|
| Licences | | Casual Drivers Wages | 5,536 |
| Drivers | 7 | Fuel | 3,346 |
| Taxi Operators | 10 | Oil, grease and filter | 374 |
| Registration | 45 | Repairs and maintenance | 1,850 |
| Third Party Insurance | 358 | Tyres and tubes | 600 |
| Depreciation | 2,456 | Radio Service | 50 |
| Comprehensive Insurance | 300 | Vehicle Washing | 400 |
| Third Party Property Insurance | 225 | Meter Repairs | 70 |
| Personal Accident Insurance | 175 | Base Subscriptions | 1,380 |
| Interest | 680 | Miscellaneous | 493 |
| Association Subscriptions | 15 | | 9,829 |
| | 4,271 | | |

(1) Average annual distance travelled = 140,000 kilometres. Average fare carrying distance approximately 60 per cent of total distance travelled.

Source: Costs supplied to BTE by ACT Taxi Association.

TABLE B.24 - TAXI FARES AND CHARGES(1)

| Fare Type | Fare Rate |
|---|---|
| | (cents) |
| Flag fall including fare for first 400 metres or part thereof | 40 |
| Every additional 200 metres or part thereof | 5 |
| Detention of taxi while waiting for hirer's convenience during hiring for every 40 seconds | 5 |
| For hiring commencing between 6 p.m. and 6 a.m. daily and between 6 a.m. and 6 p.m. on Sundays and statutory Public Holidays only, the maximum fare as herein prescribed is increased by | 20 |

(1) Data supplied to BTE by ACT Taxi Association.

## User Costs

The BTE user time costs shown in Table B.25 are used in the analyses below to reflect the user costs. No attempt has been made to quantify variables such as passenger comfort.

TABLE B.25 - USER TIME COSTS: 1975
($/hr)

| | Work | Non-work |
|---|---|---|
| In-vehicle time | 1.00 | 1.00 |
| Waiting time | 2.00 | 2.00 |
| Walking | 2.00 | 2.00 |

## ALTERNATIVE CORRIDOR TRANSPORT SYSTEM COSTS

### Operating Costs for Collection/Distribution Systems

Combining the information presented above on operating characteristics and unit costs of alternative collection/distribution transport systems with the corridor characteristics described above results in the collection and distribution costs summarised in Tables B.26 to B.28. Tables B.27 and B.28 show the total collection/distribution costs of the 'park-and-ride' and the 'kiss-and-ride' systems for corridors A and B(1) only. The unit cost for each trip is the same for all corridors.

### Operating Costs for Line-Haul Systems

Combining the information presented above on operating characteristics and unit costs of alternative line-haul transport systems with the alternative corridor characteristics described above results in the line-haul costs summarised in Tables B.29 to B.31.

TABLE B.26 - ROUTE BUS COLLECTION AND DISTRIBUTION COSTS PER SUBURB

| Derivation of Variable Cost | A&B(1) | B(2) | C |
|---|---|---|---|
| Round trips/route/day | 40 | 32 | 44 |
| Routes per suburb | 4 | 4 | 4 |
| Distance per round trip (km) | 4.4 | 4.4 | 4.4 |
| Distance per suburb per day (km) | 704 | 563.2 | 774.4 |
| Average operating speed (km/hr) | 11 | 11 | 11 |
| Variable cost(1) (cents/km) | 89 | 89 | 89 |
| Variable cost per day ($) | 627 | 501.25 | 689.22 |
| Variable cost per annum ($) | 188,000 | 150,375 | 206,766 |
| **Derivation of Fixed Cost** | | | |
| Peak vehicles requirements | 8 | 4 | 10 |
| Total buses including spares | 9 | 5 | 11 |
| Licence, registration, insurance per bus ($) | 1,060 | 1,060 | 1,060 |
| Depreciation per bus ($) | 2,000 | 2,000 | 2,000 |
| Interest per bus ($) | 1,500 | 1,500 | 1,500 |
| Fixed costs/bus/annum ($) | 4,560 | 4,560 | 4,560 |
| Total fixed costs per annum ($) | 41,000 | 22,800 | 50,160 |
| Total operating cost per annum ($) | 229,000 | 173,175 | 256,926 |

(1) Extrapolated from Table B.15.

TABLE B.27 - PARK AND RIDE COLLECTION AND DISTRIBUTION COSTS FOR SUBURBS IN CORRIDORS A AND B(1)

| | |
|---|---|
| Average trip distance (km) | 1.5 |
| Operating cost (cents/km) | 10.8 |
| Operating cost/trip ($) | 0.32 |
| Parking charge/trip ($) | 0.20 |
| Total cost/trip ($) | 0.52 |
| Cost p.a. ($'000) | 780 |

TABLE B.28 - KISS AND RIDE COLLECTION AND DISTRIBUTION COSTS FOR SUBURBS IN CORRIDORS A AND B(1)

| | |
|---|---|
| Average distance per trip (km) | 3 |
| Operating cost/km (cents) | 7.4 |
| Operating cost/trip ($) | 0.22 |
| Driver time/trip (hr) | 0.16 |
| Driver cost/trip ($) | 0.41 |
| Total cost/trip ($) | 0.63 |
| Cost p.a. ($'000) | 945 |

TABLE B.29 - RAIL LINE-HAUL COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Services/day | 40 | 44 | 40 | 82 |
| Length(km) | 4 | 10 | 10 | 30 |
| Daily 2-car train-km | 320 | - | 800 | - |
| Daily 4-car train-km | - | 880 | - | 2520 |
| Daily 8-car train-km | - | - | - | 2400 |
| Variable cost - 2-car (cents/km) | 139 | - | 139 | - |
| - 4-car (cents/km) | - | 214 | - | 214 |
| - 8-car (cents/km) | - | - | - | 365 |
| Daily variable cost ($) | 445 | 1883 | 1112 | 14153 |
| No. Stations | 2 | 5 | 5 | 15 |
| Daily station cost ($) | 544 | 360 | 1360 | 4080 |
| Total operating cost/day ($) | 989 | 3243 | 2472 | 18232 |
| Variable cost p.a. ($000) | 297 | 973 | 742 | 5470 |
| No. 2-car sets in peak | 2 | 8 | 3 | 72 |
| No. 2-car sets incl. spares | 2 | 9 | 3 | 79 |
| Fixed costs/2-car set ($000) | 41.7 | 41.7 | 41.7 | 41.7 |
| Rolling stock fixed costs p.a($000) | 83 | 375 | 123 | 3284 |
| Track costs per route/km ($000) | 112 | 1120 | 1120 | 3360 |
| Total track fixed costs p.a.($000) | 448 | - | - | - |
| Capital costs/station ($000) | 47 | 47 | - | 47 |
| Total station fixed costs p.a.($000) | 94 | 235 | 235 | 705 |
| Track and building charge p.a.($000) | 42 | 1355 | 1355 | 4065 |

TABLE B.30 - ROUTE BUS LINE-HAUL COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Services/day | 136 | 334 | 136 | 1315 |
| Vehicle-km/day | 1088 | 5978 | 2438 | 62088 |
| Variable cost/km($) | 0.58 | 0.58 | 0.58 | 0.58 |
| Variable cost/day ($) | 631 | 3467 | 1414 | 36011 |
| Variable cost p.a. ($000) | 189 | 1040 | 424 | 10803 |
| Peak vehicles | 11 | 60 | 24 | 579 |
| Peak vehicles incl. spares | 12 | 66 | 26 | 637 |
| System fixed costs/vehicle($) | 4560 | 4560 | 4560 | 4560 |
| Fixed costs p.a.($000) | 55 | 301 | 119 | 2905 |
| Total operating cost p.a.($000) | 244 | 1341 | 543 | 13708 |

TABLE B.31 - EXPRESS BUS LINE-HAUL COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Services/day | 136 | 334 | 136 | 1315 |
| Vehicle km/day | 1088 | 5978 | 2438 | 62088 |
| Variable cost/km($) | 0.44 | C.44 | 0.44 | 0.44 |
| Variable cost/day ($) | 479 | 2630 | 1073 | 27319 |
| Variable cost p.a. ($000) | 144 | 789 | 322 | 8196 |
| Peak vehicles | 7 | 37 | 15 | 61 |
| Peak vehicles incl. spares | 8 | 41 | 17 | 97 |
| Fixed cost per vehicle p.a.($000) | 4560 | 4560 | 4560 | 4560 |
| System costs p.a. ($000) | 36 | 187 | 78 | 1810 |
| Total operating cost p.a.($000) | 180 | 76 | 400 | 10006 |

Operating Costs for Private Motor Vehicles Used for Door-to-Door Trips

The private motor vehicle was assumed to travel 16,000km p.a. An average of 1.4 persons/vehicle and an average parking charge of $1/vehicle day was assumed. Therefore the costs/vehicle km are the same as those for 'kiss and ride' shown in Table B.22. The costs shown in Table B.32 are for the total trip, that is, for both collection and distribution and the line-haul phase.

TABLE B.32 - PRIVATE CAR COLLECTION AND DISTRIBUTION AND LINE-HAUL

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Route length (km) | 4 | 10 | 10 | 30 |
| Average trip length(km) | 3.5 | 6.5 | 6.5 | 16.5 |
| Pax trips/day('000) | 10 | 25 | 10 | 100 |
| Vehicle trips/day ('000) | 7.1 | 17.9 | 7.1 | 71.4 |
| Cost/vehicle km ($) | .074 | .074 | .074 | .074 |
| Operating cost/vehicle trip($) | 0.26 | 0.48 | 0.48 | 1.22 |
| Total cost/trip(1) ($) | 0.76 | 0.98 | 0.98 | 1.72 |
| System cost/day ($) | 5396 | 17542 | 6958 | 122808 |
| System cost p.a. ($) | 1619 | 5263 | 2081 | 36842 |

(1) Includes $0.50 parking fee per trip.

User Costs

Cost of Transfer Times: An average transfer time of 3 minutes and a waiting time equivalent to half the scheduled service interval was assumed for service intervals less than five minutes. For intervals of more than five minutes a waiting time of one fifth the service interval was adopted. Table B.33 shows the combined transfer and schedule delays for each line-haul mode. The cost of transfer time is included with the line-haul cost for presentational purposes.

TABLE B.33 - TRANSFER AND SCHEDULE DELAY

(hr)

| Period | Rail Routes | | | | Bus Routes | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B(1) | B(2) | C | A | B(1) | B(2) | C |
| 6 - 7am | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.09 | 0.15 | 0.06 |
| 7 - 9am | 0.10 | 0.09 | 0.10 | 0.09 | 0.07 | 0.06 | 0.07 | 0.05 |
| 9 - 4pm | 0.15 | 0.15 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 | 0.06 |
| 4 - 6pm | 0.10 | 0.09 | 0.10 | 0.09 | 0.07 | 0.06 | 0.07 | 0.05 |
| 6 - 10pm | 0.15 | 0.15 | 0.15 | 0.12 | 0.12 | 0.10 | 0.12 | 0.06 |

Collection/Distribution System Travel Time Cost: From the data given above the user time costs for the various systems are calculated and shown in Tables B.34 to B.38. Both 'park and ride' and 'kiss and ride' incur the same user cost, as they were both assumed to take the same length of time of .08 hr. Total Costs/ day/suburb are as follows:

| CORRIDOR | COST ($) |
|---|---|
| A&B(1) | 400 |
| B(2) | 160 |
| C | 520 |

and annual costs per suburb are as follows:

| CORRIDOR | COST ($'000) |
|---|---|
| A&B(1) | 120 |
| B(2) | 48 |
| C | 156 |

TABLE B.34 - ROUTE BUS COLLECTION/DISTRIBUTION SYSTEM USER TIME COSTS

| | Peak | | Off-Peak |
|---|---|---|---|
| CORRIDORS A&B(1) | | | |
| Daily passengers/suburb | 3100 | | 1900 |
| Walk distance (km) | .25 | | .25 |
| Walk speed (km/hr) | 5 | | 5 |
| Walk time (hr) | .05 | | .05 |
| Wait time (hr) | .05 | | .125 |
| Total walk time/wait time/pax (hr) | .10 | | .175 |
| Walk/wait time/suburb/day(hr) | 310 | | 333 |
| Journey time/pax (hr) | 0.14 | | 0.14 |
| Journey time/suburb/day(hr) | 434 | | 266 |
| Walk/wait cost/day ($) | | 1286 | |
| Journey time cost/day ($) | | 700 | |
| Total cost/suburb/day ($) | | 1986 | |
| Cost/suburb p.a. ($) | | 596,000 | |
| CORRIDOR B(2) | | | |
| Daily passengers/suburb | 1240 | | 760 |
| Walk distance (km) | .25 | | .25 |
| Walk speed (km/hr) | 5 | | 5 |
| Walk time (hr) | .05 | | .05 |
| Wait time (hr) | 0.125 | | 0.125 |

TABLE B.34 - CONTINUED

| | Peak | | Off-Peak |
|---|---|---|---|
| Total walk time/Wait time/pax (hr) | .175 | | 0.175 |
| Walk/wait time/suburb/day(hr) | 217 | | 133 |
| Journey time/pax (hr) | 0.14 | | 0.14 |
| Journey time/suburb/day(hr) | 174 | | 106 |
| Walk/wait cost/day ($) | | 700 | |
| Journey time cost/day ($) | | 280 | |
| Total cost/suburb/day ($) | | 980 | |
| Cost/suburb p.a. ($) | | 294,000 | |
| CORRIDOR C | | | |
| Daily passengers/suburb | 4030 | | 2470 |
| Walk distance (km) | .25 | | .25 |
| Walk speed (km/hr) | 5 | | 5 |
| Walk time (hr) | .05 | | .05 |
| Wait time (hr) | .04 | | .125 |
| Total walk time/wait time/pax (hr) | .09 | | .175 |
| Walk/wait time/suburb/day(hr) | 363 | | 432 |
| Journey time/pax (hr) | 0.14 | | 0.14 |
| Journey time/suburb/day(hr) | 564 | | 345 |
| Walk/wait cost/day ($) | | 1590 | |
| Journey time cost/day ($) | | 909 | |
| Total cost/suburb/day ($) | | 2499 | |
| Cost/suburb p.a. ($) | | 749,700 | |

TABLE B.35 - RAIL LINE-HAUL SYSTEM USER TIME COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Peak trips/day | 6200 | 15500 | 8200 | 62000 |
| Peak passenger transfer time(hr) | 0.10 | 0.09 | 0.10 | 0.09 |
| Off-peak trips/day | 3800 | 9500 | 3800 | 38000 |
| Off-peak passenger transfer time(hr) | 0.15 | 0.15 | 0.15 | 0.11 |
| Total transfer time/day(hr) | 1190 | 2820 | 1190 | 9760 |
| Average journey time (hr) | 0.09 | 0.17 | 0.17 | 0.46 |
| Total journey time/day (hr) | 860 | 4250 | 1700 | 46000 |
| User cost/day ($) | 3240 | 9890 | 4080 | 65520 |
| User cost p.a. ($000) | 972 | 2967 | 1224 | 19656 |

TABLE B.36 - ROUTE BUS LINE-HAUL USER TIME COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Peak trips/day | 6200 | 15500 | 6200 | 62000 |
| Transfer time (hr) | .07 | .06 | .07 | .05 |
| Off-peak trips/day | 3800 | 9500 | 3800 | 38000 |
| Transfer time (hr) | .11 | .10 | .11 | .06 |
| Total transfer time/day (hr) | 852 | 1880 | 852 | 5380 |
| Average route length (km) | 3 | 6 | 6 | 16 |
| Average journey time(hr) | .15 | .3 | .3 | .80 |
| Total journey time/day (hr) | 1500 | 7500 | 3000 | 80000 |
| User cost/day ($) | 3204 | 11260 | 4704 | 90760 |
| User cost/annum ($000) | 961 | 3378 | 1411 | 27228 |

TABLE B.37 - EXPRESS BUS LINE-HAUL USER TIME COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Total transfer time/day (hr) | 852 | 1880 | 852 | 5380 |
| Average trip length(km) | 3 | 6 | 6 | 16 |
| Average journey time at 32 km/hr(hr) | 0.09 | 0.19 | 0.19 | 0.5 |
| Total journey time (hr) | 900 | 4750 | 1900 | 50000 |
| User cost/day ($000) | 2604 | 8510 | 3604 | 60760 |
| User cost/annum ($000) | 781 | 2553 | 1081 | 18228 |

TABLE B.38 - MOTOR VEHICLE LINE-HAUL USER TIME COSTS

| | Corridor | | | |
|---|---|---|---|---|
| | A | B(1) | B(2) | C |
| Pax/day ('000) | 10 | 25 | 30 | 100 |
| Av. journey time (hr) | 0.1 | .19 | .19 | .41 |
| User cost/day ($'000) | 1 | 4.75 | 1.9 | 47 |
| User cost p.a. ($'000) | 300 | 1425 | 570 | 14100 |

## RESULTS AND DISCUSSION

Before discussing the results of this study some of the implications of the major concepts and assumptions upon which it is based need to be emphasised. Although an attempt was made to base the characteristics of the corridors considered upon conditions such as residential densities and demands that can be expected in an Australian city, it does not follow that these corridors accurately represent any specific parts of Australian cities. For instance, it is unlikely that different parts of a city with similar CBD attraction characteristics would have constant widths as typified in this study. In fact in many cases, corridor width varies directly with the distance from the CBD. This has important connotations regarding the route design of the public transport system, both for the line-haul and the collection/distribution systems.

Furthermore, the effect of traffic flowing across the corridor was not included except in so far as, the low average speeds assumed for the vehicles reflect the influence of cross traffic flows.

### Comparison of Alternative Collection/Distribution Systems

Table B.39 compares the operating and user costs of the three collection and distribution systems for all corridors included in the study. Additional comparisons are given in Figures B.3, B.4 and B.5. These comparisons show that for the medium density suburbs considered for corridors A and B(1) the route bus system is the cheapest. The 'park and ride' is slightly more expensive than the route bus regarding total costs with a much smaller user cost component.

The 'kiss and ride' system fares poorly compared with 'park and ride' since the latter's parking charges and lower utilisation are more than offset by the extra distance travelled and the time cost of the ferrying driver in the former. 'Kiss and ride'

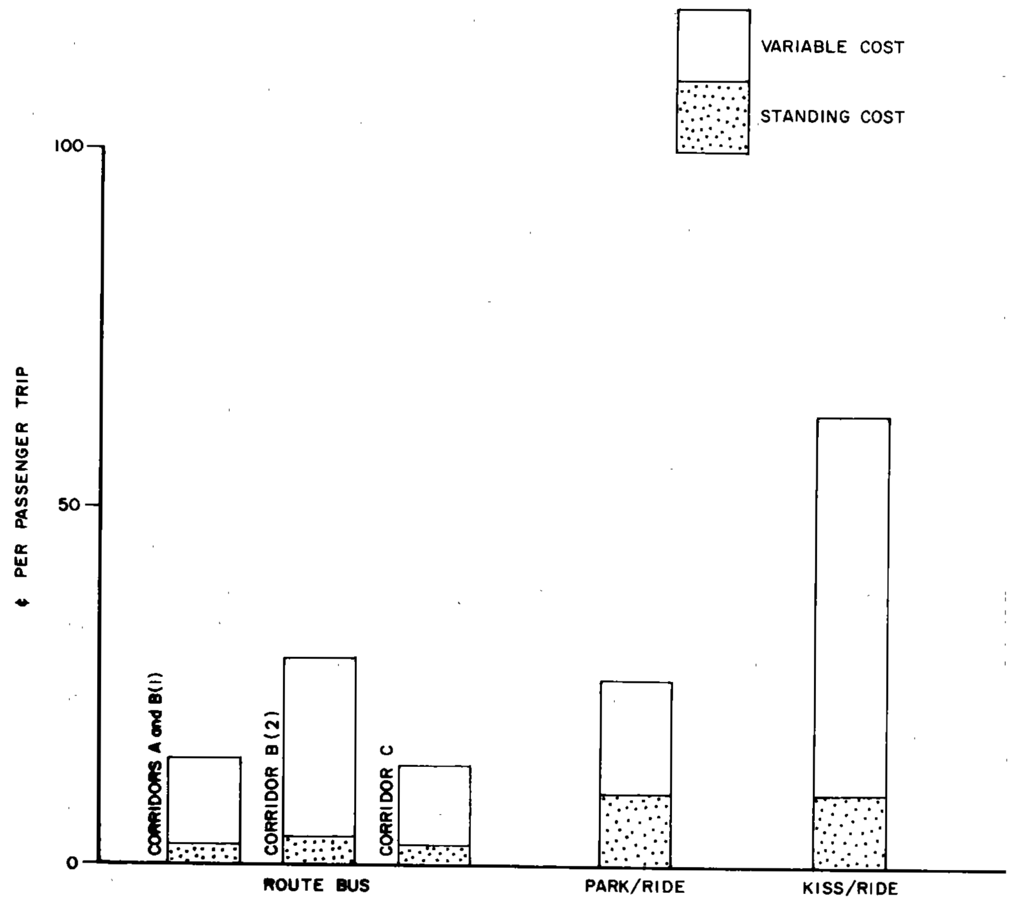


**FIGURE B-3**
**COLLECTION / DISTRIBUTION OPERATING COSTS**

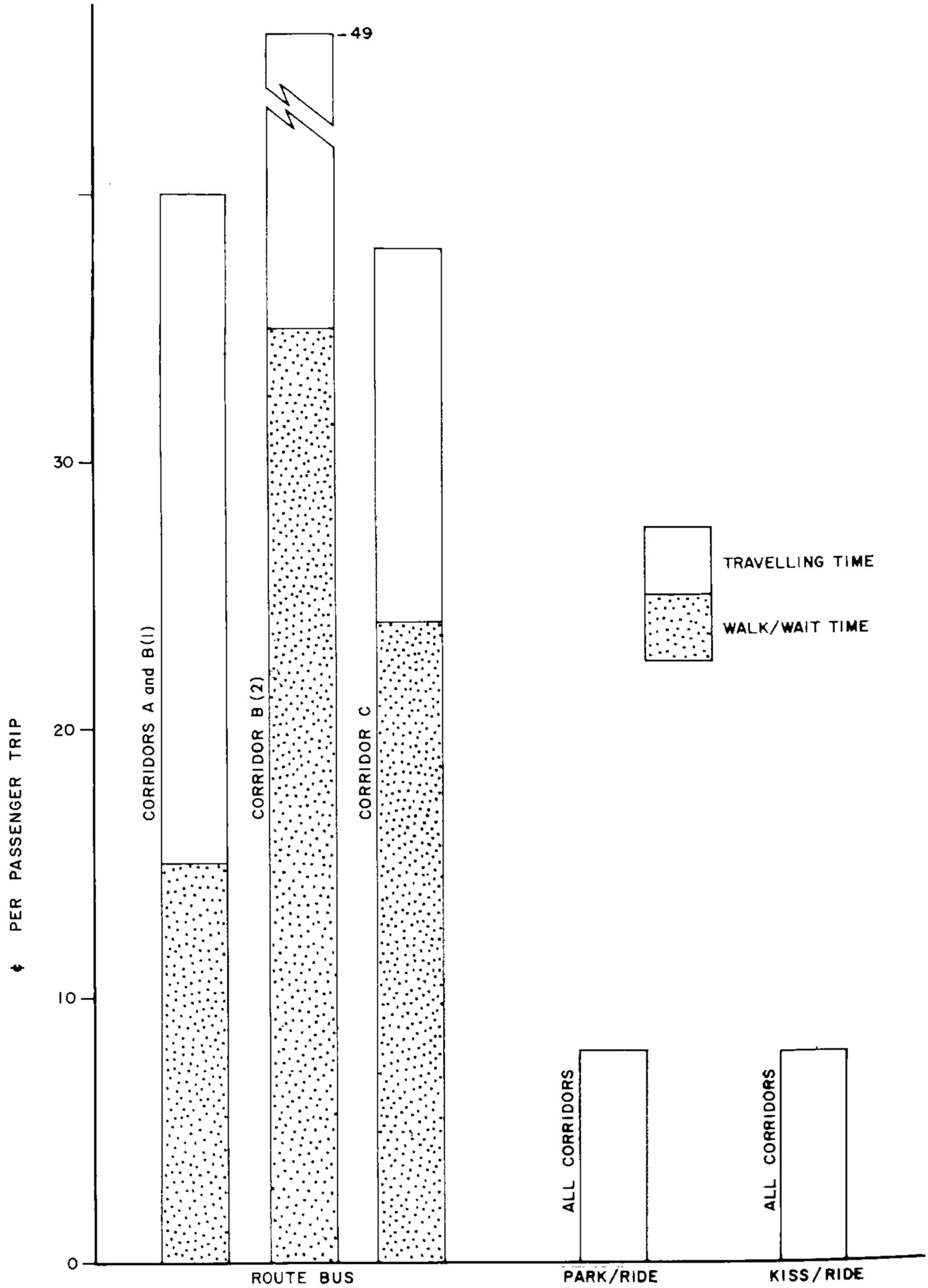


FIGURE B-4
COLLECTION / DISTRIBUTION USER COSTS

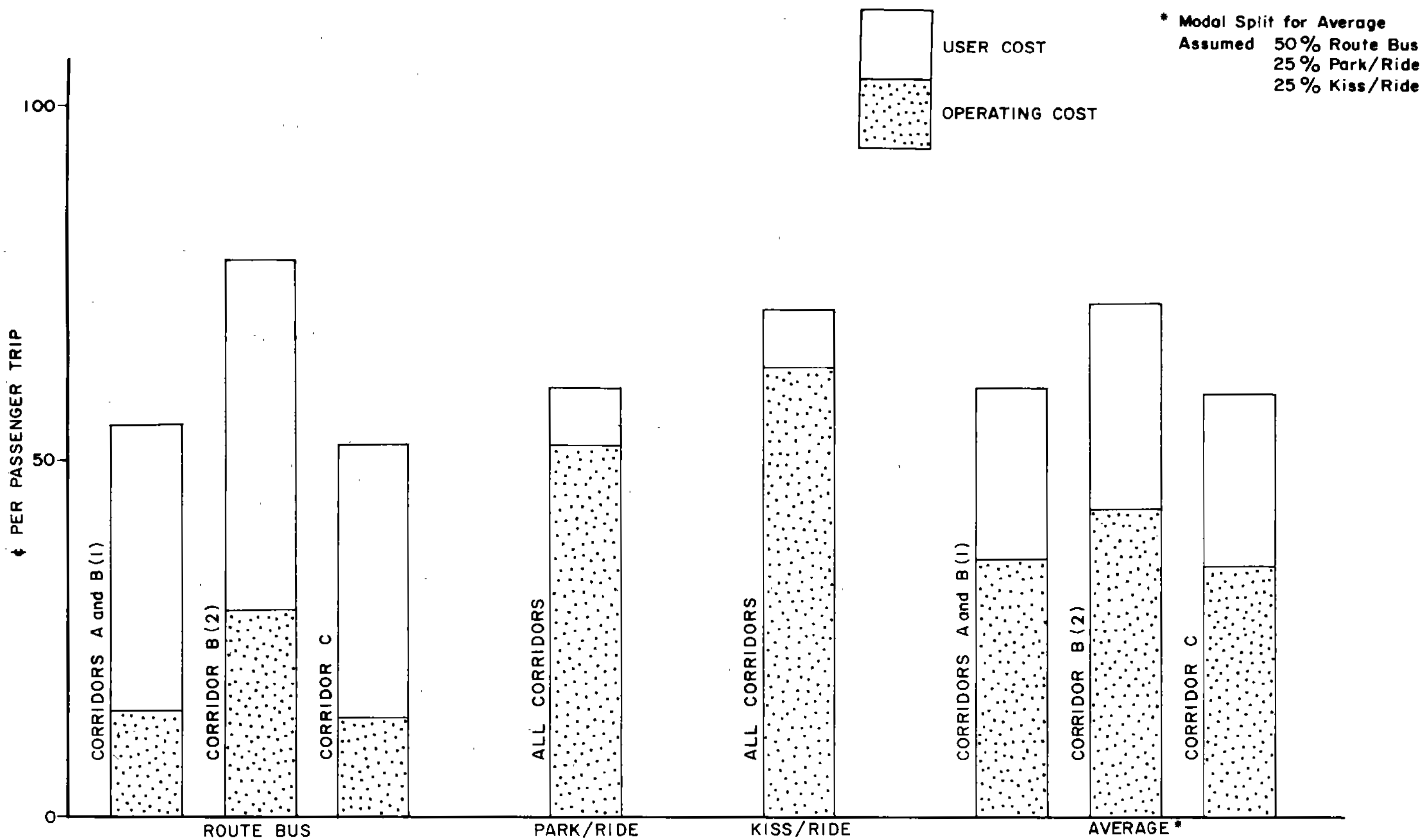


FIGURE B-5
COLLECTION / DISTRIBUTION TOTAL COSTS

becomes more favourable than 'park and ride' if the drivers time cost is not taken into account, and becomes cheaper than the route bus system in both operating and user cost terms if this use of the vehicle is truly marginal to other uses and bear none of the fixed costs of vehicle operation. For the denser corridor C, a similar result is obtained. With the less dense corridor B(2), the reduced bus frequency causes a rise in the user costs of the bus system. In this case 'park and ride' is the cheapest followed by 'kiss and ride' in terms of total system cost, but with respect to operation cost the ranking remains the same.

TABLE B.39 - ALTERNATIVE SYSTEM ANNUAL COSTS: COLLECTION AND DISTRIBUTION

| | Annual Cost ($'000) | | | Cost/ passenger journey ($) |
|---|---|---|---|---|
| | Operating | User | Total | |
| CORRIDORS A&B(1) | | | | |
| Route Bus | 229 | 596 | 825 | 0.55 |
| Park/ride | 780 | 120 | 900 | 0.60 |
| Kiss/ride | 945 | 120 | 1065 | 0.71 |
| CORRIDOR B(2) | | | | |
| Route Bus | 173 | 294 | 467 | 0.78 |
| Park/ride | 312 | 48 | 360 | 0.60 |
| Kiss/ride | 378 | 48 | 426 | 0.71 |
| CORRIDOR C | | | | |
| Route Bus | 257 | 750 | 1007 | 0.52 |
| Park/ride | 1014 | 156 | 1170 | 0.60 |
| Kiss/ride | 1229 | 156 | 1385 | 0.71 |

The corridor model employed results in the generation of relatively high levels of demand for transport services which largely explains the good performance of the route bus. However, if the demand is reduced, route bus costs cannot be reduced without a drastic reduction in services whereas the costs of the private car stay pretty well constant and its competitive position is improved. This is illustrated in Table B.39 with the less dense suburbs of corridor B(2).

The principal difference in the externalities that arise from the different systems analysed is the road congestion caused by private vehicles, particularly for cars parked in residential streets near line-haul interchanges. This has partly been taken into account by the inclusion of a parking charge of 20 cents. Further internalisation would result in the cost per journey of 'park and ride' becoming similar to 'kiss and ride' costs.

## Comparison of Alternative Line-Haul Systems

Table B.40 summarises the operating and user costs for the three mass transit line-haul systems as applied to each corridor defined above. The private motor vehicle and the taxi have not been included in this table as it was considered inappropriate to separate the collection and distribution costs from the line-haul costs of these options. The results should be interpreted with considerable caution as the user costs generally reflect the assumptions concerning operational speeds of the various modes.

TABLE B.40 - ANNUAL AND AVERAGE LINE-HAUL SYSTEM COSTS

| Corridor and Mode | Annual Cost ($'000) | | | Average cost per passenger journey ($) |
|---|---|---|---|---|
| | Operating | User | Total | |
| **CORRIDOR A** | | | | |
| Rail | 380 | 972 | 1352 | 0.45 |
| Route Bus | 244 | 961 | 1205 | 0.40 |
| Express Bus | 180 | 781 | 961 | 0.32 |
| **CORRIDOR B(1)** | | | | |
| Rail | 1348 | 2967 | 4315 | 0.58 |
| Route Bus | 1341 | 3378 | 4719 | 0.63 |
| Express Bus | 976 | 2553 | 3529 | 0.47 |
| **CORRIDOR B(2)** | | | | |
| Rail | 867 | 3224 | 2091 | 0.70 |
| Route Bus | 543 | 1411 | 1954 | 0.65 |
| Express Bus | 400 | 1081 | 1481 | 0.49 |
| **CORRIDOR C** | | | | |
| Rail | 8764 | 19656 | 28420 | 0.95 |
| Route Bus | 13708 | 27228 | 40936 | 1.36 |
| Express Bus | 10006 | 18228 | 28234 | 0.94 |

The rail and route bus modes are similar for corridor A, with the express bus being much less costly regarding total and operating costs. The situation is much the same for corridor B(1). For the longer corridor, C, the rail and the express bus modes incur similar total costs, although rail is less costly to operate. In the less heavily trafficked medium length corridor B(2), the express bus is cheapest both in terms of total cost and operating cost terms followed by the ordinary route bus.

The superiority of the express bus over the ordinary bus, in all cases, principally comes about because of the higher operating speed of the express bus. Such speed results in the achievement of a greater bus distance per driver hour, which in terms results in the need for fewer vehicles and a shorter journey-time for passengers. Express bus operation would, however, impose costs on other road users as some form of reserved lane or other priority measures would be required to ensure their rapid transit.

Figures B.6 and B.7 show the operating and user costs of the alternative mass transit and motor vehicle modes for the line-haul trip phase for the various corridors while total costs for this trip phase are shown in Figures B.8 to B.11 for corridors A, B(1), B(2) and C respectively.

The track capital costs associated with rail and bus modes have not been considered in the results presented above. The situation is postulated in which the track has already been constructed and the costs associated with it are regarded as sunk. The necessity to build new track for a railway would increase annual operating costs by about 50 per cent in the case of corridor A and 15 per cent in the case of Corridor C. Including the track capital costs shown in Table B.29 would result in a total cost for rail only slightly higher than that for bus in Corridor C. This is principally due to the high traffic flow assumed in this corridor. If a flow of 50,000 persons, instead of 100,000 is

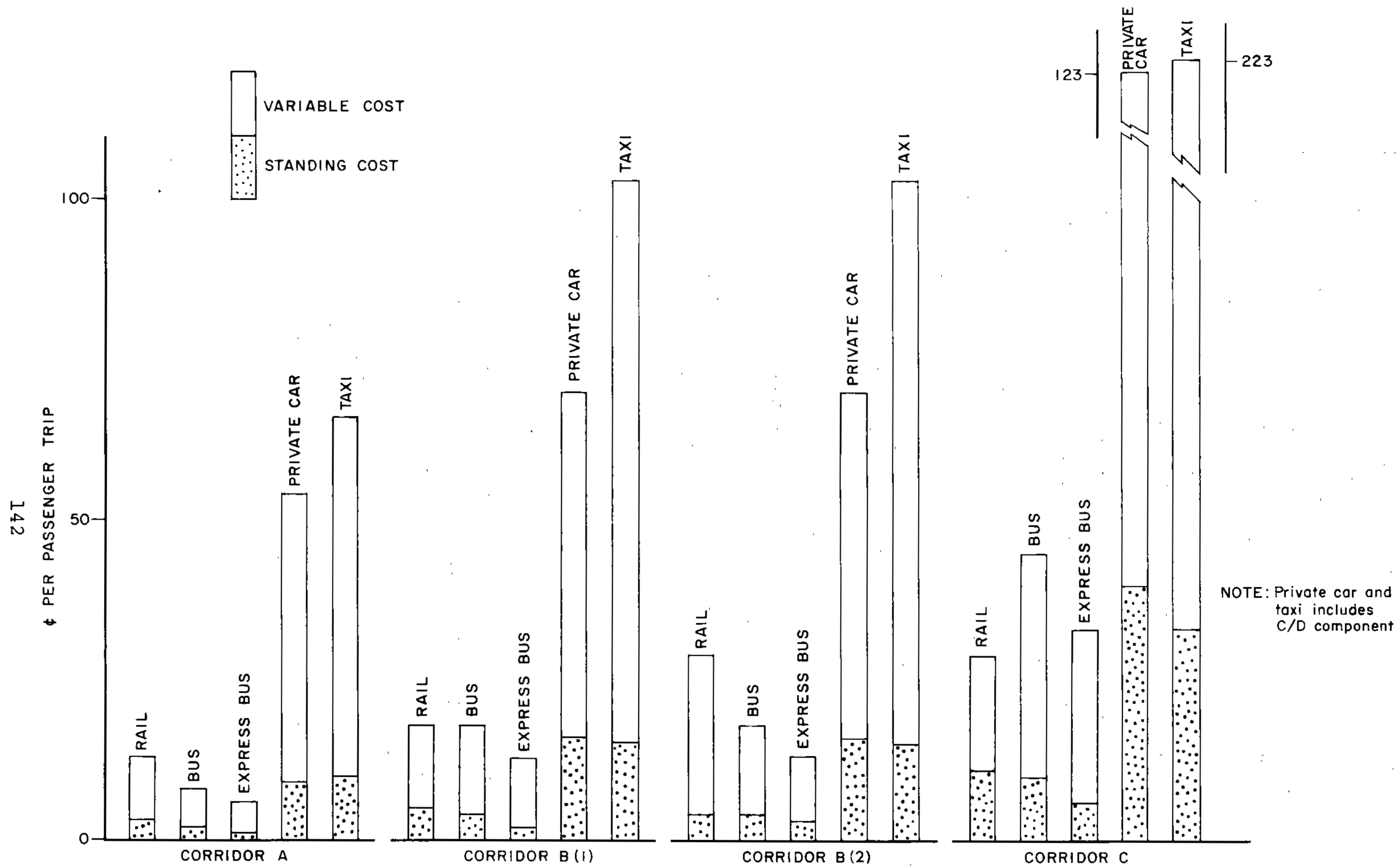


FIGURE B·6
LINE-HAUL OPERATING COSTS

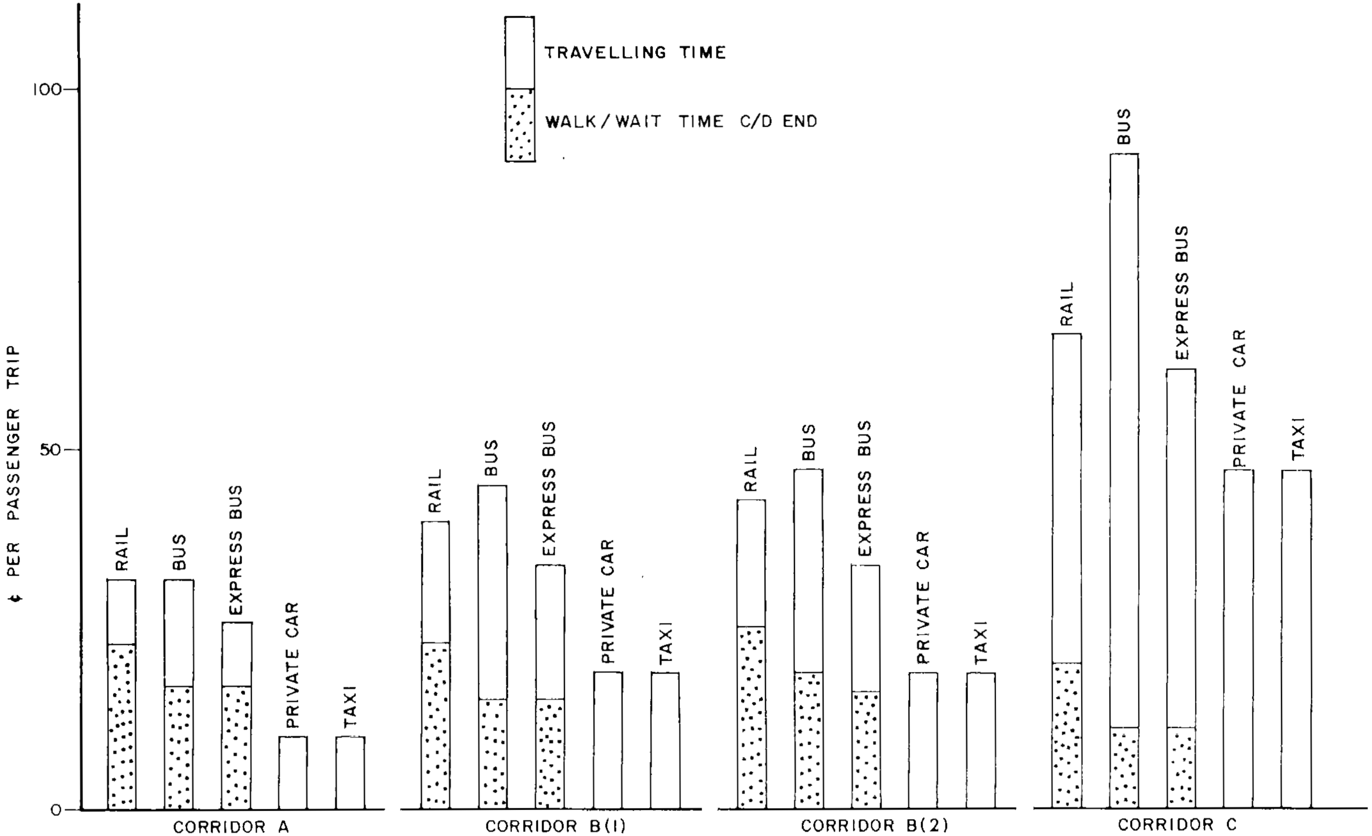


FIGURE B·7
LINE-HAUL USER COSTS

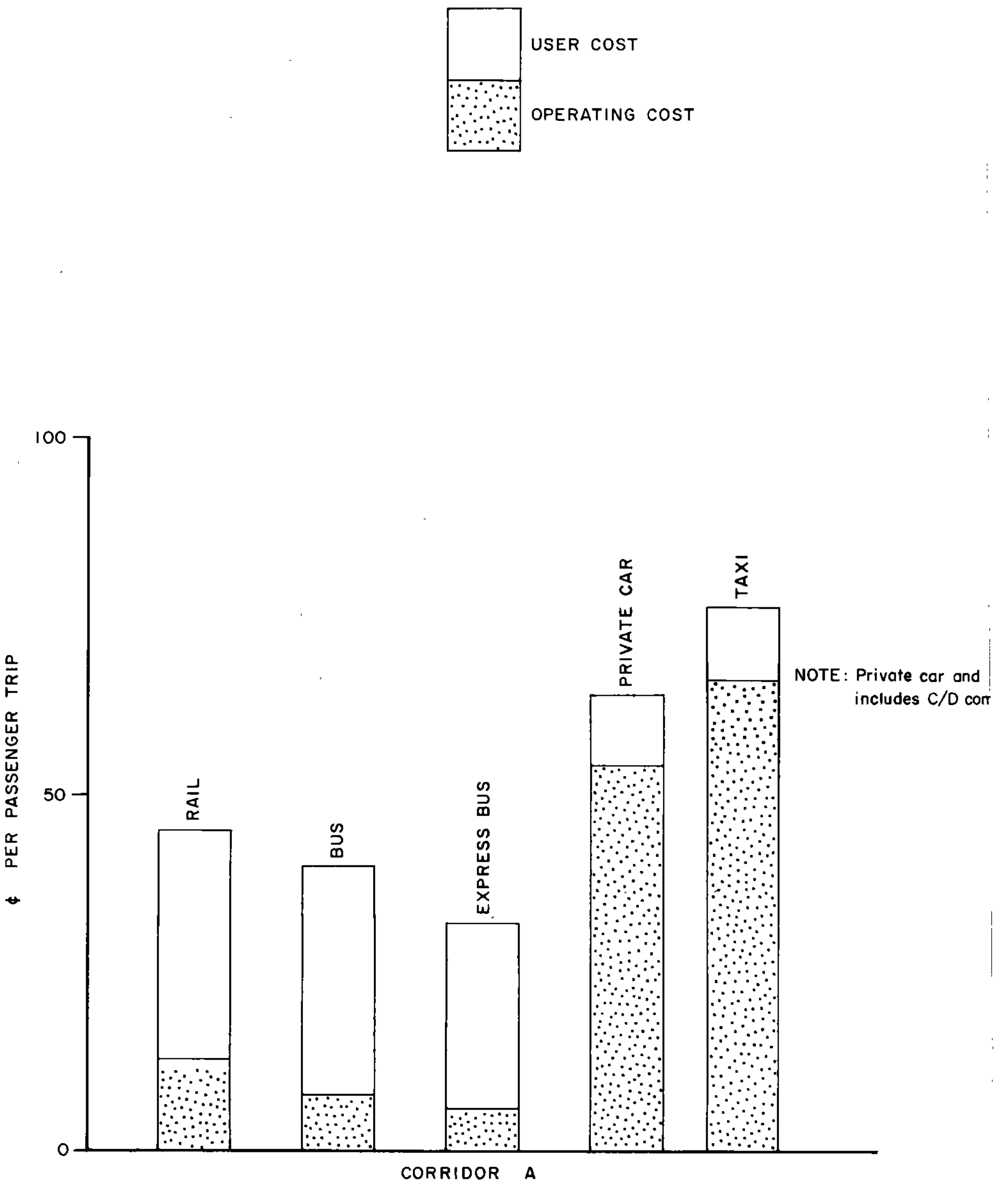


FIGURE B-8
LINE-HAUL TOTAL COSTS

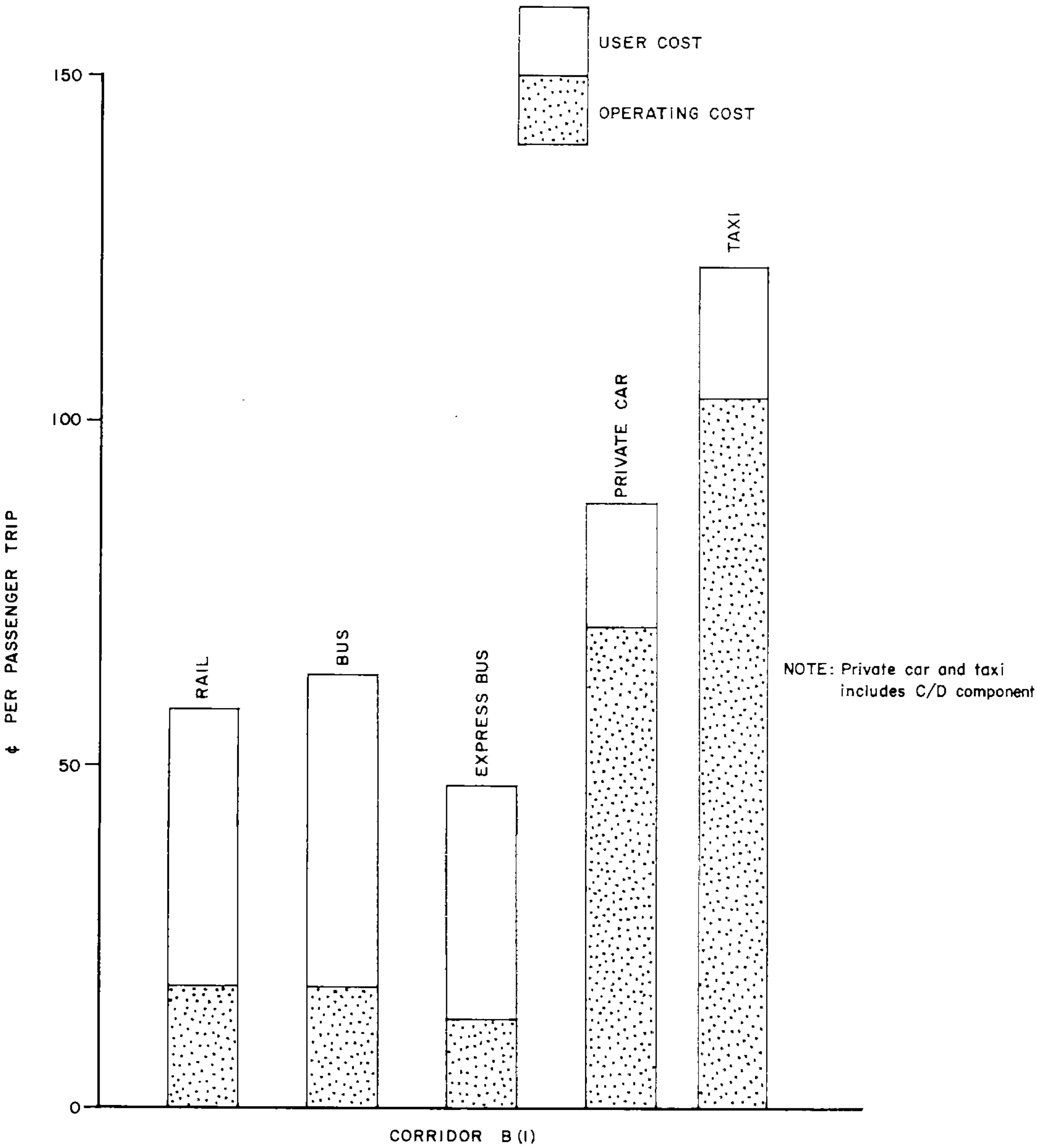


FIGURE B-9
LINE-HAUL TOTAL COSTS

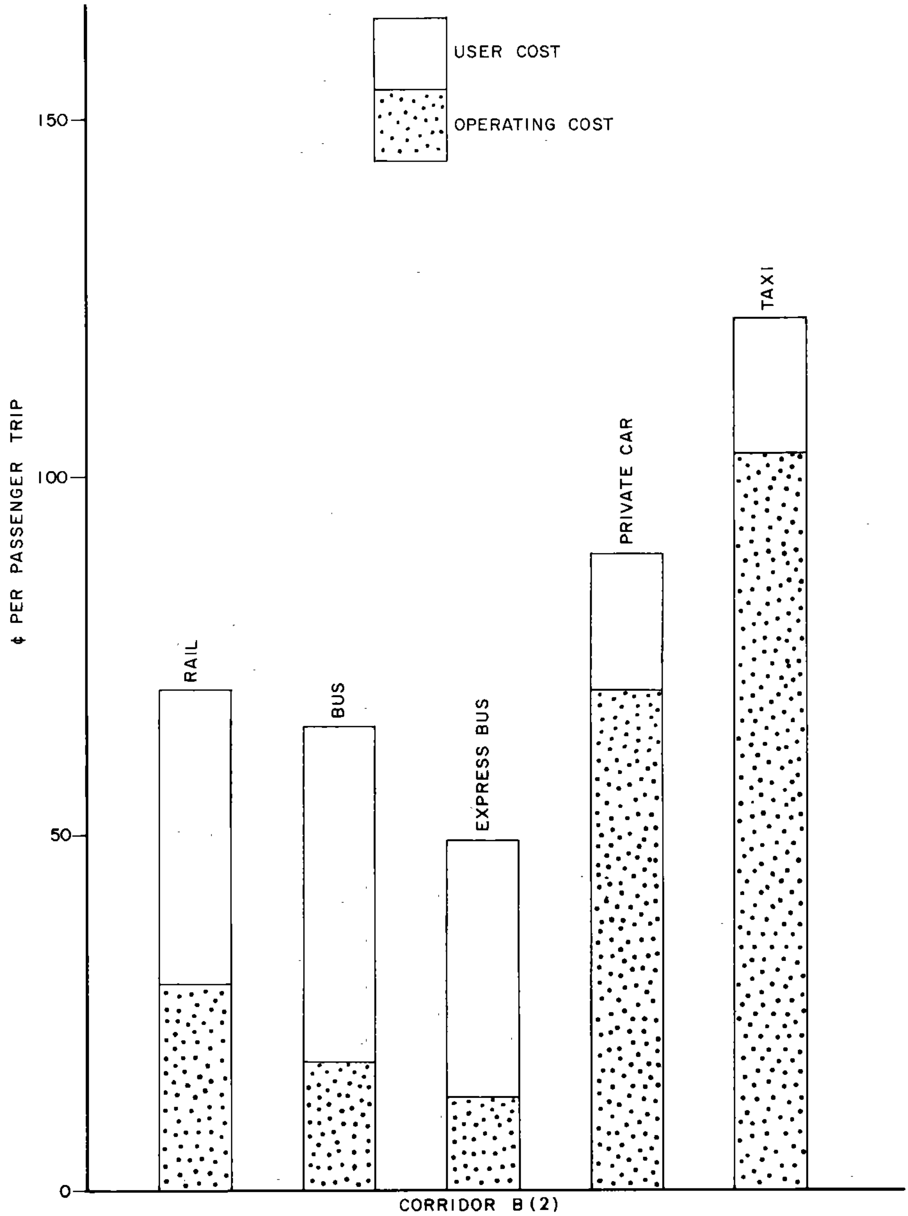


FIGURE B-10
LINE-HAUL TOTAL COSTS

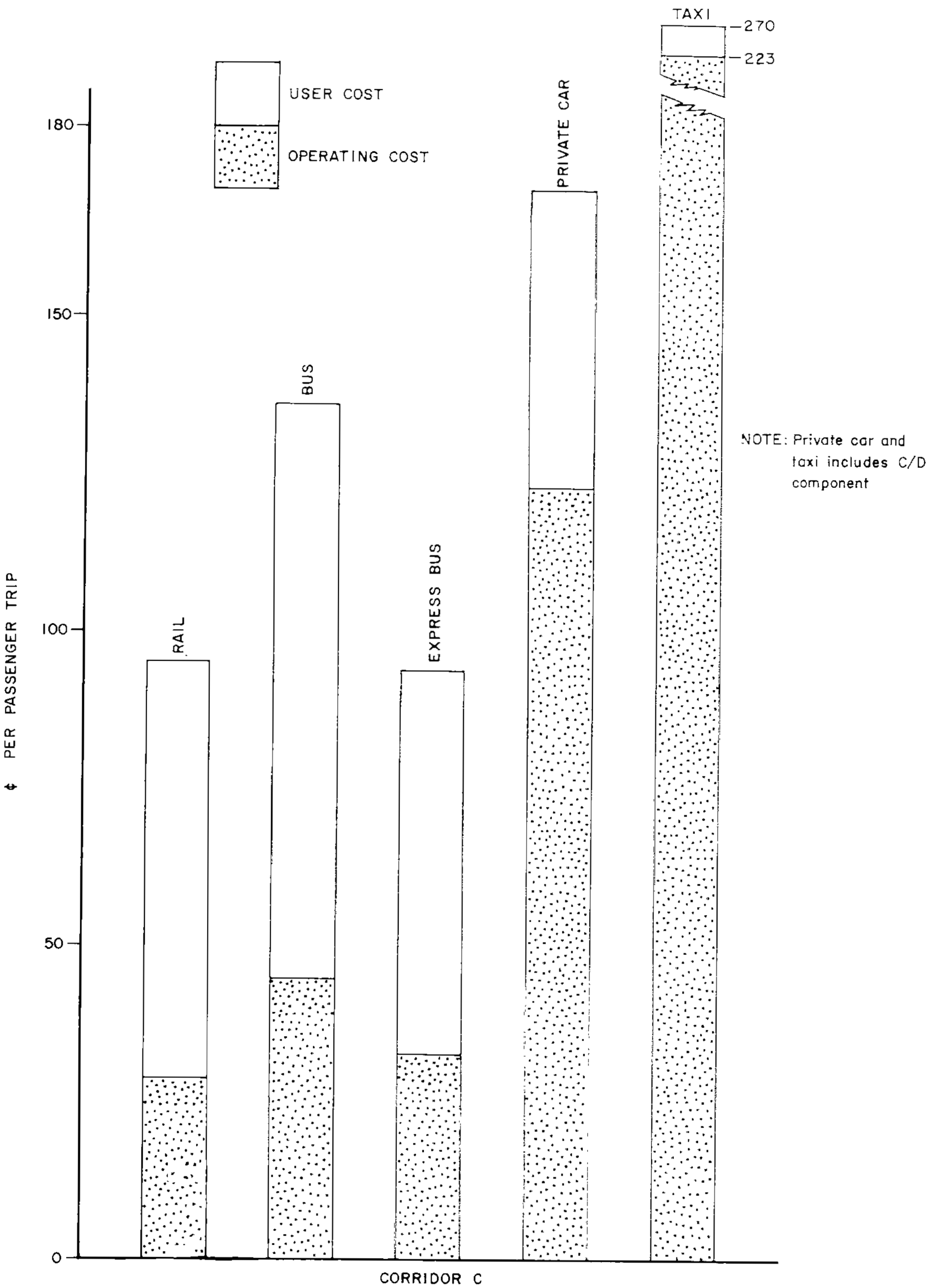


FIGURE B·11
LINE-HAUL TOTAL COSTS

considered in this corridor the annual per capita track cost is immediately doubled and the express bus becomes superior. This can be seen by comparing the results of corridors B(1) and B(2).

The inclusion of an allowance for road track capital costs in bus system costs is unlikely to increase the total costs by more than an equivalent of 5 cents/vehicle km. Based on a $1 million/lane km cost equivalent, capital charges are $120,000 per annum if spread over 10,000 vehicles per day for 300 days per annum. This cost on a per passenger basis is unlikely to add more than 10 per cent to total bus system costs.

The principal externalities of line-haul operations are congestion caused to other road users by the bus and car modes and the effects of arterial road and rail construction and use of these facilities on the non-users. The former cost can be estimated by costing the increase in congestion caused by additional traffic. However, this was not practicable for this study. With respect to the latter the analysis has implicitly assumed that some form of traffic management scheme is introduced to enable successful express bus operation. Such action will result in extra congestion being imposed upon other road users, both private and public vehicles.

The effects of arterial road construction and operation upon the population in general have been examined in the United Kingdom in some depth. Six problem areas have been identified:

- loss of householder surplus
- house price depreciation
- disamenity during construction
- severance upon construction
- vehicle noise
- vehicle pollution.

While several conclusions can be reached from the results of the investigation, firm recommendations cannot be drawn from the study because of the uncertainty arising from its general nature, in particular, the appropriateness of the assumptions made concerning the nature of the system. However, the general impact of the various modes upon other road users and the general population is summarised in Table B.41.

TABLE B.41 - THE EXTENT OF EXTERNALITIES

| | Rail | Bus | Express Bus | Car |
|---|---|---|---|---|
| Road congestion | Nil | Low | Medium | High |
| Construction problems | High | Medium (1) | Medium (1) | High |
| Vehicle Noise | High | Medium (1) | Medium (1) | High |
| Vehicle pollution | Low | Medium (1) | Medium (1) | High |
| Effect on house prices | Unknown | Unknown | Unknown | Probably negative |

(1) Both bus modes are ascribed only a share of road externalities.

## Comparison of Total System Costs

Table B.42 and Figures B.12 to B.15 show the average trip cost for each mode for each of the four corridors considered. These results assume a modal split for the collection/distribution phase of trips taken by mass transit modes of 25 per cent, 25 per cent and 50 per cent of traffic respectively to 'park and ride', 'kiss and ride' and route bus. The results are also based on equivalent collection/distribution costs at the high density end of the trip. It is considered that this assumption disadvantages the taxi, especially in the short corridor where the taxi could be slightly cheaper than the private car, principally due to the absence of parking costs.

Notwithstanding the reservations mentioned above, the private car is the least cost mode of travel in corridor A. For corridor B(1) the car was also shown to be the cheapest mode, followed by the express bus, rail, with the route bus and taxi being nearly equivalent. The higher operating costs of the private car compared to the public transport modes on a per passenger basis, were offset by reduced user costs.

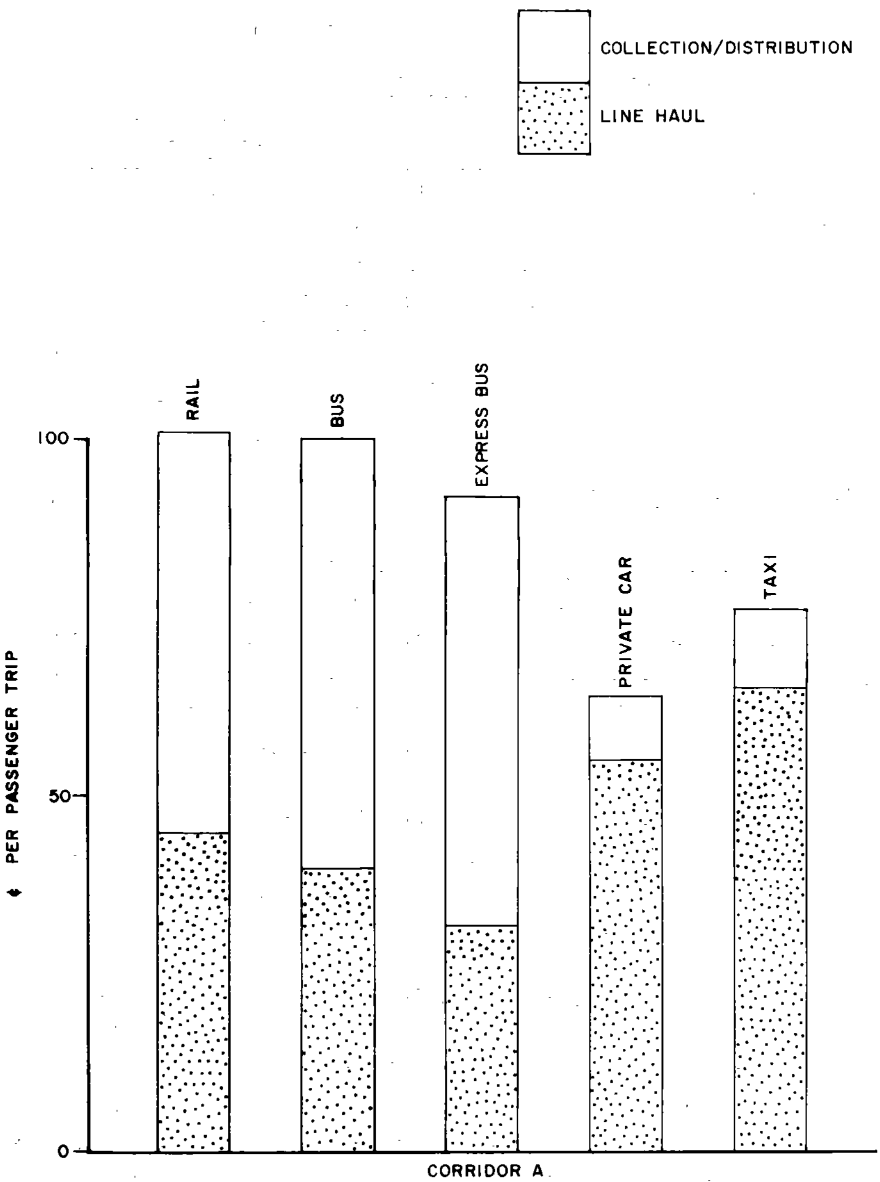


**FIGURE B-12**
**TOTAL COSTS**
**LINE-HAUL AND COLLECTION / DISTRIBUTION**

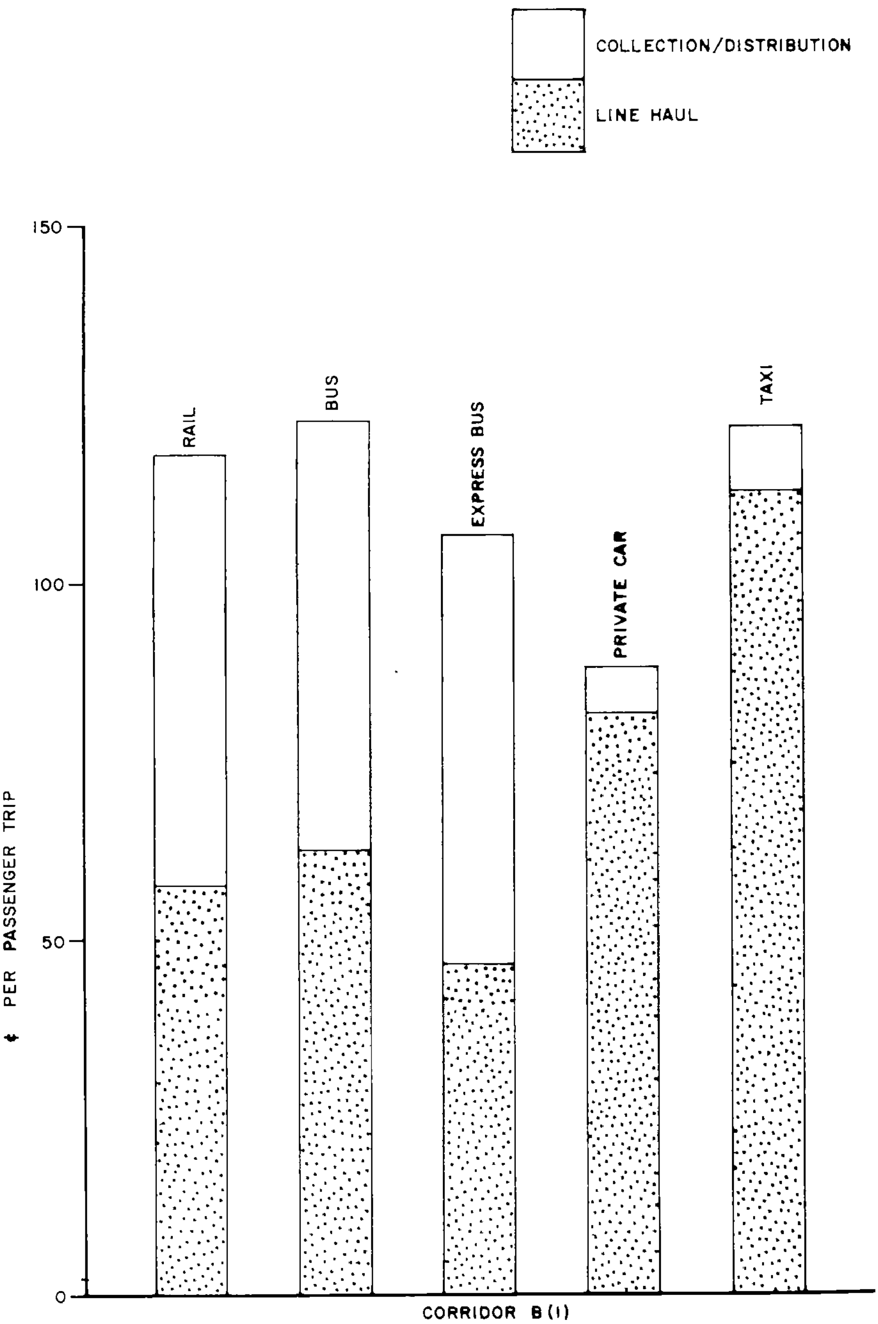


FIGURE B·13
TOTAL COSTS
LINE-HAUL AND COLLECTION / DISTRIBUTION

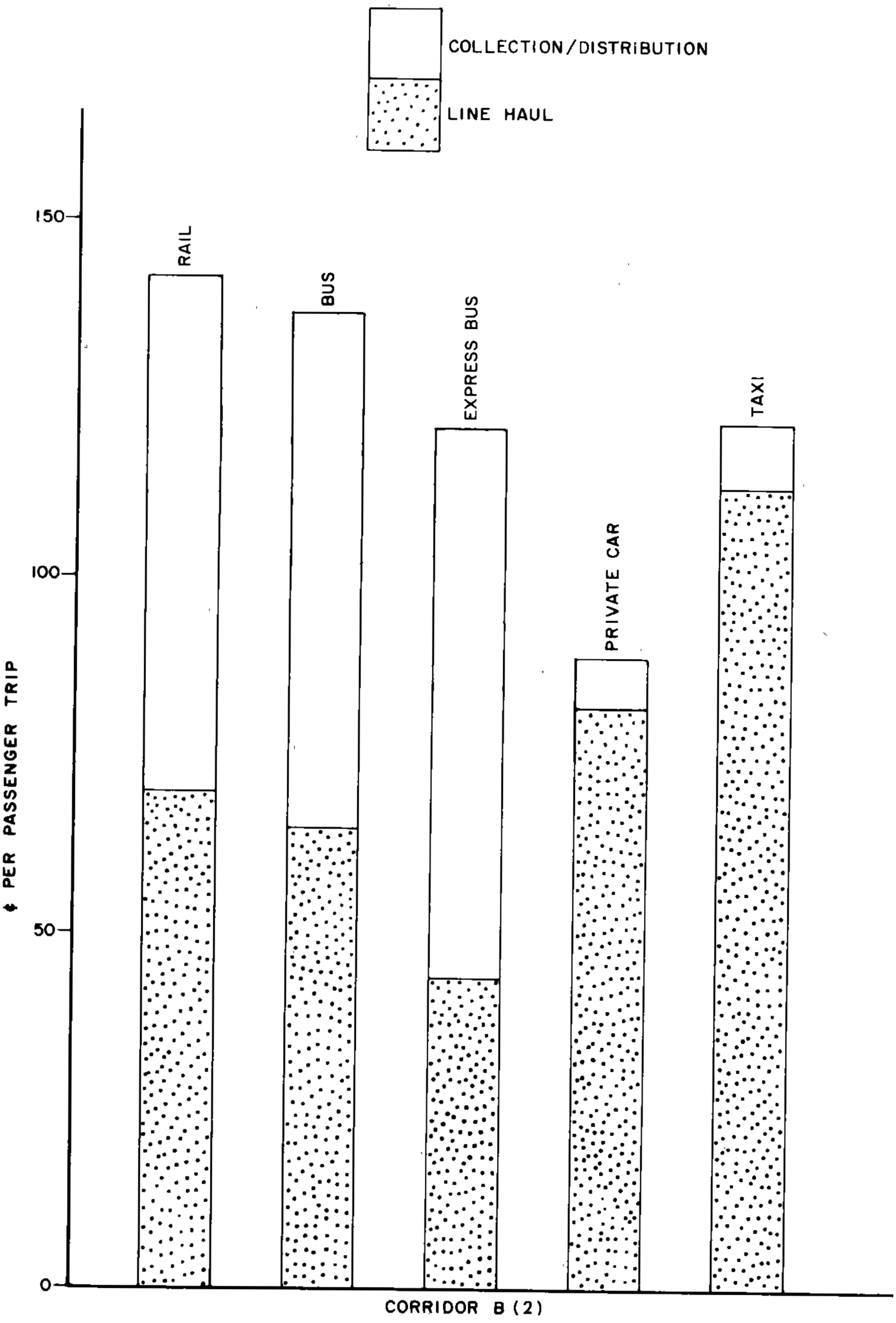


FIGURE B-14
TOTAL COSTS
LINE-HAUL AND COLLECTION / DISTRIBUTION

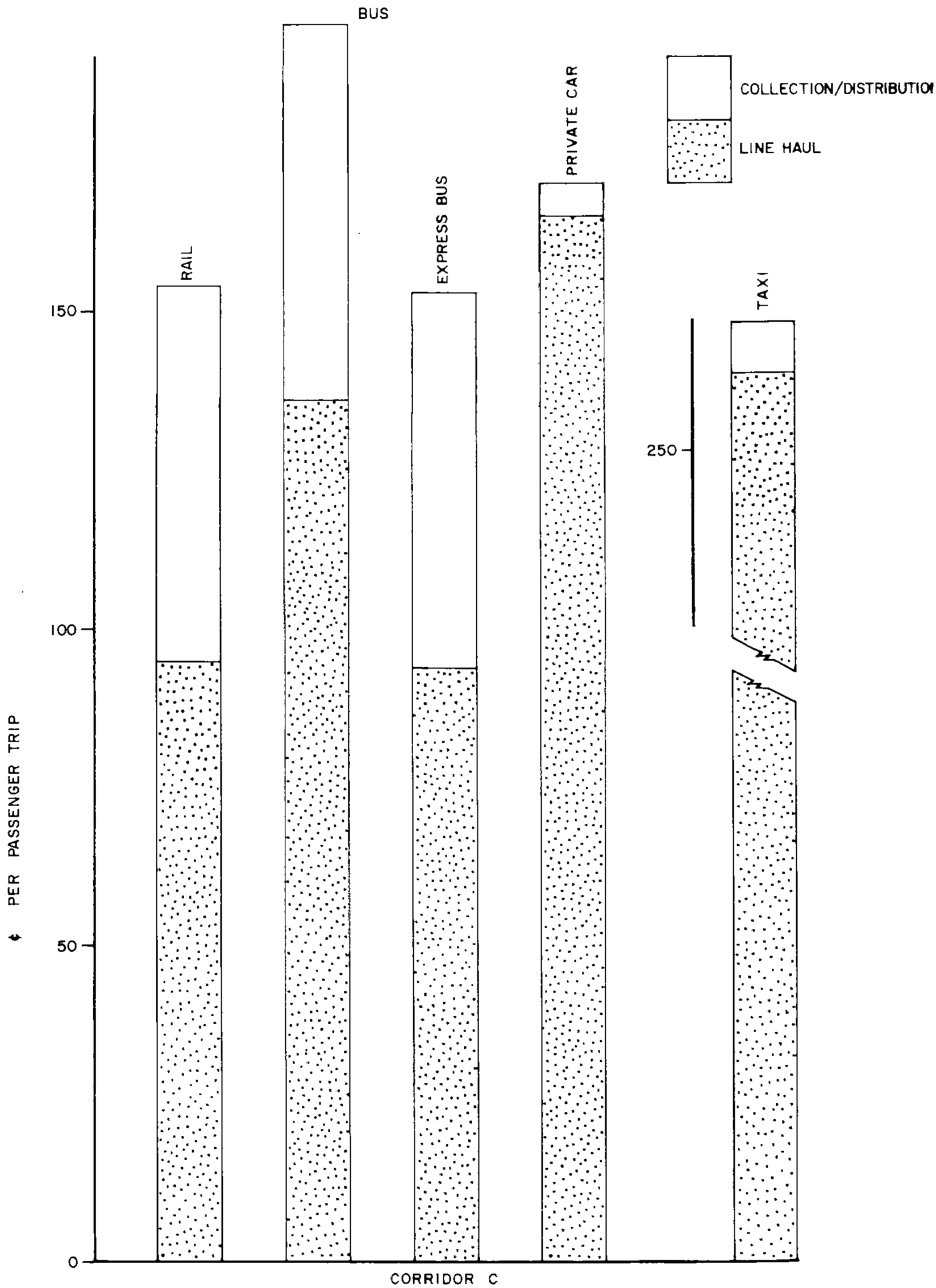


FIGURE B-15
TOTAL COSTS
LINE-HAUL AND COLLECTION / DISTRIBUTION

TABLE B.42 - AVERAGE TOTAL SYSTEM COSTS

| Corridor | Mode | Average Cost/Passenger Journey ($) |
|---|---|---|
| A | Rail | 1.05 |
| | Route bus | 1.00 |
| | Express Bus | 0.92 |
| | Car | 0.64 |
| | Taxi | 0.76 |
| B(1) | Rail | 1.18 |
| | Route Bus | 1.23 |
| | Express Bus | 1.07 |
| | Car | 0.89 |
| | Taxi | 1.22 |
| B(2) | Rail | 1.42 |
| | Route Bus | 1.37 |
| | Express Bus | 1.21 |
| | Car | 0.89 |
| | Taxi | 1.22 |
| C | Rail | 1.54 |
| | Route Bus | 1.95 |
| | Express Bus | 1.53 |
| | Car | 1.70 |
| | Taxi | 2.70 |

Express bus and rail are approximately equivalent least costly modes in Corridor C, followed by the car.

For the less heavily trafficked, medium length corridor B(2), the private car incurs the least cost followed by the express bus and the taxi.

SOME GENERAL COMMENTS

This study has attempted to obtain some insight into the relative costs of alternative transport systems. The model employed for the analyses is a much simplified simulation of what are very complicated corridor systems in practice. The overall results should be regarded as indicative of potentialities for the various modes in alternative situations rather than prescriptive of what would actually pertain in any practical situation. However, the similarity of the results obtained to those of Meyer, Kain and Wohl[1] tends to lend support to their validity. It also tends to suggest that U.S. urban transport experience could be directly applicable in the Australian context.

The possibilities for the development of para-transit schemes can be gauged from the results. The favourable results of the taxi in Corridor A and to a lesser extent in corridor B(2), coupled with the cheapness of the private car for corridors A, B(1) and B(2)indicates that any increase in the load factors of cars will further enhance their competitive position. In fact, closer examination of Table B.42 soon reveals that increases in load factors, through say car-pooling or multiple pricing could make the car, or taxi the units of least cost for all cases considered. This conclusion effectively supports the work of Richardson[2] who concluded that car pooling in the inner suburbs of Melbourne was a viable alternative to the public system. Such a solution will not necessarily incur a higher energy consumption use than the urban public transport options. A simple extension of the work of Howard P. Ross & Associates[3] reveals that with the load factors envisaged, the energy consumption of the private car would be similar to that of commuter rail. Other institutional and social objections to such systems are being overcome[4], and with some capital and a great deal of enterprise, such para-transit system could become a reality and be very cost effective.

The results of this study also lend support to the establishment of bus priority measures such as those reported by Robertson and Vincent[5]. Such measures are necessary since it is difficult to

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(1) Meyer, J.R., Kain, J.F., and Wohl, M., op.cit.
(2) Richardson, A.J., "Car Pooling: A People-Mover for Melbourne", Transport in the Years Ahead Seminar, Institute of Engineers, Melbourne, 1975.
(3) Referred to in Anon., "Mass Transit Energy Consumption", Transportation, Volume 4, No. 2 July 1975, PP 183.
(4) Refer to the project NMT 75/7 Car Pooling on a Geographic basis, Transport (Research & Planning) Act, 1974.
(5) Robertson, R.I. and Vincent, R.M., Bus Priority in a Network of Fixed-Time signals, Department of the Environment TRRL Report 666, Crowthorne 1975 (Transport & Road Research Laboratory).

increase bus speeds by improving the speed performance of the bus by design because of the limitations that must be placed on acceleration and deceleration rates to meet passenger safety and comfort requirements.

APPENDIX B.1 - TRANSPORTATION STUDIES REFERRED TO FOR DATA

Geelong Transportation Study - Survey and Travel Characteristics, Wilbur Smith & Associates, November, 1970.

Melbourne Transport Study, Vol. 1; Survey, Wilbur Smith & Associates, and Len T. Frazer and Associates, July 1969.

Perth Regional Transport Study, 1970.

Report on Metropolitan Adelaide Transportation Study, de Leuw Cather and Co., Rankine and Hill, Alan M. Voorhees & Associates, Inc., June 1968.

Sydney Area Transportation Study, SATS Volume, Base Year (1971), Data Report, Sydney 1974.

# ANNEX C

## POPULATION FORECASTS

An important determinant of demand for urban transport is the growth in population of urban regions. The population projections considered by the National Population Inquiry[1] (referred to as the Borrie Commission) to be the "most likely" are the bases for the forecasts presented here. These projections embody growth rates which are substantially below growth rates experienced in the 1960's and they are below previous population forecasts.[2] The forecasts assume that recent downward movements in net reproduction rates and overseas immigration levels are not short term phenomena but are indicative of longer term trends.

The Borrie Commission's first concern was with projections of total population. But projections were also made for major urban areas with a population over 100,000 persons. The Borrie projections extend to the year 2001. The major interest of this report however, is with forecasts to 1981.

DEFINITIONS

One concept of an urban area has been defined by the Australian Bureau of Statistics to be a bounded area with a minimum population density of 311 persons per square km, having a minimum population of 1,000 persons, and being separated from other urban areas by more than 3.2 kms by the shortest route by road or rail. For the derivation of the population tables shown in this report, this definition was altered to include only those centres having a population of over 40,000 persons in 1971. In this Annex the urban areas so defined are called urban centres. Urban centres do not have rigid boundaries but are dynamic in character expanding as the population moves outward.

(1) First report of the National Population Inquiry, Population and Australia: A Demographic Analysis and Projection, A.G.P.S., Canberra, 1975.
(2) Australian Bureau of Statistics, Projection of the Population of Australia, States and Territories, Dec. 1971.

Another definition of an urban area has been used by the CBR and the Borrie Commission and in the main text of this report. The ABS Statistical Divisions and Statistical Districts provide boundaries for capital cities and large provincial cities respectively and these are normally used to define fixed urban areas. The urban centre definition must be used for urban areas other than capital cities and large provincial cities since the fixed boundaries of smaller provincial cities relate to a smaller area than the urban centre definition. The reverse is true for capital and large provincial cities where the Statistical Division or District is larger than the urban centre. The boundaries are fixed so that they circumscribe an area which is socially and economically oriented toward the urban centre. The resultant areas defined by the statistical boundaries for the larger cities and urban centres for the smaller cities will be termed <u>urban areas</u> in keeping with the terminology of the CBR[1] and the Borrie Commission.

A complete list of urban centres and urban areas with their projected growth rates is provided in Table C.5. An examination of this table shows that no urban area is projected to grow faster than the corresponding urban centre. The faster growth of urban centres over urban areas occurs as a result of the relatively slow growth of the periphery of Statistical Divisions and Districts compared with the dynamic nature of an urban centre.

The choice of definitions depends on the purpose for which the population projections are required since urban centres and urban areas have differing characteristics. The urban centres are 'built-up' urban areas such that heavy concentrations of people exist toward the periphery as well as in the inner areas. Outer parts of urban areas tend to be rural in nature and are often designated as green belt areas. The 'built-up' urban areas of both definitions, of course, have the same transport characteristics but these differ from the characteristics in the outer

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(1) Commonwealth Bureau of Roads, (1975), <u>op. cit</u>, p. 25.

TABLE C.1 - TRENDS AND PROJECTIONS OF AUSTRALIAN POPULATION

| Year | Population ('000) | Growth Rate (% per annum) |
|---|---|---|
| 1961 | 10548 | |
| | | 1.81 |
| 1966 | 11550 | |
| | | 1.99 |
| 1971 | 12756 | |
| | | 1.30 |
| 1976 | 13614 | |
| | | 1.13 |
| 1981 | 14406 | |
| | | 1.12 |
| 1986 | 15235 | |
| | | 1.06 |
| 1991 | 16063 | |
| | | 0.91 |
| 1996 | 16865 | |
| | | 0.87 |
| 2001 | 17612 | |

Sources: (1) Australian Bureau of Statistics, Official Year Book of Australia, Canberra, 1973.
(2) First Report of the National Population Inquiry, Population and Australia: A Demographic Analysis and Projection, AGPS, Canberra, 1975, p. 281.

TABLE C.2 - PROJECTED POPULATIONS, STATES AND TERRITORIES

('000)

| State | 1966 | 1971 | 1981 | 1991 | 2001 |
|---|---|---|---|---|---|
| New South Wales | 4237.9 | 4601.2 | 5103.2 | 5589.4 | 6014.7 |
| Victoria | 3220.2 | 3502.4 | 3857.4 | 4192.5 | 4477.1 |
| Queensland | 1674.3 | 1827.1 | 2117.5 | 2398.1 | 2681.6 |
| South Australia | 1095.0 | 1173.7 | 1261.1 | 1332.8 | 1369.6 |
| Western Australia | 848.1 | 1030.5 | 1260.8 | 1528.2 | 1809.3 |
| Tasmania | 371.4 | 390.4 | 417.9 | 445.5 | 462.4 |
| Northern Territory | 56.5 | 86.4 | 129.1 | 180.1 | 241.6 |
| A.C.T. | 96.0 | 144.1 | 259.5 | 396.0 | 555.5 |
| TOTAL | 11599.5 | 12755.6 | 14406.2 | 16062.6 | 17611.8 |

Source: First Report of the National Population Inquiry, Population and Australia: A Demographic Analysis and Projection, AGPS, Canberra, 1975, p. 428.

districts of the urban areas. In the outer districts the road network is less dense and has more of the characteristics of rural networks than urban networks. Although the CBR have included them in the urban roads category, a distinction is made between them and inner urban roads for modelling purposes.[1] Public transport is of very minor significance in the rural periphery of the urban areas.

POPULATION FORECASTS

The Borrie Commission tabulated projected populations based on alternative sets of assumptions regarding fertility and overseas immigration rates. They then examined the likely trends of the components of fertility and immigration to develop a set of 'most likely' assumptions. The assumptions thought to be most likely were a decline in the net reproduction rate to 1.0 by 1976 and a net gain of 50,000 persons per year from immigration. The projections derived for Australia, together with associated growth rates and historic trends, are given in Table C.1.

Having projected the Australian population, the Borrie Commission examined historic patterns of internal and overseas migration in order to distribute the growth of the population amongst the States. A table of interstate migrations for the period 1966 to 1971 was developed. These were used as a basis for determining future migration trends. Net immigration to Australia was distributed according to historic patterns.[2] The resultant projected population distribution by State is contained in Table C.2.

With regard to within State population distributions, the Borrie Commission only provided projections for major urban areas[3].

(1) Ibid, p. 31.
(2) A more complete description of the methodology is given in Borrie Commission, op. cit., pp. 310-312.
(3) "Major urban areas" referred to by the Borrie Commission are the urban Statistical Divisions and Districts with a population over 100,000 (viz., Capital Cities, and Newcastle, Wollongong and Geelong).

The Commission discussed two possible methods of distributing State growth to these areas. The first assumed that major urban areas retain their 1971 proportions of State population throughout the projection period, that is, that no rural to major urban drift will occur. The second assumes that the proportion of the projected population increase attributed to the major urban areas in each State is in accordance with the trends displayed between 1966 and 1971, that is, that the urban drift will continue. Clearly, the forecasts for major urban areas depend on which of these is regarded as the most likely. The future of the growth centres[1] is of importance in making this choice.

It has been suggested that the influence of growth centres on the population growth of the major urban areas in toto would be relatively small, even under the most optimistic assumptions about their future performance.[2] This is particularly true in the short term. Furthermore "...The slowing down of the whole national growth pattern may well effect new city development more severely than the growth of existing cities"[3]. The growth centres that are likely to be most successful, especially in the short term, are those whose growth is largely self generated and have been growing strongly over the period 1966 to 1971. For these reasons the second of Borrie's assumptions, which assumes a continuation of the drift to the major urban areas observed between 1966 and 1971, has been used in this report.

As noted above, the Borrie Commission did not provide projections for urban areas with populations less than 100,000. However, the approach described above has been employed to develop population forecasts for all urban areas. In addition, forecasts have been prepared for urban centres[4] on the same basis.

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(1) Growth centres are towns and small cities which are developing, or intending to be developed, rapidly. Some are designated as such by Governments which actively promote accelerated growth (e.g. Albury/Wodonga). Others have natural features which attract migrants (e.g. Gold Coast).

(2) Borrie, op. cit., pp. 424, 425, 435, 436.

(3) Borrie, op. cit., p. 436.

(4) As defined earlier.

The population forecasts for urban areas and urban centres by State, together with historic changes, are given in Tables C.3 and C.4 respectively. Forecasts for individual cities are given in Table C.5.

The forecasts for urban areas given in Table C.3 differ somewhat from those used by the CBR in their 1975 report on Australian roads. The CBR projections were prepared before the Borrie Report was released and are generally higher. The growth rates embodied in the BTE and CBR projections are compared in Table C.6.

The significance of the assumptions employed by the Borrie Commission can be illustrated by comparing the resultant population forecasts with a projection based on a simple extrapolation of historic trends. The forecast average growth rate for population in urban areas between 1971 and 1981 is 1.5 per cent per annum and the population forecast for 1981 is 10.59 million. The average rate of growth for these areas between 1961 and 1971 was 2.4 per cent per annum which is 0.9 of a percentage point higher than the forecast based on Borrie. A continuation of this rate would result in a population of 11.64 million in 1981 which would be 10 per cent higher than the Borrie forecast for that year.

Preliminary population figures from the 1976 Census for some Statistical Divisions are available. The growth rates they imply for the period 1971 to 1976 are shown in Table C.7 together with the 1961 to 1971 growth rates and the forecast rates for 1971 to 1981 for purposes of comparison.

Actual growth between 1971 and 1976 has been 1.20 per cent per annum and Borrie's projected growth between 1971 and 1981 is 1.13 per cent per annum. The 1971 to 1981 rates are expected to be lower than the 1971 to 1976 rates because of the assumed decline in the net reproduction rates until 1976.

TABLE C.3 - GROWTH IN POPULATION OF URBAN AREAS[1]

| State and Territory | Urban Population ('000) | | | Urban Growth Rate (%p.a.) | | |
|---|---|---|---|---|---|---|
| | 1961[2] | 1971[2] | 1981 | 1961-71 | 1971-81 | 1961-81 |
| New South Wales | 2738 | 3359 | 3788 | 2.0 | 1.2 | 1.6 |
| Victoria | 2186 | 2730 | 3094 | 2.2 | 1.3 | 1.7 |
| Queensland | 879 | 1144 | 1402 | 2.6 | 2.0 | 2.3 |
| South Australia | 659 | 843 | 922 | 2.5 | 0.9 | 1.7 |
| Western Australia | 475 | 703 | 885 | 3.9 | 2.3 | 3.1 |
| Tasmania | 187 | 215 | 235 | 1.4 | 0.9 | 1.1 |
| Total | 7124 | 8994 | 10326 | 2.3 | 1.4 | 1.9 |
| A.C.T. | 56 | 159 | 260 | 10.4 | 4.9 | 7.7 |
| TOTAL | 7180 | 9153 | 10586 | 2.4 | 1.5 | 1.9 |

(1) See text for definition of urban areas.
(2) Figures obtained from Australian Bureau of Statistics, Population: Principal Cities and Towns, 1961 and 1971.

TABLE C.4 - GROWTH IN POPULATION OF URBAN CENTRES (1)

| State and Territory | Urban Population ('000) | | | Urban Growth Rate (% p.a.) | | |
|---|---|---|---|---|---|---|
| | 1961 (2) | 1971 (2) | 1981 | 1961-71 | 1971-81 | 1961-81 |
| New South Wales | 2524 | 3161 | 3601 | 2.3 | 1.3 | 1.8 |
| Victoria | 2099 | 2614 | 2994 | 2.2 | 1.4 | 1.8 |
| Queensland | 808 | 1094 | 1388 | 3.0 | 2.4 | 2.7 |
| South Australia | 588 | 809 | 900 | 3.2 | 1.1 | 2.1 |
| Western Australia | 420 | 642 | 821 | 4.2 | 2.5 | 3.4 |
| Tasmania | 173 | 192 | 210 | 1.0 | 0.9 | 1.0 |
| Total | 6612 | 8360 | 9913 | 2.4 | 1.7 | 2.0 |
| A.C.T. | 56 | 159 | 260 | 10.4 | 4.9 | 7.7 |
| TOTAL | 6668 | 8512 | 10173 | 2.4 | 1.8 | 2.1 |

(1) See text for definition of urban centres.
(2) Figures obtained from Australian Bureau of Statistics, Population: Principal Cities and Towns, 1961 and 1971.

TABLE C.5 - GROWTH IN POPULATION BY LOCATION

| Location | Urban Centres[1] | | | Urban Areas[1] | | |
|---|---|---|---|---|---|---|
| | 1971[2] ('000) | 1981 ('000) | %p.a. | 1971[2] ('000) | 1981 ('000) | %p.a. |
| Sydney | 2725 | 3109 | 1.3 | 2808 | 3175 | 1.2 |
| Newcastle | 250 | 273 | 0.9 | 352 | 385 | 0.9 |
| Wollongong | 186 | 219 | 1.6 | 199 | 229 | 1.4 |
| Melbourne | 2394 | 2753 | 1.4 | 2503 | 2846 | 1.3 |
| Geelong | 115 | 128 | 1.1 | 122 | 136 | 1.1 |
| Ballarat | 59 | 61 | 0.5 | 59 | 61 | 0.5 |
| Bendigo | 46 | 51 | 1.0 | 46 | 51 | 1.0 |
| Brisbane | 818 | 1062 | 2.6 | 868 | 1076 | 2.2 |
| Townsville | 75 | 96 | 3.3 | 75 | 96 | 3.3 |
| Toowoomba | 58 | 70 | 2.0 | 58 | 70 | 2.0 |
| Gold Coast | 74 | 106 | 4.3 | 74 | 106 | 4.3 |
| Rockhampton | 48 | 55 | 1.4 | 48 | 55 | 1.4 |
| Adelaide | 809 | 900 | 1.1 | 843 | 922 | 0.9 |
| Perth | 642 | 821 | 2.5 | 703 | 885 | 2.3 |
| Hobart | 130 | 145 | 1.1 | 153 | 170 | 1.1 |
| Launceston | 62 | 65 | 0.4 | 62 | 65 | 0.4 |

(1) See text for definitions.
(2) Figures obtained from Australian Bureau of Statistics, Population: Principal Cities and Towns, 1971.

TABLE C.6 - AVERAGE ANNUAL GROWTH RATES FOR PERIOD 1971-81 EMBODIED IN BTE AND CBR POPULATION PROJECTIONS

(% p.a.)

| State and Territory | BTE [(1)] | CBR [(2)] |
|---|---|---|
| New South Wales | 1.2 | 1.5 |
| Victoria | 1.3 | 2.1 |
| Queensland | 2.0 | 1.8 |
| South Australia | 0.9 | 2.0 |
| Western Australia | 2.5 | 2.8 |
| Tasmania | 0.9 | 1.9 |
| Total | 1.4 | 1.9 |
| A.C.T. | 4.9 | 6.0 |
| TOTAL | 1.5 | 2.0 |

(1) Based on projections shown in Table C.3.
(2) Based on population projections given in Commonwealth Bureau of Roads, Report on Roads in Australia 1975, Melbourne, December 1975, p. 109.

TABLE C.7 - COMPARISON OF FORECAST GROWTH RATES WITH HISTORIC CENSUS DATA

(% p.a.)

| Statistical Division | 1961-71 | 1971-76 | Projected [(a)] 1971-81 |
|---|---|---|---|
| Sydney | 2.04 | 0.38 | 1.23 |
| Newcastle | 1.67 | 0.64 | 0.90 |
| Wollongong | 2.80 | 1.18 | 1.40 |
| Melbourne | 2.32 | 0.79 | 1.28 |
| Geelong | 1.39 | 2.02 | 1.09 |
| Brisbane | 2.25 | 1.97 | 2.15 |
| Adelaide | 2.46 | 1.32 | 0.90 |
| Perth | 3.91 | 2.72 | 2.30 |
| Hobart | 1.63 | 1.15 | 1.06 |

(1) Based on the assumption that the rural-urban drift experienced in the period 1966-71 will continue.

The 1971 to 1976 growth rates for the major cities are substantially lower than the 1961 to 1971 rates with the exception of Geelong which increased and Brisbane which fell only slightly.

The Census data indicates a redistribution of the population from large conurbations to the smaller urban areas. Sydney and Melbourne have had the lowest growth rates of all the major cities between 1971 and 1976 and their growth rates have decreased rather more dramatically than was forecast.

## ANNEX D

## DERIVATION OF URBAN PUBLIC TRANSPORT CAPITAL INVESTMENT NEEDS

### DELINEATION AND EVALUATION OF INVESTMENT NEEDS

In previous evaluations undertaken by the BTE(1) the procedure adopted has been to take a list of projects formally proposed by that projects be completely defined and that they have reached a planning stage where detailed cost estimates can be provided. In most instances, State planning authorities have not developed detailed plans for projects intended to be undertaken in the period 1977-78 to 1979-80 and so a different approach was adopted.

In deriving urban public transport capital investment needs a five stage procedure was used:

- examination of State Capital city urban public transport systems to identify weaknesses and problem areas and to define projects to overcome these;
- production of order-of-cost estimates for the projects;
- estimation of the economic merits of each project based upon the results of previous BTE evaluations of a wide range of similar projects;
- combination of economically warranted projects into a coherent program of investment for each State;
- adjustment of the timing of projects to give a reasonable profile of the needs for funds and to allow for limitations to the physical resources available within each State.

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(1) a. Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June 1972.
b. Bureau of Transport Economics, A Review of Public Transport Investment Proposals for Australian Cities 1973-74, Canberra, August 1973.
c. Bureau of Transport Economics, A Review of Public Transport Investment Proposals for Australian Cities 1974-75, Canberra, April 1975.

## Program of Capital Works and Associated Costs

The first step in defining urban public transport capital investment needs was to examine the investment programs submitted by the States for Australian government support during the period 1972 to 1975, and those projects being undertaken by the States without Australian government support(1). Using this as a basis it was possible to identify many projects that follow logically from those already underway or planned in detail. Extension of railway electrification, provision of additional services, provision of busways, replacement and addition of rolling stock, bus priority measures, etc., can be foreshadowed with some degree of confidence from existing projects.

In addition, much of the current urban public transport planning being undertaken by State authorities is based upon the results and recommendations of major transport studies(2).

Using these studies and the known line of development adopted by State planning authorities it was possible to identify a series of projects likely to be undertaken towards the end of the present decade.

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(1) For example the Eastern Suburbs Railway in Sydney and the Melbourne Underground Rail Loop.

(2) a. Sydney Area Transportation Study, May 1974

b. Melbourne Transportation Committee, Melbourne Transportation Study Volume 3: The Transportation Plan, December 1969

c. Wilbur Smith and Associates, South-East Queensland Brisbane Region Public Transport Study, April 1970

d. De Leuw Cather of Australia, Rankine and Hill and Alan M. Voorhees and Assoc. Inc., Report on Metropolitan Adelaide Transportation Study, June 1968

e. Perth Regional Transport Study 1970, January 1971

f. Wilbur Smith and Associates, Perth Central City Railway Feasibility Study, 1974

The next step was to make estimates of the cost and timing of each project. The usual process of establishing preliminary engineering designs as a basis for estimation was not possible because of time constraints and so order-of-cost estimates were made. These were based on the unit costs of projects of a similar nature that had previously been costed. Timing for new projects was similarly based on that actually achieved for projects of a similar nature and magnitude.

At the completion of this stage, the list of projects developed and the associated cost estimates were discussed informally with State authorities to ensure that they were in reasonable accord with State planning objectives. The resulting list of projects is shown in Table D.1.

Project Evaluation

The most accurate method of determining the economic merit of a range of alternative public transport projects is to evaluate each project individually. However, there was insufficient time available in which to carry out a detailed evaluation of each of the public transport improvement projects identified in Table D.1. An alternative way of obtaining an indication of the economic justification of those projects was therefore required.

TABLE D.1 - PROJECTS CONSIDERED IN FORMULATING THE 1977-78 to 1979-80 CAPITAL INVESTMENT NEEDS

| State, Mode and Project Type | Project Name |
|---|---|
| NEW SOUTH WALES | |
| RAILWAY | |
| . Additional Track: | North Sydney-Gordon, Cabramatta-Campbelltown |
| . Electrification: | Gosford-Newcastle (planning) |
| . Signalling: | Broadmeadow-Newcastle area. |

TABLE D.1 - CONTINUED

| State, Mode and Project Type | Project Name |
|---|---|
| . Rolling Stock: | Suburban DD cars (202 motor, 67 trailer, 100 driving trailer), Suburban DD cars (conversion of 33 trailer), Inter-urban DD cars (25 motor, 24 trailer). |
| . New Routes: | East Hills-Glenfield. |
| . Miscellaneous: | Rail/bus interchange, Public address at metrop. stations, Central city sub-station, Improved station facilities (Macquarie), Sectioning hut modernisation, Flemington workshop improvements, Microwave radio (Sydney-Newcastle), Carparks at stations, Canterbury footbridge renewal, Escalators at Central, Concrete sleepers, Exterior painting of trains, Digital train signs, Provision of wheel slip controls on rail cars, Modernisation of sub-stations Workshop buildings, Plant and equipment stores and buildings, Amenities, Lewisham sub-station upgrading, Sefton sub-station upgrading, Caringbah sub-station upgrading. |
| BUS | |
| . Busway: | Bus priority lanes, exclusive bus lanes. |
| . Rolling Stock: | New buses (600) |
| . Miscellaneous: | Belmont bus depot bus parking, Twin ram hydraulic hoists, Terminal facilities, Passenger shelters (Newcastle), Hamilton bus washing unit, Additional fuel storage Newcastle |
| TRAM | |
| . Route upgrading: | nil |
| . Rolling stock: | nil |
| . Miscellaneous: | Pitt Street tramway (planning) |
| FERRY | |
| . Vessels: | Replacement ferries (3), Additional ferries (3), Borragoola and North Head ferry replacement, Hydrofoils for Manly (2) |
| . Miscellaneous: | Ferry/bus interchanges |
| MISCELLANEOUS | Bus/rail/ferry transfer terminals Newcastle-Wollongong minor projects. |

TABLE D.1 - CONTINUED

| State, Mode and Project Type | Project Name |
|---|---|
| VICTORIA | |
| RAILWAY | |
| . Additional Track: | Box Hill - Ringwood, Caulfied-Oakleigh, Victoria Park-Jolimont, Clifton Hill-Westgarth, Model lines, Little River-Corio, Footscray-Newport, Kensington-Essendon, South side of Viaduct. |
| . Electrification: | Newport-Werribee, Frankston-Mornington, St. Albans-Sunbury, Broadmeadow-Craigieburn, Sunshine-Melton. |
| . Signalling: | Improvements to Clifton Hill-Epping line, Improvements to Hurstbridge line, Improvements to Upfield line. |
| . Rolling Stock: | Train replacements, Additional trains for specific lines. |
| . New routes: | Altona-Westona (construction only) |
| . Miscellaneous: | Major interchanges at Frankston, Box Hill, Ringwood, Dandenong, Carparks at Stations, End door communication (Harris trains), Modification of Tait trains, New Stations construction, Refurbishing Geelong line carriages Jolimont workshop extension, Workshop extensions and improvements. |
| BUS | |
| . Busway: | Nil |
| . Rolling stock: | Bus purchases for fleet expansion, Private bus replacements. |
| . Miscellaneous: | Depots and workshops, Two-way radios in buses, Automatic Ticketing machines. |
| TRAM | |
| . Route Upgrading: | East Burwood Tramway extension, East Preston tramway extension (stages I and II), Other tramway upgrading. |
| . Rolling Stock: | Tram replacements |
| . Miscellaneous: | Minor passenger terminals, two-way radios for trams, Automatic ticketing, Depots and workshops, Replacement of sub-station equipment, Passenger shelters. |

TABLE D.1 - CONTINUED

| State, Mode and Project Type | Project Name |
|---|---|
| FERRY | |
| . Vessels: | Nil |
| . Miscellaneous: | Nil |
| MISCELLANEOUS | Nil. |
| QUEENSLAND | |
| RAILWAY | |
| . Additional Track: | Nil |
| . Electrification: | Mayne-Petrie, Roma Street-Lota, Park Road-Kingston, Yerongpilly-Corinda, Kingston-Beenleigh. |
| . Signalling: | Signals and Communication (for electrification) |
| . Rolling Stock: | Electric vehicles |
| . New Routes: | Brisbane-Gold Coast, Extension of rail to Samford, Darra, Coopers Plains. |
| . Miscellaneous: | Refurbishing of Stations, Brisbane-Gold Cost feasibility study, Major car/rail interchanges, Major multi-storey car/rail, bus/rail interchanges (6 |
| BUS | |
| . Busway: | Nil |
| . Rolling Stock: | Replacement buses (75), Replacement buses (99), Replacement buses for private companies (75), Special purpose buses (10), Special purpose electric buses (20). |
| . Miscellaneous: | Car/bus and bus/bus interchanges, Central city depot, Private bus company facilities, Bus priority measures, Car/bus parking facilities, Passenger shelters, Workshops and admin. buildings, Two-way radios in buses, Acquisition of land for depots, Terminus toilet facilities, Modernisation of cash receiving depots, Bus washing and cleaning equipment, Support facilities, Bus depots in CBD, Bus depots (5), Reconstruction of Light Street Depot, Central Bus control centre, Miscellaneous garage equipment. |

*TABLE D.1 - CONTINUED*

| State, Mode and Project Type | Project Name |
|---|---|
| TRAM | |
| . Route upgrading: | Nil |
| . Rolling Stock: | Nil |
| . Miscellaneous: | Nil. |
| FERRY | |
| . Vessels: | Replacement ferries (3) |
| . Miscellaneous: | Construction of new ferry wharves (6) |
| MISCELLANEOUS | Master ticketing system (rail/bus) Moving walkways in CBD, Demand responsive passenger system. |
| SOUTH AUSTRALIA | |
| RAILWAY | |
| . Additional Track: | Nil |
| . Electrification: | North Gawler, Tonsley Branch |
| . Signalling: | Modernisation of Adelaide yard. |
| . Rolling Stock: | Christie Downs trains, North Gawler trains. |
| . New Routes: | West Lakes line. |
| . Miscellaneous: | Interchanges at Christie Downs (Stage I and II), Elizabeth, Salisbury and Glanville, Continuous track welding (Christie Downs), Curve Improvement (Christie Downs), North Gawler preliminary design. |
| BUS | |
| . Busway: | Nil |
| . Rolling Stock: | Replacement buses (310), Electric buses (7) |
| . Miscellaneous: | Bus priority measures and route improvements, Ticket machines, Improvements to buildings, Service vehicles, Purchase of computer, Purchase of maintenance vehicles. |
| TRAM | |
| . Route Upgrading: | Nil |
| . Rolling Stock: | Nil |
| . Miscellaneous: | Refurbishing trams, Interchanges (Plympton Park, Glenelg). |

TABLE D.1 - CONTINUED

| State, Mode and Project Type | Project Name |
|---|---|
| FERRY | |
| . Vessels: | Nil |
| . Miscellaneous: | Nil |
| MISCELLANEOUS | Marketing facilities. |
| WESTERN AUSTRALIA | |
| RAILWAY | |
| . Additional Track: | Nil |
| . Electrification: | Nil |
| . Signalling: | Nil |
| . Rolling Stock: | Nil |
| . New Routes: | Freight diversion railway |
| . Miscellaneous: | Relocation of railway facilities, Rail terminal east of Barrack Street. |
| BUS | |
| . Busways: | Mitchell busway (Stage II and subsequent stages), Armadale busway, Fremantle busway, Midland busway. |
| . Rolling Stock: | Buses for busways |
| . Miscellaneous: | East city bus station, South City bus station, Riley Road bus terminal, Booragoon bus terminal, Mirrabooka bus terminal, Beach Road bus terminal, Fremantle bus terminal Central bus station extensions, CBD passenger distribution service, Radio telephones in buses, Passenger shelters, Ticket machines, Fare collection boxes, Carparks at bus stations. |
| TRAM | |
| . Route Upgrading: | Nil |
| . Rolling Stock: | Nil |
| . Miscellaneous: | Nil. |
| FERRY | |
| . Vessels: | Nil |
| . Miscellaneous: | Coode Street ferry services. |
| MISCELLANEOUS | Nil |

TABLE D.1 - CONTINUED

| State, Mode and Project Type | Project Name |
|---|---|
| TASMANIA | |
| RAILWAY | |
| . Additional Track: | Nil |
| . Electrification: | Nil |
| . Signalling: | Nil |
| . Rolling Stock: | Nil |
| . New Routes: | Nil |
| . Miscellaneous: | Nil |
| BUS | |
| . Busway: | Nil |
| . Rolling Stock: | Replacement buses, Additional buses |
| . Miscellaneous: | Ticket machines, Depots and workshops, Passenger shelters. |
| TRAM | |
| . Route upgrading: | Nil |
| . Rolling Stock: | Nil |
| . Miscellaneous: | Nil |
| FERRY | |
| . Vessels: | Nil |
| . Miscellaneous: | Nil |
| MISCELLANEOUS | Nil |

The method adopted involved estimating the likely ratio of project benefits to project costs on the basis of the evaluation results obtained in previous BTE analyses of urban public transport projects.

The rationale for using historical evaluation results to provide an indication of the economic merit of newly proposed projects is that the evaluation of two identical projects in exactly the same circumstances will produce identical benefit-cost ratios. The projects listed in Table D.1 and the circumstances will not of course, be identical to those projects that have already been subjected to detailed evaluations by the BTE. Nevertheless, the

TABLE D.2 - RANGES OF BENEFIT - COST RATIOS AND INTERNAL RATES OF RETURN FOR URBAN PUBLIC TRANSPORT PROJECTS

| | Benefit Cost Ratios | | | Internal rate of Return (%) |
|---|---|---|---|---|
| | 7% | 10% | 15% | |
| RAIL | | | | |
| - Additional Track | 0.9-3.6 | 0.7-2.4 | 0.6-1.5 | 8.0-16.0 |
| - Electrification | 0.8-3.0 | 0.6-2.0 | 0.4-1.3 | 5.0-20.0 |
| - Signalling | 0.8-3.0 | 0.7-2.2 | 0.5-1.7 | 7.0-19.0 |
| - Rolling Stock | 1.3-1.7 | 1.1-1.5 | 0.9-1.2 | 12.0-14.0 |
| - New Routes | 1.1-4.2 | 0.9-2.9 | 0.7-2.1 | 7.0-15.0 |
| - Miscellaneous (1) | 0.8-5.3 | 0.5-4.9 | 0.2-2.9 | 5.0-39.0 |
| BUS | | | | |
| - Busways | 2.5-8.8 | 2.0-6.7 | 1.6-5.1 | 27.0-39.0 |
| - Rolling Stock | 0.8-1.4 | 0.8-1.3 | 0.5-1.2 | 6.0-15.0 |
| - Miscellaneous (1) | 0.8-4.8 | 0.7-3.9 | 0.2-3.0 | 5.0-33.0 |
| TRAM | | | | |
| - Route Upgrading | 0.9-2.7 | 0.7-2.3 | 0.6-1.9 | 9.0-20.0 |
| - Rolling Stock | n.a. | n.a. | n.a. | n.a. |
| - Miscellaneous (1) | 0.8-2.8 | 0.6-2.2 | 0.4-1.7 | 5.0-25.0 |
| FERRY | | | | |
| - Vessels | 1.1-2.8 | 1.0-2.5 | 0.8-2.0 | 10.0-11.0 |
| - Miscellaneous (1) | 1.0 | 1.0 | 0.8 | 10.0 |
| MISCELLANEOUS | 0.9-8.5 | 0.7-6.6 | 0.8-5.6 | 6.0-37.0 |

(1) Includes Passenger interchange projects.
n.a. not available.

Sources: (1) Bureau of Transport Economics, Economic Evaluation of Capital Investment in Urban Public Transport, Canberra, June 1972.
(2) Bureau of Transport Economics, A Review of Public Transport Investment Proposals for Australian Cities 1973-74, Canberra, August 1973.
(3) Bureau of Transport Economics, A Review of Public Transport Investment Proposals for Australian Cities 1974-75, Canberra, April 1975.

evaluation results from similar projects used in conjunction with the known difference between the projects, both in form and circumstances, can be used to estimate the likely economic return from implementing the improvement projects identified.

On this basis it was feasible to obtain an indication of the economic merit of each of the projects listed in Table D.1. The benefit-cost ratio and internal rate of return ranges shown in Table D.2 give an indication of the likely confidence intervals of the results obtained. The projects used to derive Table D.2 are listed in Table D.3.

The approach only provides an approximation of the economic merit of a project and does not obviate the need to undertake a rigorous evaluation of projects when they have been planned and costed in detail.

## Evaluation Results

Table D.4 shows investment needs by mode and project category for each State capital city for projects which have benefit-cost ratios greater than one using a discount rate of 10 per cent and which could be expected to be commenced in the period 1977-78 to 1979-80. This table includes expenditure which it is expected would be incurred after 1979-80. The expenditure which could be expected to be incurred wholly within the triennium 1977-78 to 1979-80 is shown in Table D.5.

## SENSITIVITY OF RESULTS

In order to determine the robustness of the investment program presented in Tables D.4 and D.5, two sensitivity tests were performed. Firstly the impact on the investment program of excluding various classes of benefits from the analysis was determined. Secondly, because there is a body of opinion which suggests that the appropriate discount rate to be used in the

TABLE D.3 - SAMPLE OF URBAN PUBLIC TRANSPORT PROJECTS PREVIOUSLY EVALUATED BY THE BTE

| Mode and Project Type | Project Name and State |
|---|---|
| RAILWAY | |
| . Additional Track: | N.S.W.: Riverwood-Glenfield, Seven Hills-Penrith, Redfern-Tempe, Tempe-East Hills, North Sydney-Gordon, Strathfield-Epping, Cabramatta-Campbelltown. |
| | VIC: Glen Waverley, Ringwood-Bayswater, McLeod-Greenborough, Caulfield-Mordialloc, South Kensington-Footscray, Sunshine-Deer Park. |
| | QLD: Brunswick Street-Northgate. |
| | S.A.: Brighton-Christie Downs. |
| . Electrification: | N.S.W.: Blacktown-Riverstone, Sutherland Waterfall, Campbelltown corridor, Illawarra Corridor. |
| | VIC: Sunshine-Deer Park, Werribee electrification. |
| | QLD: Ipswich-Darra, Northern corridor. |
| | S.A.: Christie Downs. |
| . Signalling: | N.S.W.: Sydney station signalling, Broadmeadow-Newcastle. |
| | VIC: Frankston-Mordialloc, Newport Area, Melbourne Central Area, Signalling Improvements (Melb). |
| . New Routes: | N.S.W.: East Hills-Glenfield. |
| | VIC: East Doncaster, Westonia ext. |
| | QLD: Merivale Street Bridge. |
| . Rolling Stock: | N.S.W.: Double Deck Cars (106), Double deck cars (other). |
| . Miscellaneous: | QLD: Rail/bus interchanges, car/rail interchanges. |
| BUS | |
| . Busways | W.A.: Perth-Fremantle busway, Mitchell Freeway busway, Armadale busway, Perth-Clermont busway. |

TABLE D.3 - CONTINUED

| Mode and Project Type | Project Name and State |
|---|---|
| . Rolling Stock: | N.S.W.: Bus replacements (4) |
| | VIC: Bus replacements (50) |
| | QLD: Bus replacements (30) |
| | S.A.: Bus replacements (43) |
| | W.A.: Bus replacements (186) |
| | Tas: Bus replacements. |
| . Miscellaneous: | W.A.: Innaloo bus transfer station, Amelia Street bus transfer station, Whitford bus transfer station, Perth Central bus station. |
| TRAM | |
| . Routh Upgrading: | SA: Glenelg tramway. |
| . Rolling Stock: | Nil. |
| . Miscellaneous: | Nil |
| FERRY | |
| . Vessels: | N.S.W.: Gladesville Ferry. |
| . Miscellaneous: | W.A.: South Perth Ferry jetties, South Perth Ferry Terminal. |
| MISCELLANEOUS | Nil. |

TABLE D.4 - ECONOMICALLY WARRANTED CAPITAL INVESTMENT FOR STATE CAPITAL CITY PUBLIC TRANSPORT PROJECTS: 1977-78 TO 1979-80 (1) (2)

($ million, 1974-75 prices)

| | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| RAIL | | | | | | | |
| - Additional Track | 35.87 | 56.94 | - | - | - | - | 92.81 |
| - Electrification | 3.42 | 18.00 | 20.72 | 15.00 | - | - | 57.14 |
| - Signalling | 2.70 | 8.83 | 23.50 | 4.80 | - | - | 39.83 |
| - Rolling Stock | 175.10 | 15.50 | 54.00 | 48.00 | - | - | 292.60 |
| - New Routes | 21.40 | 0.50 | 0.60 | 2.60 | 4.00 | - | 29.10 |
| - Miscellaneous | 93.18 | 72.58 | 20.70 | 19.22 | 2.68 | - | 208.36 |
| | 331.67 | 172.35 | 119.52 | 89.62 | 6.68 | - | 719.84 |
| BUS | | | | | | | |
| - Busway | 50.00 | - | - | - | 38.61 | - | 88.61 |
| - Rolling Stock | 29.00 | 19.80 | 15.40 | 1.0 | 22.51 | 8.40 | 96.11 |
| - Miscellaneous | 16.74 | 1.30 | 41.49 | 6.87 | 22.14 | 0.12 | 88.66 |
| | 95.74 | 21.1 | 56.89 | 7.87 | 83.26 | 8.52 | 273.38 |
| TRAM | | | | | | | |
| - Route Upgradings | - | 20.30 | - | - | - | - | 20.30 |
| - Rolling Stock | - | 4.90 | - | - | - | - | 4.90 |
| - Miscellaneous | - | - | - | 1.58 | - | - | 1.58 |
| | - | 25.20 | - | 1.58 | - | - | 26.78 |
| FERRY | | | | | | | |
| - Vessels | 8.2 | - | 0.30 | - | 0.02 | - | 8.58 |
| - Miscellaneous | - | - | 1.80 | - | - | - | 1.80 |
| | 8.2 | - | 2.10 | - | 0.02 | - | 10.32 |
| MISCELLANEOUS | 18.8 | - | - | 5.25 | - | - | 24.05 |
| TOTAL | 454.41 | 218.65 | 178.51 | 104.32 | 89.96 | 8.52 | 1054.37 |

(1) Table includes all projects with benefit-cost ratios greater than one at a discount rate of 10 per cent.

(2) Comprises total capital needs for investment in economically warranted projects that could be commenced in the period 1977-78 to 1979-80.

TABLE D.5 - CAPITAL NEEDED IN THE PERIOD 1977-78 TO 1979-80 FOR INVESTMENT IN ECONOMICALLY WARRANTED PROJECTS THAT COULD BE COMMENCED IN THAT PERIOD(1)

($ million, 1974-75 prices)

| | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| RAIL | | | | | | | |
| - Additional Track | 25.47 | 49.44 | - | - | - | - | 74.91 |
| - Electrification | 3.42 | 11.00 | 14.53 | 8.00 | - | - | 36.95 |
| - Signalling | 2.10 | 7.28 | 13.30 | 3.50 | - | - | 26.18 |
| - Rolling Stock | 102.10 | 7.10 | 18.00 | 30.00 | - | - | 157.20 |
| - New Routes | 21.40 | 0.50 | 0.30 | 2.60 | 4.00 | - | 28.80 |
| - Miscellaneous | 53.98 | 27.88 | 10.70 | 5.57 | 2.68 | - | 100.81 |
| | 208.47 | 103.20 | 56.83 | 49.67 | 6.68 | - | 424.85 |
| BUS | | | | | | | |
| - Busway | 32.50 | - | - | - | 6.03 | - | 38.53 |
| - Rolling Stock | 28.40 | 12.60 | 15.40 | 1.00 | 8.45 | 4.80 | 70.65 |
| - Miscellaneous | 12.34 | 1.30 | 25.87 | 4.37 | 11.45 | 0.12 | 55.45 |
| | 73.24 | 13.90 | 41.27 | 5.37 | 25.93 | 4.92 | 164.63 |
| TRAM | | | | | | | |
| - Route Upgrading | - | 13.30 | - | - | - | - | 13.30 |
| - Rolling Stock | - | 4.05 | - | - | - | - | 4.05 |
| - Miscellaneous | - | - | - | 1.58 | - | - | 1.58 |
| | - | 17.35 | - | 1.58 | - | - | 18.93 |
| FERRY | | | | | | | |
| - Vessels | 8.2 | - | 0.2 | - | 0.02 | - | 8.42 |
| - Miscellaneous | - | - | 0.9 | - | - | - | 0.90 |
| | 8.2 | - | 1.1 | - | 0.02 | - | 9.32 |
| MISCELLANEOUS | 10.8 | - | - | 1.00 | - | - | 11.80 |
| TOTAL | 300.71 | 134.45 | 99.20 | 57.62 | 32.63 | 4.92 | 629.53 |

(1) Table includes all projects with benefit-cost ratios greater than one for a discount rate of 10 per cent.

evaluation of public sector investment projects is somewhat higher than 10 per cent, the impact on the investment program of increasing the discount rate was examined.

Sensitivity of Results to the Composition of Benefits

The evaluations leading to the capital investment needs reported in Tables D.4 and D.5 included all benefits that would result from the investment. An analysis of a sample of urban public transport projects previously evaluated by the BTE[1] showed that:

- 16.3 per cent of aggregate benefit accrued to the public transport operator in the form of maintenance and rolling stock replacement cost savings;
- 28.6 per cent of aggregate benefits accrued to the existing public transport users in the form of in-vehicle and waiting time savings (as well as comfort improvements in some cases);
- 4.1 per cent of aggregate benefits accrued to generated public transport users, that is, those people who, for reasons of costs, comfort, time, etc., chose not to travel at all before the investment was made;
- 16.6 per cent of aggregate benefits accrued to travellers who changed their mode of travel (but not their destination) from automobile to public transport as a result of the reduction in public transport travel cost occasioned by the investment;
- 5.7 per cent of aggregate benefits accrued to remaining road users who benefited from the reduction in automobile travel cost (i.e. time, accidents, operating and other costs) brought about by the conversion of other road users to public transport;
- 28.7 per cent of the aggregate benefits were residuals which are those benefits attributable to the investment at the end of the study period, and comprise the above types of benefits.

(1) The list of projects comprising the sample is given in Table D.3.

Of the above, only those benefits which accrue to the public transport operator are direct financial savings. Benefits due to time savings and comfort improvements do not involve a direct monetary saving. Because of the measurement problems associated with the valuation of non-monetary and intangible benefits, the impact on the evaluation of investment programs of varying these valuations has been examined. Further, the figures show that much of the justification for improving public transport in urban areas hinges on the realisation of non-monetary and intangible benefits and the consequent expectation of increased patronage. Since several recent public transport upgrading schemes carried out in Australia(1) have not achieved patronage increases as large as expected, there must be some doubt as to the true value that travellers attach to non-monetary benefits associated with improvements to service levels. It was therefore decided to examine the impact on the investment program presented in Tables D.4 and D.5 of varying the traffic growth assumptions employed in deriving those levels of investment.

In order to conduct these sensitivity tests, the distribution of benefits for each of the projects listed in Table D.2 was determined and the proportion of expenditure which was economically justified in terms of all benefits, benefits to the public transport operator and existing public transport users only and benefits to transport operators only were derived. Since the sample of projects was representative of those listed in Table D.1, it was considered that, in aggregate, these proportions could be applied directly to Tables D.4 and D.5. The results are shown in Tables D.6 and D.7.

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(1) a. Victorian Railway, Glen Waverley Model Project Comparison of Results of "Before" and "After" Studies, Development and Planning Division, Sept. 1975.

b. Victorian Railways, The Glen Waverley Model Line Project-Report on the "Before" and "After" Studies, prepared by P.G. Pak-Poy and Associates, June 1976.

c. N.S.W. Department of Motor Transport, Evaluation of Transit Lanes, 1976.

TABLE D.6 - EFFECT ON URBAN PUBLIC TRANSPORT CAPITAL INVESTMENT OF EXCLUDING SOME CATEGORIES OF BENEFIT(1)

($ million, 1974-75 prices)

| Benefit Type | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| All benefits | 454 | 219 | 178 | 104 | 90 | 9 | 1054 |
| Operator and existing public transport benefits alone | 264 | 127 | 104 | 61 | 52 | 5 | 613 |
| Operator benefits alone | 86 | 41 | 34 | 20 | 17 | 2 | 200 |

(1) Includes projects that yield benefit-cost ratios greater than one using a 10 per cent discount rate and includes all expenditure that would be incurred on those projects.

TABLE D.7 - EFFECT ON THREE YEAR URBAN PUBLIC TRANSPORT CAPITAL INVESTMENT OF EXCLUDING SOME CATEGORIES OF BENEFIT (1)

($ million, 1974-75 prices)

| Benefit Type | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| All benefits | 301 | 134 | 99 | 58 | 32 | 5 | 629 |
| Operator and existing public transport user benefits alone | 175 | 78 | 58 | 33 | 19 | 3 | 366 |
| Operator benefits alone | 57 | 25 | 19 | 11 | 6 | 1 | 119 |

(1) Includes projects that yield benefit-cost ratios greater than one at a 10 per cent discount rate and only relates to expenditures that could be expected to be incurred on those projects during the triennium 1977-78 to 1979-80.

It can be seen that while a total of $1054 million is economically warranted when all benefits are included, only 58.1 per cent is warranted on the basis of benefits to the operator and existing public transport users alone and 19.0 per cent is warranted on the basis of benefits to the operator alone. It can thus be concluded that between 50 and 75 per cent of the investment program is sensitive to the value attached to non-monetary and intangible benefits. This re-inforces the view that it would be desirable to undertake a more rigorous evaluation of the projects listed in Table D.1 when they have been planned and costed in detail.

## Sensitivity of Results to Increases in Discount Rate

The discount rate used to determine the economic warrant of public transport projects was 10 per cent. To gauge the effects of increasing the discount rate, a rate of 15 per cent was used in determining the economic merit of projects that could be commenced during the period 1977-78 to 1979-80. The higher discount rate will tend to favour projects which have a low initial capital cost or higher initial benefits. It was therefore expected that increasing the rate from 10 to 15 per cent would result in the deletion of major capital works such as rail additional track, electrification and new route projects.

The impact on the investment program of increasing the discount rate is shown in Tables D.8 and D.9. From Table D.8 it can be seen that there has been a 52.3 per cent reduction in total expenditure. Expenditure on rail, bus, tram and ferry projects has been reduced by 55.7, 42.8, 59.1, and 99.8, per cent respectively.

As expected there was a considerable reduction in expenditure on major capital works: 57.6 per cent on rail additional track, 27.9 per cent on rail electrification and 98.3 per cent on new rail route projects. Not expected was the considerable reduction in expenditure on rolling stock for all modes: 81.5 per cent for

TABLE D.8 - EFFECT ON TOTAL WARRANTED INVESTMENT EXPENDITURE FOR URBAN PUBLIC TRANSPORT OF INCREASING THE DISCOUNT RATE TO 15 PER CENT (1)

($ million, 1974-75 prices)

| Mode | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| RAIL | | | | | | | |
| - Additional Track | 26.00 | 13.30 | - | - | - | - | 39.30 |
| - Electrification | 3.42 | 18.00 | 4.77 | 15.00 | - | - | 41.19 |
| - Signalling | 2.70 | 8.83 | 23.50 | 4.80 | - | - | 39.83 |
| - Rolling Stock | - | - | 54.00 | - | - | - | 54.00 |
| - New Routes | - | 0.50 | - | - | - | - | 0.50 |
| - Miscellaneous | 84.98 | 17.85 | 20.70 | 19.22 | 1.0 | - | 143.76 |
| | 117.10 | 58.48 | 102.97 | 39.02 | 1.0 | - | 318.57 |
| BUS | | | | | | | |
| - Busways | 50.00 | - | - | - | 38.61 | - | 88.61 |
| - Rolling Stock | - | - | - | - | 14.69 | - | 14.69 |
| - Miscellaneous | 14.32 | - | 21.22 | 6.05 | 11.33 | - | 52.92 |
| | 64.32 | - | 21.22 | 6.05 | 64.63 | - | 156.22 |
| TRAM | | | | | | | |
| - Route Upgrading | - | 6.30 | - | - | - | - | 6.30 |
| - Rolling Stock | - | 3.40 | - | - | - | - | 3.40 |
| - Miscellaneous | - | - | - | 1.26 | - | - | 1.26 |
| | - | 9.70 | - | 1.26 | - | - | 10.96 |
| FERRY | | | | | | | |
| - Vessels | - | - | - | - | 0.02 | - | 0.02 |
| - Miscellaneous | - | - | - | - | - | - | - |
| | - | - | - | - | 0.02 | - | 0.02 |
| MISCELLANEOUS | 11.8 | - | - | 5.25 | - | - | 17.05 |
| TOTAL | 193.22 | 68.18 | 124.19 | 51.58 | 65.65 | - | 502.82 |

(1) Includes all projects that yield benefit-cost ratios greater than one for a discount rate of 15 per cent and includes all expenditure which would be incurred on those projects.

TABLE D.9 - EFFECT ON THREE YEAR WARRANTED INVESTMENT EXPENDITURE FOR URBAN PUBLIC TRANSPORT OF INCREASING THE DISCOUNT RATE TO 15 PER CENT (1)

($ million, 1974-75 prices)

| Mode | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| RAIL | | | | | | | |
| - Additional Track | 15.60 | 10.30 | - | - | - | - | 25.90 |
| - Electrification | 3.42 | 11.00 | 2.98 | 8.00 | - | - | 25.40 |
| - Signalling | 2.10 | 7.28 | 13.30 | 3.50 | - | - | 26.18 |
| - Rolling Stock | - | - | 18.00 | - | - | - | 18.00 |
| - New Routes | - | 0.50 | - | - | - | - | 0.50 |
| - Miscellaneous | 47.58 | 9.85 | 10.70 | 5.57 | 1.00 | - | 74.70 |
| | 68.70 | 38.93 | 44.98 | 17.07 | 1.00 | - | 170.68 |
| BUS | | | | | | | |
| - Busway | 32.50 | - | - | - | 6.03 | - | 38.53 |
| - Rolling Stock | - | - | - | - | 5.69 | - | 5.69 |
| - Miscellaneous | 10.82 | - | 15.22 | 4.05 | 9.75 | - | 39.84 |
| | 43.32 | - | 15.22 | 4.05 | 21.47 | - | 84.06 |
| TRAM | | | | | | | |
| - Route Upgrading | - | 3.30 | - | - | - | - | 3.30 |
| - Rolling Stock | - | 2.55 | - | - | - | - | 2.55 |
| - Miscellaneous | - | - | - | 1.26 | - | - | 1.26 |
| | - | 5.85 | - | 1.26 | - | - | 7.11 |
| FERRY | | | | | | | |
| - Vessels | - | - | - | - | 0.02 | - | 0.02 |
| - Miscellaneous | - | - | - | - | - | - | - |
| | - | - | - | - | 0.02 | - | 0.02 |
| MISCELLANEOUS | 7.8 | - | - | 1.0 | - | - | 8.8 |
| TOTAL | 119.82 | 44.78 | 60.2 | 23.38 | 22.49 | - | 270.67 |

(1) Includes all projects with benefit-cost ratios greater than one for a discount rate of 15 per cent and only relates to expenditure that could be expected to be incurred on those projects during the triennium 1977-78 to 1979-80.

TABLE D.10 - EFFECT OF DELETING CERTAIN TYPES OF BENEFITS FROM THREE YEAR URBAN PUBLIC TRANSPORT CAPITAL INVESTMENT WARRANTED PROGRAM USING A DISCOUNT RATE OF 15 PER CENT (1)

($ million, 1974-75 prices)

| Benefit Type | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| All benefits | 120 | 46 | 60 | 23 | 22 | - | 271 |
| Operator & existing public transport user benefits alone | 65 | 24 | 32 | 12 | 12 | - | 145 |
| Operator benefits alone | 14 | 5 | 7 | 3 | 2 | - | 31 |

(1) Includes projects that yield benefit-cost ratios greater than one at a 15 per cent discount rate and only relates to expenditure that could be expected to be incurred on those projects during the triennium 1977-78 to 1979-80.

rail, 84.7 per cent for bus, 30.6 per cent for tram and 99.8 per cent for ferry. The conclusion that can be drawn from these results is that most major capital works and rolling stock projects have fairly low rates of return, or, on the other hand, are projects of only very marginal economic merit.

The impact of excluding various types of benefits from the evaluations used to determine investment needs for the period 1977-78 to 1979-80 using a 15 per cent discount rate is demonstrated in Table D.10.

## ANNEX E

## WARRANTED INVESTMENT IN URBAN PUBLIC TRANSPORT BY STATE WITH CAPITAL RATIONING

This annex describes how the data given in Annex D can be used to allocate capital to urban public transport projects to ensure that the marginal rate of return on the investment in each State is approximately equalised. The procedure is applicable for any level of investment in new projects over the triennium 1977-78 to 1979-80 within the range $498 million and $209 million, both in 1974-75 prices.[1] The upper bound ensures that all projects have a rate of return of at least 10 percent, while the lower bound ensures a rate of return to all projects of at least 15 per cent.

The allocation between States of the investment represented by these bounds is performed by interpolating mid-way between the warranted investment program obtained by including all types of benefits and that obtained by excluding benefits from traffic generation. The relevant data for the upper bound is given in Table D.7 in Annex D and for the lower bound in Table D.10 of Annex D. The rationale for the interpolation has been given in the text of the report.

The rate of return that would be required of investment for any amount of capital that is within these bounds can be approximately determined by linear interpolation. For example, if capital available for investment in new urban public transport projects in the State capital cities was $382 million, then it would be possible to undertake all projects with a rate of return of 12 per cent.[2] To allocate the $382 million between States so that the marginal rate of return on investments in each State are approximately equalised at 12 percent now only requires linear interpolation between the upper and lower bound investment

(1) An additional $215 million is estimated to be required for investment in projects already commenced.
(2) 10% + 5(498-382)/(498-209)% = 12%.

programs for each State. The result for this example is given below.

TABLE E.1 - RESULTS OF LINEAR INTERPOLATION BETWEEN THE UPPER AND LOWER BOUND INVESTMENT PROGRAMS FOR EACH STATE

($ million, 1974-75 prices)

| | N.S.W. | Vic. | Qld. | S.A. | W.A. | Tas. | Total |
|---|---|---|---|---|---|---|---|
| 10% | 238 | 106 | 78 | 46 | 26 | 4 | 498 |
| 15% | 93 | 35 | 46 | 18 | 17 | 0 | 209 |
| 12% | 180 | 78 | 65 | 35 | 22 | 2 | 382 |