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Urban Transport

Volume 2: Appendices

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Inquiry Procedures

APPENDIX A INQUIRY PROCEDURES

Following the receipt of the terms of reference on 18 September 1992, the Commission advertised the commencement of the inquiry in the press and dispatched an initial circular to those considered to have an interest in the inquiry.

From October 1992 to May 1993 the Commission met with a wide range of Australian and foreign organisations including government departments, researchers, unions, private operators and user groups to seek background information and to discuss inquiry issues. Their names are listed in section A1.

In November 1992, an issues paper was sent to interested parties and submissions were invited. The initial public hearings were held in Adelaide, Perth, Brisbane, Sydney, Melbourne and Canberra during February and March 1993. A total of 83 participants attended — see section A2.

Circulars were mailed at regular intervals to encourage people to peruse and comment on submissions. The circulars also detailed the progress of the inquiry.

Nearly 200 submissions were received by the publication of the draft report in October 1993. Public hearings on the draft report were held in November and December 1993 in Adelaide, Perth, Canberra, Brisbane, Sydney and Melbourne. 89 participants attended — see section A3.

A further 148 submissions were received after the draft report. All submissions received during the inquiry are listed in section A4.

Two consultancies were let to:

- University of Sydney's Institute of Transport Studies (Professor David Hensher and Ms Rhonda Daniels) for a report entitled *Productivity measurement in the urban bus sector: 1991/92;* and
- Travers Morgan (New Zealand) Ltd for a report entitled *Urban Bus Operations: Productive Efficiency and Regulatory Reform — International Experience.*

A.1 Visits

Besides travelling extensively on all modes of urban public transport during the inquiry, the Commission met the following:

A1.1 Overseas visits

Canada — Toronto

Canadian Urban Transit Association
City of Toronto, Planning and Development Department
Commission on Planning and Development Reform in Ontario
GO Transit
Office for the Greater Toronto Area
Ontario Ministry of Municipal Affairs
Toronto Transit Commission

Canada — Vancouver

BC Transit (Vancouver)
Dr W. G. Waters (University of British Columbia, Transportation and Logistics)
Greater Vancouver Regional District, Strategic Planning Department
British Columbia Ministry of Municipal Affairs
Transport 2021
Western Transportation Advisory Council

Canada — Victoria

BC Transit (Victoria)
Capital Regional District, Regional Transportation and Development Strategies
City of Victoria, Engineering Department
British Columbia Ministry of Transportation and Highways
British Columbia Ministry of Municipal Affairs, Recreation and Housing

France — Paris

European Conference of Ministers of Transport

Germany — Munich

Autobus Oberbayern
Bayerisches Staatsministerium für Wirtschaft und Verkehr
(Bavarian Ministry for Industry and Transportation)
Deutsche Bundesbahn, Bundesbahndirektion München
(Munich Office of the Federal Railways)

Landesverband bayerischer Omnibusunternehmer E.V.
(Federation of Bavarian Omnibus Companies)
Münchner Verkehrs-und Tarifverbund GmbH
(Transport Coordinator for Munich)
Regionalverkehr Oberbayern GmbH (Bavarian Regional Transport Authority)
Stadtwerke München Werkbereich Technik Verkehrsbetriebe
(Munich City Transport Authority)

Ireland — Dublin

Department of the Environment (Dublin Transport Initiative)
Transport Policy Research Institute, University College

New Zealand

New Zealand Bus and Coach Association
New Zealand Ministry of Transport
New Zealand Rail
New Zealand Taxi Federation
New Zealand Treasury
Transit New Zealand
Wellington City Transport Ltd
Wellington Regional Council

Singapore

Public Transport Council
Registry of Vehicles
Singapore Bus Service Ltd
Singapore Mass Rapid Transit Ltd

Switzerland — Zurich

Schweizerische Bundesbahnen (Swiss Federal Railways)
Sihltal-Zürich-Uetliberg-Bahn (Private Rail Operator)
Verkehrsbetriebe Zürich (Zurich City Transport Authority)
Zürcher Verkehrsverbund (Transport Coordinator for Zurich)

United Kingdom

Chelmsford City Council
Essex County Council
London Transport, London
Urban and General Directorate, Department of Transport, London
Travers Morgan, London
Tyne and Wear Passenger Transport Executive, Newcastle-upon-Tyne

Yorkshire Rider Group, Leeds

United States of America — Washington, DC

Alan E. Pisarski (Transport consultant)
American Public Transit Association
Federal Transit Administration, Department of Transportation
The World Bank
Transportation Research Board, National Research Council
Washington Metropolitan Area Transit Authority

A1.2 Australian visits

New South Wales

Australian Tramways and Motor Omnibus Employees Association
Blue Ribbon Buslines
CityRail
Department of Transport
Hunter Valley Transport Improvement Association
New South Wales Bus and Coach Association
New South Wales Government Pricing Tribunal
Newcastle Buses
Newcastle City Council
Road Traffic Authority
State Transit Authority
Toronto Bus Company

Victoria

Action on Disability within Ethnic Communities
Australian Conservation Foundation (Victoria)
Bellarine Bus Lines
Benders/Cook Bus Lines
Bicycle Victoria
City of Bendigo
Conservation Council of Victoria
Department of Transport
Disability Resource Centre
Geelong Regional Commission
Hills Transport Action Group
Kangaroo Flat Bus Lines
McHarry's Bus Lines
Melbourne City Council
National Road Transport Commission
Pensioners and Superannuants Association
Public Transport Corporation
Public Transport Corporation (Bendigo and Geelong)
Public Transport Users Association
Shire of Pakenham, Council and residents
Trans Otway Pty Ltd
VicRoads
VicRoads (Bendigo)
Victorian Bus Proprietors Association

Victorian Office of the Environment
Victorian Taxi Association

Queensland

Australian Tramways and Motor Omnibus Employees Association
Brisbane City Council
Dr Ken Davidson
Gold Coast City Council
Hagan’s Buses
Hornibrook Bus Lines Group
Logan City Council
Department of Transport (Brisbane and Toowoomba)
Queensland Rail (Citytrain)
Taxi Council of Queensland
Toowoomba City Council

Western Australia

Australian Railways Union (Western Australian Branch)
Australian Tramway and Motor Omnibus Employees Union
(Western Australian Branch)
Department of Main Roads
Department of Planning and Urban Development
Department of Transport
Royal Automobile Club of W. A. Inc
Swan Taxis
Transperth
Western Australian Chamber of Commerce and Industry
Western Australian Treasury
Westrail

South Australia

Australian Federated Union of Locomotive Enginemen
Bus and Coach Association (South Australia)
Business Regulation Review Office
Community Bus Operators (City of Enfield and City of Unley)
Happy Valley Council
Metropolitan Taxi-Cab Board
Office of Transport Policy and Planning
Professor Michael Taylor
South Australian Taxi Association
South Australian Government

State Transport Authority
Trade Practices Commission

Tasmania

Hobart City Council
Launceston City Council
Metro Tasmania
Mr Greg Alomes
Tasmanian Government

Northern Territory

Darwin Bus Service
Department of Transport and Works

Australian Capital Territory

Australian Capital Territory Internal Omnibus Network (ACTION)
Australian Automobile Association
Australian City Transit Association
Bureau of Transport and Communications Economics
Commonwealth Grants Commission
Commonwealth Department of Transport and Communications
ACT Department of Urban Services

A.2 Initial public hearings participants

Adelaide (22 and 23 February 1993)

State Transport Authority
Mr John Hutchinson and Mr Adrian Gargett
Easton Business Consultants
Rail 2000
People for Public Transport
Bus and Coach Association
Mount Barker Passenger Service
Bicycle Institute of South Australia
Council of Pensioners and Retired Persons Associations

Perth (25 February 1993)

Dr Jeff Kenworthy and Mr Peter Vintila
City of Fremantle
Mr Phil McManus
City of Perth
Institute of Engineers, Western Australian Division
Ecocity Planning Association
Mr Michael Pearson
Western Australian Municipal Association

Brisbane (3 and 4 March 1993)

Bus and Coach Association of Queensland
Hornibrook Transit Management
Hornibrook Bus Lines Group
Local Government Association of Queensland
Mr John Douglass
Public Transport Union (formerly Australian Railways Union)
Urban Coalition
Dr Ken Davidson
Professor Colin Taylor
Australian Tramway and Motor Omnibus Employees Association, Brisbane Branch
Mr David Engwicht
Institution of Engineers, Australian Transport Panel
Mr Jeff Mitchell
Mr John Dudgeon

Sydney (9 to 11 March 1993)

Action for Public Transport
Manly-Warringah Public Transport Coalition
Coalition For Urban Transport Sanity
Greenpeace
Blue Mountains Commuter and Transport Users Association
Campbelltown and District Commuter Association
Central Sydney Community Transport Group
CityRail
Coalition of Transport Action Groups
North Ryde Residents Group
Community Transport Organisation
Bicycle Institute of New South Wales
Light Rail Association
Friends of The Earth
Australian Road Federation
Leichhardt Municipal Council
Australian Bus and Coach Association
Bus and Coach Association of New South Wales
Gwynne Scotford and Associates
Mr Ken Johnson
New South Wales Urban Environment Coalition
Australian Taxi Industry Association
Combined Pensioners and Superannuants Association of New South Wales
Greenpeace

Melbourne (17 and 18 March 1993)

SMC Pneumatics
Town and Country Planning Association
Bus Proprietors' Association (Vic) Inc
Public Transport Users Association
Croydon Bus Service
Peter A. Hill and Associates
Institution of Engineers
Monash University: Patrick Moriarty and Helen Hammersley
City of Brunswick
Professor David Yencken
Inner Metropolitan Regional Association
CSIRO
Australian Paper Manufactures

Canberra (24 and 25 March 1993)

Mr Ian Morison
South Australian Government
ACROD
Australian Gas Association
Australian Automobile Association
Dr John Quiggin
Canberra-Queanbeyan Region Transport Action Group and
North Canberra Protection Group
Mr David Hughes
Commonwealth Department of Transport and Communications
Mr Gary Glazebrook
Commonwealth Office of Local Government

A.3 Draft report public hearings participants

Adelaide (23 November 1993)

Bicycle Institute of South Australia
Bus and Coach Association (SA) Incorporated
Mr Ken Mason

Perth (25 November 1993)

Westrail
Greens WA
Western Australian Government
Institute of Science and Technology Policy, Murdoch University
Bureau of Disability Services and Authority for the Intellectually Handicapped
Bicycle Federation of Australia
Mr Mike Seboa

Canberra (2 December 1993)

ACT Government
Commonwealth Department of Human Services and Health
Professor Max Neutze
ACROD
Mr David Hughes
Royal Australian Planning Institute, ACT Division
Aerial Taxi Cabs Co-operative Society Ltd
Dr Peter Forsyth
Mr James Schuurmans-Stekhoven

Brisbane (6 December 1993)

Brisbane Transport
Hornibrook Bus Lines
National Accessible Transport Committee
Public Transport Union (Bus and Tram Division) Queensland Branch
Australian Local Government Association
Passenger Transport Systems Pty Ltd

Sydney (8 and 9 December 1993)

Coalition for Urban Transport Sanity
Australian Taxi Industry Association
CityRail
Blue Mountains Commuter Association
Mr Faruque Ahmed
Taxi Industry Services Association of New South Wales

Community Transport Organisation
NRMA
Australian Road Federation
Central Coast Commuters Association
NSW Combined Commuters' Organisations Forum
Mr Peter Boyce
Bus and Coach Association of New South Wales
Healthy Cities Illawarra
Combined Pensioners and Superannuants Association of New South Wales

Melbourne (13 and 14 December 1993)

Bus Proprietors' Association (Vic) Inc
Bicycle Institute of Victoria
ACTU/Public Transport Unions
Mr John Legge
Victorian Minister for Public Transport
Australian Automobile Association
Friends of the W-Class Trams
Travellers Aid Support Centre
Silver Top Taxi Service Ltd
Mr Tuan Miskin
Australian Citizens Action Network
Town and Country Planning Association
Municipal Association of Victoria
Victorian Community Transport Association
Mr Ross Nolan

A.4 Submissions received

The following submissions were received during the Urban Transport Inquiry.

Company/Organisation	Submission Number
ACROD	52, 217
ACT Government	167, 228
ACT Transport Action Group	145
Action for Public Transport	42, 135, 152, 193, 335
ACTU / Public Transport Unions	271, 293
Adelaide Mini Bus	79
Aerial Taxi Cabs Co-operative Society Ltd	165, 191,229, 244
Ahmed, Mr Faruque	287
Arvanitis, Mr Peter	237
Australian Automobile Association	140, 190, 279
Australian Bureau of Agricultural and Resource Economics	119
Australian Bus and Coach Association	78, 151
Australian Citizens Action Network	282
Australian City Transit Association	174
Australian Gas Association	107
Australian Local Government Association	215, 262
Australian Paper Manufacturers	90
Australian Railways Union (Queensland Branch)	63
Australian Railways Union (National Office)	70
Australian Railways Union (New South Wales Branch)	14, 39
Australian Road Federation	13, 118, 127, 221, 248
Australian Road Research Board	126
Australian Taxi Industry Association	94, 169, 254
AUSTROADS	255
Authority for the Intellectually Handicapped / Bureau for Disability Services (WA)	209
Bayley, Mr John M.	226
Bell, Mr Douglas	130
Bendall, Mr Kirk	303
Bendigo City Council and the “Regional Australia Now” Campaign	12
Benevolent Society of New South Wales	38
Bicycle Federation of Australia	111, 207, 235, 306, 309
Bicycle Institute of New South Wales Inc	93, 278
Bicycle Institute of South Australia	88, 202, 242

Commonwealth Department of Human Services and Health	294, 321
Commonwealth Department of Immigration, Local Government and Ethnic Affairs	122
Commonwealth Department of Industrial Relations	333
Commonwealth Department of Transport and Communications	156
Commonwealth Grants Commission	203
Community Transport Organisation (NSW)	28, 249
Conservation Council of Victoria	101
Consumers’ Transport Council	102, 225
Cook, Mr Jonathan	53
Cotgrove, Mr R. D. M.	160, 199
Council of Pensioner and Retired Persons Associations of South Australia Inc	66
Council of the City of South Sydney	8
Council of The City of Sydney	80
Council On The Ageing	184, 301
Craig, Mr William	24, 197
Craigieburn Family Services	258
Crevola, Mr Michael	236
Croydon Bus Service Pty Ltd	95, 265
CSIRO, Division of Building, Construction and Engineering	43, 143, 264
CSIRO, Division of Information Technology, Centre for Spatial Information Systems	176
Douglass, Mr John	74, 171, 154
Easton, Mr E. W.	49
Ecocity Planning Association	150
Engwicht, Mr David	83
Environment Centre of Western Australia	87
Ettinger House Inc, Fairfield Family Resource Centre	216
Farmar-Bowers, Mr Quentin	10, 15
Forsyth, Dr P. J.	223
Friends of the Earth	29
Friends of the W Class Trams	274
Glazebrook, Mr G.	123, 146
Grafton Radio Taxis Cooperative	194
Greenhouse Association Inc	26
Greenpeace	50
Greens WA	212
Griffiths, Mr David R.	124, 281
Gwynne Scotford Associates Pty Ltd	110
Healthy Cities Illawarra	40, 208

APPENDIX B

Determinants of demand for urban travel

APPENDIX B DETERMINANTS OF DEMAND FOR URBAN TRAVEL

The Commission has reviewed the modelling literature on demand for urban travel. Although findings vary across studies, they permit certain generalisations. Demand for public transport appears to be only moderately sensitive to changes in fares, with a ten per cent increase in fares typically reducing demand by about three per cent. Demand is typically more sensitive to changes in travel times than to changes in money costs, both for public transport and car travel. Demand for petrol is moderately responsive to changes in petrol prices and the response is realised only gradually. The evidence is less clear on other issues reviewed here: the influence on demand of service quality attributes other than time; the value of travel time relative to wage rates; and trip scheduling decisions. Problems in modelling various aspects of urban travel demand are also described in this appendix.

B.1 Introduction

The terms of reference for this inquiry ask the Industry Commission to report on the impact of government taxation and funding policies on traveller behaviour. This appendix responds to this request by reviewing evidence on determinants of demand for urban travel. It presents quantitative estimates of travellers' responses to given changes in the conditions of travel, and of the values of travel time. These measures permit some inferences about the effects of possible policy reforms, such as changes to public transport fares. However, since the estimates reported are only as good as the models on which they are based, this review also discusses methodological issues in some detail.

B.2 Modelling approaches

Models of the demand for travel are highly diverse in the questions they address, the type of data they use and the assumptions they make. The characteristics of three broad categories of models are explored below, in the order of mode choice models, trip scheduling models and 'other travel demand models'. (The latter category includes models that are not 'mode choice models' but which examine the demand for travel on a particular mode, a useful but awkward distinction that is explained later.) This is followed by an examination of the findings from these models and from less structured analyses, such as simple comparisons of travel patterns before and after the implementation of some reform. Not all useful approaches are represented in the Australian literature, so characteristics and findings from models for foreign cities are considered for additional insights.

Models of the demand for travel are building blocks to UTP (Urban Transport Planning) models, which have been developed for all Australian capital cities. UTP models describe a full system of passenger travel with both supply and demand features, enabling them to explain patterns that are merely inputs to mode choice models. In particular, road travel times, which are taken as given in mode choice models, are explained in UTP models by traffic volumes and road capacity. Both classes of model allow travel time to affect people's travel decisions, but only the UTP models incorporate the reverse influence of travel decisions on travel times (through congestion effects). In addition, some UTP models seek to explain the distribution of trips by origin and destination in terms of travel times and costs. Such a model could be used, for example, to simulate the increase in total trips between the CBD and a particular suburb if connecting train service became twenty per cent faster. Indeed, typical applications have been for planning of individual transport corridors. Applications to broad metropolitan strategies are less common, although examples can be found in Kilsby et al (1992) and RJ Nairn and Partners (1992), among other Australian studies. The features of UTP models, and of other models used for transportation planning, are described in Horn and Kilby (1992) and Luk (1992).

The Commission has not found any recent survey of Australian research on the determinants of travel demand such as that provided here. Luk (1992) touches only briefly on this literature and calls for a more thorough review.[1]

Mode choice models

Mode choice models are often estimated with city-based data on individuals. Such data are cross-sectional in that they provide a snapshot of travel patterns and related circumstances at a point in time. The Commission has found no mode choice models that use panel data (both time-series and cross-sectional data), as would be required for a dynamic analysis. Thus, while events which

[1] Subsequent to the publication of this literature review in the Commission's draft report on *Urban Transport* (IC 1993), Luk and Hepburn (1993) published a similar study reviewing Australian travel demand elasticities. Their conclusions are similar to those presented here.

shape mode choices, such as an increase in public transport fares, may exert their impacts gradually as people adjust, such dynamics are not accommodated in the models being examined.

Several Australian studies, and many overseas studies, have modelled the mode choices of commuters (defined as travellers to and from work). The present discussion of this literature (mode choice) considers only studies using data on individuals, since the use of aggregated data can produce biases (Anas 1982). For non-commuting trips, the Commission has found only a few comparable studies and these used American data from the 1960s. Given this lack of evidence based on individual-level data, it might be worth considering other analyses of mode choices for non-commuting trips that have used aggregated data. However, while such analyses have been undertaken for building UTP models (including models for Australian cities), documentation can be fairly sketchy and difficult to obtain.[2] Hence, the following discussion considers only the mode choices of commuters.

The high costs of collecting data for individual travellers sometimes result in samples being small (see Ampt 1992 for costs of a pilot survey in Melbourne). The use of small samples limits the range of relationships that can be reliably estimated, particularly when multi-collinearity is severe.[3] For example, Hensher and Truong (1983) excluded income from a mode choice model they estimated for Sydney, on the basis that it was highly correlated with in-vehicle travel times and other variables. However, a priori, one would expect income to affect mode choice: the affluent should feel less of a need to economise by choosing cheap but slow modes. Moreover, when a relevant variable is excluded from the model the findings for remaining variables become questionable. Bajic (1984) includes income in his mode choice model for Toronto, but does so in a restrictive way to limit multi-collinearity. Effectively, he specifies the model so that an increase in income necessarily disinclines people to travel on slow modes, and then estimates the magnitude of this effect. Although the plausibility of this restriction has already been noted, it should ideally be tested rather than simply imposed.

2 For example, a transport planning model of Adelaide included mode choice equations for various trip purposes, which were estimated with zonal data (Director-General of Transport South Australia 1992). Documentation for this model was readily obtained by the Commission, but it omitted the estimates of demand elasticities by mode which are reported in studies discussed here.

3 Multi-collinearity refers to the situation where two or more explanatory variables in the data set are highly correlated, making it hard to estimate their separate effects on the behaviour being modelled. It is frequently offered as a reason for odd or statistically insignificant findings, for the omission of variables from a model, or for incorporating variables in a restrictive way.

Revealed versus stated preference approaches: Experimental versus non-experimental data

Multi-collinearity is a particular problem with non-experimental data sets, which are standard in studies of mode choice. For each individual in the sample, the data indicate the actual choice of mode in some real situation (the journey to work), the attributes of this and alternative modes that are available, and normally other information such as income. Statements of preferences about travel mode are generally absent, but studies using non-experimental data infer people's preferences from their actual choices — the so-called revealed preference approach. Once the preferences are understood, people's choices can be predicted under circumstances different from current ones. However, the modeller taking the revealed preference approach can only hope to minimise multi-collinearity among explanatory variables in the database.

Another problem with using non-experimental data arises from the influence of travel considerations on choices of home and work locations. Since this influence is not captured in mode choice models, the findings from these models can be ambiguous. Consider, for example, a finding that commuters with easy access to work by public transport are far likelier to use public transport than other commuters. Does this mean that expanding the public transport network to areas now poorly served will greatly expand the demand for public transport? Or does it mean that commuters with preferences for public transport tend to choose work and home locations that are well connected by public transport? Under the latter interpretation, neighbourhoods now poorly served by public transport would contain many people who strongly prefer car travel, so an improvement of the public transport network in these neighbourhoods might have little effect on mode choices.

Both this ambiguity and multi-collinearity can be avoided with well-designed experimental data sets, but relatively few mode choice studies have used them. The Commission has found only one such Australian study, which was conducted for CityRail of New South Wales by Steer Davies Gleave (1993). Because of confidentiality restrictions on this study, the experimental approach is illustrated here by another Australian travel demand study, albeit not one of mode choices (Hensher and Truong 1985). The data from this alternative study were from a survey of Sydney commuters, defining a set of twenty-seven hypothetical commuting trips by money cost, the number of transfers, and times spent walking, waiting and in-vehicle. The main concern of the study being values of time rather than mode choice, the options were not defined by mode. Respondents rated the desirability of each alternative on a ten point scale beside providing standard survey information, such as actual mode of commuting and income. Importantly, in both cases, the alternatives were designed so that the multi-collinearity was absent among the hypothetical attributes. There was, for example, no correlation between the in-vehicle time and money cost, which would normally be positively correlated in non-experimental data, each tending to increase with the distance travelled. Although the absence of correlation between explanatory variables helps estimate their separate effects, there are also problems in using data on stated preferences. Even when the hypothetical situations are clearly defined, respondents may have difficulty deciding their preferences and reporting them accurately. Hensher and Truong found a significant number of ratings in their database that implied seemingly irrational preferences, such as favouring the more costly of otherwise identical trips.

Definition of travel modes

Models reviewed for this discussion considerably simplify the mode choices of commuters. They do not generally explain how modes are combined: for example, whether commuters choose to walk or drive their car to a bus service. (Rather, as is explained below, such questions often need to be answered before the models can be estimated.) They all omit certain modes less frequently used for commuting, like taxi and bicycle.

Table B.1 characterises several mode choice models plus the rail demand model of Voith (1991). As can be seen, the mode choice analysed is generally between car travel and one major alternative. The alternative may be ‘public transport’, which is used as a loose synonym for ‘mass transport’ in this appendix, or a particular mode of mass transport (bus or train). Among models estimated for Australian cities, more than two modes have been distinguished only in the aforementioned Hensher and Truong (1983) and in subsequent studies which Hensher authored individually or in collaboration. These studies distinguish four options among Sydney commuters: car as driver, car as passenger, bus and train.

Several of the studies listed in table B.1 leave unanswered questions about their treatment of multiple-mode trips. Did the original database identify combinations of modes used by individual travellers in the sample? Possibly not — some surveys, such as that used by Hensher (1986), ask respondents to identify only their main mode of commuting. If so, were multiple-mode trips simply deleted from the sample or were they somehow mapped to single modes? One possible mapping is to select the mode on which travel time is likely to have been longest. The decision of Groenhout et al (1986), to include in public transport all trips involving both car and public transport, conforms to this: on these ‘park and ride’ trips, the public transport segment usually takes most of the time. Several other studies in table B.1 are less forthcoming about their handling of multi-mode trips.

Modelling of travel times and costs

Models of mode choice usually distinguish between in-vehicle time and other travel time (see table B.1). This is most frequently done for public transport, which has a larger out-of-vehicle time component than car travel. Although people normally dislike spending time commuting (and recall that mode choice models focus on commuting), their aversion may be greater for some inputs of time than for others; for example, they might regard waiting for a bus as a nuisance and time on board as a chance to read. These imply differences in the values of travel time savings — that is, differences in the amount of money people would willingly pay for a marginal reduction in travel time. In the example just given, savings of waiting time are valued more highly than savings of in-vehicle time.

Time savings can also be valued differently across modes. Some people prefer an hour on public transport to an hour of car-driving on the grounds of greater safety and not having to concentrate on the road. Others are more concerned with the comfort and privacy of car travel compared with sometimes crowded public transport, and thus have the opposite preference. Of course, the level of comfort on public transport can vary from standing room only to a quite relaxing ride, and measuring such variation is important for analysing mode choices. Similarly, car-driving time becomes more stressful as traffic congestion increases, making alternative modes more attractive. Unfortunately, such effects have been rarely estimated in models of mode choice. However, several models have allowed the value of travel time savings to differ between modes.

Models have defined the money cost of a car trip variously, ranging from petrol costs alone to a comprehensive measure including parking and some operating costs (see table B.1). Parking costs are sometimes proxied by employment density in the work location (for example, Groenhout et al 1986) and some models measure the subsidy for someone with access to a company car (Hensher 1986). Some costs of car ownership, such as registration fees, are ‘fixed’ in the sense of being independent of how much the car is operated, yet may also influence mode choice. An increase in registration fees could, for instance, induce someone to sell their car and commute to work by public transport. However, among the samples of commuters which mode choice models rely on, fixed costs do not vary enough for their effects to be meaningfully estimated (for example, car registration fees are basically uniform among commuters in the same Australian city).

Table B.1: **Characteristics of selected econometric studies of demand for travel by mode**

					Measures of:			
Country (city)	*Author (year)*	*Survey type and year*	*Purpose of trip*	*Mode(s) modelled*	*car costs*	*car travel time*	*public transport attributes*	*Other explanatory variables*
Australia (Sydney)	Hensher (1986)	cross sectional 1981-82	commuter mode choice	car driver, car passenger, train, bus	variable costs including parking cost for car driver	in-vehicle, walk, wait	fare; in-vehicle, access and wait time	number of business registered cars in a household (including company cars), per cent of travel costs paid for by non-household source
	Groenhout, et al (1986)	cross sectional 1981-82	commuter mode choice	car, public transport	petrol cost	in-vehicle	fare; number of transfers; in-vehicle, access and wait time	income, number of cars per adult in the household, employment density at destination, indicator of whether individual is the main driver of a vehicle when there is more than one licensed driver in a household
	Hensher and Bullock (1977)	cross sectional 1973	commuter mode choice	car, train	variable costs including parking cost	total time	fare; total time	none
Canada (Toronto)	Bajic (1984)	cross sectional 1979	commuter mode choice	car, public transport	variable costs including parking cost	in-vehicle, walk	fare; in-vehicle, walk and wait time	income, age, education
USA (Philadel-phia)	Voith (1991)	panel data 1978-86	all purposes rail demand	train	variable costs incl. parking, fixed cost of owning a car	not appropriate	fare; train speed, number of peak & off-peak trains	none

Researchers often use network databases to measure travel times and other mode attributes (for example, Bajic 1984 and Groenhout et al 1986). However, this can entail high costs and other problems in modelling mode choices. For one, preliminary estimates of certain parameter values are needed to apply the database, and these may conflict with subsequent estimates obtained by econometric means. To illustrate, suppose the database records two bus services connecting a pair of zones, one with walk access and the other with car access. If the mode choice model has only one bus option — along with, say, rail and car — an algorithm must be applied to determine which bus service would be taken. In other words, one must prejudge the value of walking time relative to car travel time. Now, a value for this relativity is also required to predict choices between bus, rail and car, and logically, this should be the same as the value used to narrow the range of bus services. But this consistency is not maintained in the conventional approach, which yields a different value through econometric estimation of the mode choice model.

Another concern about network databases is their omission of within-zone variation. For example, all commuters by bus between some pair of zones will be assumed to have the same walking time, despite homes and workplaces having different proximity to a bus stop. Although the loss of detail is database-specific, American studies have found that estimates of mode choice models can change substantially when geographic detail is added to a travel network database (Train 1978, Talvitie and Dehghani 1979).[4]

Models have also used perceived measures of mode attributes. Hensher and Truong (1983), in their analysis of Sydney data, relied on respondents' perceptions of travel times and costs for both their actual mode and an alternative mode available to them (likewise Hensher and Bullock 1977). This approach has the drawback that respondents may know little about attributes of modes they do not choose. The sensitivity of the estimates of mode choice models to the use of perceived versus objective measures has not been extensively investigated. Tretvik (1993) performed a sensitivity analysis in the context of route choice by Norwegian travellers. He found that perceived time savings from taking a toll road relative to alternative routes differed

4 Talvitie and Dehghani (1979) estimated trip conditions for each traveller in their San Francisco sample, taking account of the exact origin and destination points. They estimated a mode choice model with these data and, alternatively, with times and costs from a network database that identifies locations only by zone. Train (1978) conducted a similar, but less ambitious exercise. The results of these studies need to be viewed cautiously. Talvittie and Dehgani found, when using the network database, that walking and waiting time were valued much more highly than in-vehicle time, a pattern that is widely supported by other studies. Surprisingly, they did not obtain this pattern when they used their alternative database.

significantly from actual time savings, and were better predictors of people's route choices.

Other explanatory variables

The measurement of service quality is an area in which mode choice models tend to be weak. Some models allow transfers between services to have nuisance value additional to loss of time, as transfers may expose one to crowds, bad weather and other inconveniences. Similarly, the effects of service frequency may not be transmitted solely through waiting time. More frequent service tends to reduce waiting time, but it also makes it easier for people to travel at their preferred times, and these changes will have distinct effects on mode choices. However, the Commission has not found any model that includes waiting time and service frequency as separate variables. Indeed, waiting time is often derived from data on service frequency; for example, Groenhout et al (1986), calculate waiting time as half the average time between successive services, with a set maximum of ten minutes to reflect the knowledge of service schedules by the traveller. Predictability of service and levels of in-vehicle comfort are not common variables in mode choice models, and are absent from the Australian models the Commission has discovered.

Many studies have tried to explain mode choices by measuring the traveller's ease of access to a car. Groenhout et al (1986), for example, measure the number of cars owned by the traveller's household per adult member and the availability of these cars to the traveller (see table B.1). Not surprisingly, such studies find that easier access to a car significantly raises the probability of travelling by car rather than other modes. However, the studies do not usually attempt to *explain* ease of access to a car, which is itself an outcome of household decisions depending on basically the same variables that shape mode choices. At the risk of labouring the point, an example about petrol prices can be added to that about registration fees given above: a sustained increase in petrol prices might induce someone to sell their car and commute by public transport. A model like that of Groenhout et al does not capture this response, since it takes the traveller's car situation as given; it only allows the less drastic course of holding on to one's cars and using them less often. Accordingly, these models should understate the full impacts on mode choices of changes in travel times and money costs. (Evidence from a review of USA studies supports this expectation; see Gomez-Ibanez and Fauth 1980.)

Models of trip scheduling

Models of trip scheduling seek to explain when people choose to travel, and as yet comprise a small field. Mostly, they focus on morning trips to work among individuals with a fixed starting time at work. For such commuters, arriving early at work can be a precaution against unexpected delays and a way of avoiding peak periods when roads are congested and money costs possibly higher. (Congestion raises the operating cost of cars, and fares for public transport are often higher during the peak.) Commuters will balance these advantages, when present, against any inconvenience of moving the trip forward. Late arrival at work may have similar travel advantages, but employer penalties usually make this a much less attractive option than early arrival. Trip scheduling models attempt to quantify people's willingness to trade off the inconveniences of early or late arrival with travel time and money savings. The core variables in these models are the scheduled starting time and the travel time and money cost associated with various departure times. Other variables bearing on the trip scheduling decisions may also be included in these models, such as socioeconomic characteristics of the traveller.

Models of trip scheduling suffer from most of the above-discussed problems with mode choice models. (Indeed, some models analyse both scheduling and mode choices.) An additional problem that will now be explained has particular relevance to models of trip scheduling and can arise when more than two options are involved in the decision being analysed. In this situation, there can be reasons to suspect that some pairs of options are closer substitutes than others. Returning to the mode choice context for the moment, bus and rail have in common certain attributes of mass transport and thus might be closer substitutes than bus and car. This would mean, for example, that if bus fares increased, other things assumed constant, the demand for rail travel would increase by more than the demand for car travel. This is the pattern that Hensher (1986) found among Sydney commuters, and many other studies have allowed for differential substitutability between modes. Trip scheduling models define options by time intervals — for example, departure times might be placed within ten minute periods. Yet they generally treat all options as equally close substitutes, even though adjacent time intervals should be closer substitutes than those which are widely separated. A hypothetical example: if departures after 8 am attract a new congestion charge, people will try to avoid it by leaving just before the charge goes into effect, so departures just before that hour should increase by more than departures an hour earlier. But models of trip scheduling would generally assume equal increases.

For these and other reasons, trip scheduling is an area where it is particularly important to supplement evidence from models with evidence from other sources, and this is done in section B.3 of this appendix.

Other urban travel demand models

'Mode choice models', as described above, are built along different lines from models of demand for a particular mode. To illustrate the difference, consider what happens when public transport fares increase. Certain trips are diverted from public transport to car but remain fundamentally unchanged (same origin, destination, and time of day as before). This is the intermodal substitution effect. Other trips, especially those made by 'captive' users of public transport, are cancelled or perhaps shortened — a negative 'trip generation' effect. Mode choice models would represent substitution effects only, since they take the numbers and types of trips as given. By contrast, other models analyse the total demand for travel by a public mode, allowing for both substitution and generation effects, but without estimating them separately. Such models have also been estimated for car travel, where demand is usually measured by distance travelled. Analyses of these types, together with models of petrol demand, comprise the 'other urban travel demand models' considered here. Their focus is generally wider than commuter travel, in many cases considering trips for all purposes.

Data for estimating these models are usually aggregated, but vary considerably in other respects. Willis (1989) compared patronage on public transport in South Australia shortly before and after a fare increase, and attempted to adjust for the influence of contemporaneous changes such as reductions in service. But it is difficult to adjust for other factors with only two basic data points ('before' and 'after'). Moreover, even without confounding factors, the impact of a fare change may not be fully realised for some time, which is why Willis describes his estimates as 'short-term'. Other studies have used more observations over a longer period to estimate dynamic models representing both the short- and long-term effects of fare changes and other influences on public transport demand. Time-series have also been used to estimate dynamic models of petrol demand. Panel data have been used as well, as by Voith (1991) in modelling the demand for radial rail trips in Philadelphia (see table B.1). Lago et al (1981a) term 'experimental' those studies using data from transit service demonstration projects, such as the trial test of an express bus service.

Measurement of impacts

The impacts on travel demand of changes in prices, travel times and other factors are often measured as elasticities. An elasticity is the ratio of the percentage change in travel demand to the percentage change in one of these influencing variables. For example, if an eight per cent increase in bus fares reduces the demand for bus trips by two per cent, this can be expressed as elasticity of -0.25. An own elasticity measures the response to a change in an attribute of that being demanded (whether it be fares or time). A cross elasticity indicates the response to a change in an attribute of another good. Mode-choice cross-elasticities indicate a switching effect, as the total number of trips is assumed fixed. As such, cross elasticities depend on the initial composition of travel between the modes. As the majority of commuter trips are by car in Australian capital cities, an illustrative 10 per cent of bus travellers switching to car might represent less than a two per cent increase in the number of car travellers. Hence cross-price elasticities of demand for car travel with respect to changes in public transport prices are expected to be quite low for Australia (see table B5).

Of course, the value of an elasticity may depend on the magnitude of the change in the influencing variable. In the example just given, had the percentage bus fare increase been four per cent, the percentage reduction in demand might have been 1.2 per cent, meaning an elasticity of -0.3. Most commonly reported in studies of travel demand are the 'point' elasticities, which are calculated using even smaller percentage changes in the influencing variable. Approximately, the point elasticity is the percentage change in travel demand when the influencing variable increases by one per cent. The point elasticity is also a symmetric measure, in that its negative approximates the percentage change in demand when the influencing variable decreases one per cent. Elasticities that are calculated for larger changes in the influencing variables are called 'arc' elasticities.

Arc elasticities are more directly relevant to policy evaluations, which generally consider changes in policy variables of well over one per cent (for example, a ten per cent fare increase). Unfortunately, most models of travel demand report point elasticities only and are insufficiently documented for arc elasticities to be inferred. This creates the temptation to substitute point elasticities for arc elasticities when predicting the impacts of substantial changes. However, Dunne (1984) obtained estimates of point and arc elasticities that differed somewhat in his study of the car versus bus choices of Scottish commuters. These differences translated to noticeable errors when point elasticities were used to approximate the impact of more than a five per cent change in prices and travel times. For example, for a 40 per cent increase in the cost of car travel, the demand for car travel was predicted to decline by 4.8 per cent using a point elasticity and by 6.3 per cent using an arc elasticity. While an error of this size may seem no great cause for concern, much larger errors could arise in other studies. Dunne is thus correct in recommending that estimates of arc elasticities be more widely reported in studies of travel demand.

However, estimates of arc elasticities are themselves prone to error when calculated for truly radical changes. Suppose, for example, that one is interested in the effects of raising public transport fares sufficiently to cover the full cost of public transport in Australian cities. Based on the evidence presented elsewhere in this report, fares could as much as quadruple in this scenario, making public transport far more expensive relative to car travel than has been historically the experience. So models of travel demand, which are normally estimated with historical data, could yield quite erroneous predictions about peoples responses to such unprecedented conditions. For this scenario, the modeller would be understandably reluctant to report an arc elasticity.

Beside the arc versus point distinction, other definitional differences exist among elasticities in models of travel demand. This is particularly so among models estimated with a city-based sample of individual travellers. In some models, elasticities of aggregate demand are derived by combining estimated demand responses among all individuals in the sample. This is intended to capture the variation in responses among individuals with different characteristics and travel situations. Comparing otherwise identical individuals, a model might predict, for example, that demand for car travel is less elastic with respect to petrol prices, the higher a person's income. An alternative to combining the estimated responses across sampled individuals is to report elasticities for one or more 'representative' travellers. The simplest approach is to define a notional traveller having the average scores for all variables in the database. According to naive intuition, the elasticities calculated for this typical traveller should be close to those calculated more rigorously by combining estimated responses across individuals. However, Small (1992) provides an example to show that they can be quite different.

B.3 Findings

Elasticity estimates have been taken from individual studies of urban travel demand and from literature surveys, some of which are international in scope. Other countries studied are usually at a similar stage of economic development to Australia, although Oum et al (1992) canvass evidence for less developed economies as well. Moreover, evidence from countries resembling Australia in socioeconomic terms must be approached carefully, particularly as models of urban travel demand have often failed tests of transferability between cities in the same country. Galbraith and Hensher (1980) attributed the problems in transferability to differences between cities in 'spatial culture, physical environment or cultural environment'. However, Small (1992) concludes that by incorporating information about the particular city, models can generally be adapted quite successfully. Even so, generalisations should not be made lightly.

Fortunately, certain findings are fairly standard and some of these are illustrated in table B.2, which presents the Sydney results obtained by Hensher (1986). This is the most detailed mode-choice study conducted for Australia and, like most other mode choice studies, it focuses on commuters. Results from many other studies are given in the tables B.3 to B.8.

Travel demand elasticities

The clearest pattern in our tables is that estimates of elasticities are nearly all in the inelastic range and usually below 0.5 in absolute value. While travel demand is found to respond to price and time variables in understandable directions, the estimated magnitudes of these effects are generally modest. The exceptions are the elastic responses of rail demand to changes in fares and attributes of car travel, estimated by Voith (1991) for Philadelphia. European studies of urban rail demand have also yielded some estimates of elastic responses to travel times, mainly for non-urban trips (see TRRL 1980).

Patterns among estimated elasticities, including some not presented in the tables, are discussed below in detail.

- Studies confirm that the ‘law of demand’ applies to travel modes: demand for travel on a mode decreases as the price of that mode increases. (Prices refer here to public transport fares or measures of car costs.) For both car and public modes, the estimates of own-price elasticities vary considerably within the inelastic range, making ‘best-guess’ estimates fairly subjective. That said, reviews of overseas evidence have judged -0.3 to be a representative estimate for public transport. Hensher’s results suggest that the own-price elasticity is higher for public transport than for car travel, but this does not emerge so clearly from other studies (compare tables B.3 and B.4).
- Demand for petrol is more own price-elastic than demand for car travel, at least in the long run (see table B.3). When the price of car travel is measured by petrol costs, as in Groenhout et al (1986), the explanation for this is plain: higher petrol costs would reduce the utilisation of cars and, over time, the stock of cars, and the reduction in car-driving would show up in petrol demand as well; but petrol demand would decline further as people switch to more fuel efficient cars.[5] Even when the price of car

[5] Greater fuel efficiency can be achieved even before major changes in the composition of the vehicle stock, due to changes in the relative utilisation of vehicles. For example, a family with two cars would become more likely to use their more fuel-efficient car for a family outing. Such effects are examined in the comprehensive modelling literature on vehicle ownership and use, which includes the Australian studies of Hensher (1990) and

travel includes costs other than petrol, estimates of own-price elasticities are generally lower for car travel than for petrol.

- Mode choice appears to be more sensitive to changes in travel time than to changes in prices. Hensher (1986) estimated that demand for bus travel has an elasticity of -0.36 with respect to the bus fare and -0.60 with respect to bus travel time (see table B.2). Groenhout et al (1986) also analysed Sydney data and obtained car travel own-price and own-time elasticities of -0.04 and -0.17, respectively. Not all studies support this pattern — Voith (1991) is again an exception — but they uniformly support the more critical result that own-time elasticities are indeed negative. As one would expect, fewer trips are undertaken on a given mode the more time it takes. One might also surmise from Hensher's results in table B.2 that own-time elasticities, like own-price elasticities, are larger for public transport than for car travel. The evidence in table B.7 is more ambiguous in this regard but also lends some support: some of the estimates of own-time elasticities for public transport are an order of magnitude larger than the few estimates available for car travel.
- Elasticities are usually in the order of two to three times as high in the long run as the short run. (See, for example, the findings of Voith 1991 and Goodwin 1992.) This is primarily because the range of responses to a change tends to be more limited in the short run.

Table B.2: **Elasticity estimates for Sydney**

	Elasticity of demand for trips by:			
	car as driver	*car as passenger*	*rail*	*bus*
With respect to price of:				
car travel as driver	-0.08	a	+0.11	+0.04
car travel as passenger	+0.35	-0.02	+0.11	+0.04
rail	+0.29	a	-0.27	+0.08
bus	+0.29	a	+0.16	-0.36
With respect to in-vehicle travel time of:				
car travel as driver	-0.12	+0.06	+0.19	+0.07
car travel as passenger	+0.56	-0.38	+0.19	+0.07
rail	+0.47	+0.03	-0.42	+0.14
bus	+0.47	+0.03	+0.27	-0.60

a Denotes elasticity estimate between -0.005 and +0.005.
Source: Hensher 1986

Hensher et al, 1990. For a summary of various modelling approaches, see Mannering and Hensher (1987).

- Some studies have found that demand for public transport is less price-responsive during peak periods than at other times (see the surveys by Lago et al, 1981b and TRRL, 1980). Off-peak travellers might be more responsive to fare changes because they have more discretion in their travel choices. Social, shopping and recreational trips, which are frequently made during off-peak periods, can be combined for more than one purpose, or sometimes not taken at all. In comparison, people have less discretion over trips to work or school, most of which are made during peak periods. However, the evidence from studies of travel demand is unclear on whether the lesser sensitivity of peak travellers to fare changes extends to travel times as well (see Lago et al 1981a).
- Demand for public transport seems to depend more on attributes of public transport than on attributes of car travel. For prices, this can be seen by comparing own-price (see table B.4) and cross-price (see table B.6) elasticities of demand for public transport from the same study. Hensher et al (1989) estimate, for instance, that a one per cent increase in bus fares would reduce bus demand by 0.34 per cent, but that bus demand responds hardly at all to changes in car costs (an elasticity of only +0.01). For travel times as well, there is some evidence that own-time elasticities of demand for public transport modes are larger than the cross-time elasticities with respect to car travel.
- Some studies indicate that increases in income incline people to choose car travel over public transport. Groenhout et al (1986) estimated a mode choice model for Sydney commuters in which the number of trips was fixed, so that any changes in demand by mode represent inter-modal substitution. They estimated that increases in income slightly reduce the demand for public transport, with the elasticity being -0.15. Itorralba and Balce (1992) found that among Sydney households interviewed in 1991, car trips as a proportion of total trips undertaken (including non-commuting trips), increases by about 0.9 percentage points for each additional $10 000 income. Compared to an average of 70 per cent of trips being made by car, the variation with income would seem fairly small. A positive effect of income on the car share of travel agrees with evidence that car travel is usually faster than public transport in Australian cities (see, for example, Hensher 1986), and that the more affluent value their time more highly (an issue discussed below). Another effect of higher incomes is to increase the total demand for travel. In theory, an increase in income could thus raise the demand for public transport, while still reducing its share of total travel demand. The literature on this is inconclusive. TRRL (1980) cites studies for Australia and other countries that found that demand for urban public transport decreases, on balance,

when income increases. These studies indicate that much of this decrease occurs through increases in car ownership. In comparison, Gargett (1990), in analysing Australian time series, found that an increase in income raises consumer demand for public transport, as measured by an elasticity of +0.5.[6] However, he does not consider the effect of income on car ownership levels.

No discussion of travel demand elasticities would be complete without considering influences they often fail to measure. Reliability of service and availability of seats were regarded by many people as significant influences on their use of public transport, in attitudinal surveys cited by Lago et al (1981a). However, the influence of seat availability on travel decisions has rarely been quantified. Reliability has been more frequently incorporated into models, which in the case of cars refers to the predictability of journey time. Despite this, Small (1992) notes that 'no measure of reliability has achieved statistical significance ..., even though some ... have involved considerable sophistication and effort'. Small also notes that estimated effects of transfers on traveller choices are often implausible or unstable. For public transport, the service attribute that has been best modelled, apart from time, is the frequency of service (headway). Estimates from American demonstration projects suggest that demand elasticities with respect to headway are about -0.5 for both bus and rail (Lago et al 1981a).

Parking costs have been combined with other car travel costs in many models of travel demand, but it can be questioned whether the additive treatment is appropriate. Gillen (1977) found in his mode choice model that an increase in parking costs has a greater impact on mode choices than an identical increment in running costs. In the absence of corroborating evidence, and of obvious reasons why this should be so, one cannot conclude much from this finding, but it does serve to reinforce the message from attitudinal surveys that parking considerations are important influences on mode choices. Such considerations were offered as reasons for using public transport by about one-third of public transport users responding to an Australian Automobile Association survey (Sub. 140).

6 Similarly, Selvanathan (1990) finds that the demand for travel in general, as opposed to just urban travel, increases with income.

Elasticity estimates

Table B.3: **Own-price elasticities — car travel**

Elasticity measure	*Author (year)*	*Study*[a]	*Country (city)*	*Short run*	*Long run*	*Undefined*
Car travel demand with respect to:						
Car variable costs	Oum et al (1992)	S, K	Australia USA UK	-0.09 to -0.24 -0.23	-0.22 to -0.31 -0.28	-0.22 to -0.52 -0.13 to -0.45 -0.14 to -0.36
	Hensher et al (1989)	D, K	Australia (Sydney)	-0.12		
Petrol price	Goodwin (1992)	S, V	Primarily UK	-0.2	-0.3	
	Hensher and Smith (1986)	E, K	Australia (Sydney)	-0.1	-0.3	
	Groenhout et al (1986)	E, N	Australia (Sydney)	-0.04		
Petrol demand with respect to:						
Petrol price	Goodwin (1992)	S, L	Primarily UK	-0.3	-0.7	
	Hensher and Young (1991)	D, L S, L	Australia (Sydney) Australia		-0.66 -0.54 to -0.71	
	Beesley and Kemp (1987)	S, L	USA and UK	-0.2 to -0.3	-0.3 to -1.4	
	Donnelly (1982) [b]	S, L	Primarily USA	-0.14	-0.49	

a *Study type:* D derived from elasticity estimates; E econometric; S survey of the literature. *Units of dependent variable:* K kilometres; L litres; N number of trips; V various.

b From Hensher and Young 1991

Table B.4: **Own-price elasticities — public transport**

Elasticity measure	*Author*	*Study*[a]	*Country (city)*	*Short run*	*Long run*	*Undefined*
Public transport demand with respect to:						
All fares	Oum et al (1992)	S, V	Many Countries	-0.1 to -0.6		
	Willis (1989)	B, K	Australia (Adelaide)	-0.10		
	Kyte et al (1988)	E, K	USA (Oregon)	-0.3		
	Groenhout et al (1986)	E, N	Australia (Sydney)	-0.10		
	Lago et al (1981b)	S, V	USA and UK			-0.15 (peak) -0.34 (off-peak)
	TRRL (1980)	S, V	Many Countries	-0.3		
Bus demand with respect to:						
Bus fares	Goodwin (1992)	S, V	Primarily UK	-0.33	-0.57	
	Oum et al (1992)	S, V	Many Countries			-0.04 to -0.58
	Hensher et al (1989)	D, K	Australia (Sydney)	-0.34		
	Dunne (1984)	E, K	UK (Edinburgh)	-0.13		
	Lago et al (1981b)	S, V	USA and UK			-0.30

Table B.5 (cont): **Own-price elasticities — public transport**

Elasticity measure	*Author*	*Study*[a]	*Country (city)*	*Short run*	*Long run*	*Undefined*
Rail demand with respect to:						
Rail fares	Oum et al (1992)	S, V	Many Countries			-0.22 to -0.57
	Goodwin (1992)	S, V	Primarily UK			-0.79
	Voith (1991)	E, N	USA (Philadelphia)	-0.62	-1.59	
	Hensher et al (1989)	D, K	Australia (Sydney)	-0.30		
	Doi and Allen (1986)	E, N	USA (Philadelphia)	-0.23		
	Lago et al (1981b)	S, V	USA, UK and France			-0.15
	Hensher and Bullock (1977)	E, N	Australia (Sydney)	-0.57		

a *Study type:* B before and after; D derived from elasticity estimates; E econometric; S survey of the literature.
Units of dependent variable: K kilometres; N number of trips; V various.

Table B.56: **Cross-price elasticities — car travel**

Elasticity measure	*Author (year)*	*Study*[a]	*Country (city)*	*Short run*[b]
Car travel demand with respect to:				
Public transport fares	Groenhout et al (1986)	E, N	Australia (Sydney)	+0.06
	Dodgson (1986)	D, K	Australia (Sydney) Australia (Melbourne)	+0.02 +0.01
Rail fares	Hensher et al (1989)	D, K	Australia (Sydney)	+0.04
	Hensher and Bullock (1977)	E, N	Australia (Sydney)	+0.19
Bus fares	Hensher et al (1989)	D, K	Australia (Sydney)	+0.01
Difference between car and public transport costs	Bajic (1984)	E, N	Canada (Toronto)	+0.09

a *Study type:* D derived from elasticity estimates; E econometric.
Units of dependent variable: K kilometres; N number of trips.
b No long run estimates are presented.

Table B.7: **Cross-price elasticities — public transport**

Elasticity measure	*Author (year)*	*Study*[a]	*Country (city)*	*Short run*	*Long run*	*Undefined*
Public transport demand with respect to:						
Petrol price	Goodwin (1992)	S, V	Primarily UK			+0.34
	Groenhout et al (1986)	E, N	Australia (Sydney)	+0.07		
Bus demand with respect to:						
Car variable costs	Hensher et al (1989)	D, K	Australia (Sydney)	+0.01		
Rail demand with respect to:						
Petrol price	Kyte et al (1988)	E, K	USA (Oregon)	+0.18		
	Doi and Allen (1986)	E, N	USA (Philadelphia)	+0.17		
Car variable costs	Voith (1991)	E, N	USA (Philadelphia)	+0.11	+1.13	
	Hensher et al (1989)	D, K	Australia (Sydney)	+0.02		
Car fixed costs	Voith (1991)	E, N	USA (Philadelphia)	+1.05	+2.69	

a *Study type:* D derived from elasticity estimates; E econometric; S survey of the literature.
Units of dependent variable: K kilometres; N number of trips; V various units.

Table B.8: **Own-time elasticities — car travel and public transport**

Elasticity measure	*Author (year)*	*Study*[a]	*Country (city)*	*Short run*	*Long run*
Car travel demand with respect to:					
Car in-vehicle time	Groenhout et al (1986)	E, N	Australia (Sydney)	-0.17	
Public transport demand with respect to:					
Public transport in-vehicle time	TRRL (1980)	S, V	Many countries	-0.3 to -0.5	
Wait time	Groenhout et al (1986)	E, N	Australia (Sydney)	-0.03 -0.11	
Bus demand with respect to:					
Bus in-vehicle time	Lago et al (1981a)	S, V	USA	-0.68	
Rail demand with respect to:					
Rail in-vehicle time	Lago et al (1981a)	S, V	USA London only	-0.70 -0.59	
	Voith (1991)	E, N	USA (Philadelphia)	-0.16	-0.42

a *Study type:* E econometric; S survey of the literature.
Units of dependent variable: N number of trips; V various.

Table B.9: **Cross-time elasticities — car travel and public transport**

Elasticity measure	*Author (year)*	*Study*[a]	*Country (city)*	*Short run*[b]
Car travel demand with respect to:				
Public transport:	Groenhout et al (1986)	E, N	Australia (Sydney)	
in-vehicle time				+0.04
out-of-vehicle time				+0.06
Bus in-vehicle time	Lago et al (1981a)	S, V	USA	+0.36 (peak) [c] +0.26 (off-peak)
Public transport demand with respect to:				
Car in-vehicle time	Groenhout et al (1986)	E, N	Australia (Sydney)	+0.32
Bus demand with respect to:				
Car in-vehicle time	Lago et al (1981a)	S, V	USA	+0.14 (peak) +0.07 (off-peak)

a *Study type:* E econometric; S survey of the literature.
Units of dependent variable: N number of trips; V various.
b No long run estimates are presented.

The value of travel time

In addition to people's sensitivity to travel time, the value of travel time provides important information to policy-makers. It indicates the willingness of individuals to pay for travel time savings and is often applied in the evaluation of investment projects. Because travel is generally undertaken to enhance activities that provide satisfaction in their own right, most people want to minimise the time and money spent making a particular trip. The amount a person would pay in order to save a given amount of travel time is his or her value of travel time savings. Dividing the former by the latter yields the average value of time, or 'value of time' for short. (For instance, a willingness to pay $11 to avoid 1.1 hours of travel time equates to a value of time of $10 per hour.)

It is often hypothesised that the value of time increases with a person's wage rate, since the wage rate is in a sense the opportunity cost of spending time travelling rather than working. One can also expect that as people's incomes rise, they place more emphasis on pure leisure time, as opposed to activities like urban travelling that usually afford little or no intrinsic enjoyment. Small (1992) affirms a consensus conclusion from empirical work that the value of travel time does increase with both income and wage rates, though not necessarily proportionally. Lack of proportionality could be one of many reasons why Waters (1992), in his review of 25 empirical studies, finds considerable variation in the estimated value of travel time as a percentage of the wage rate. Although the central tendency he discerns is between 30 and 60 per cent, many estimates are well outside this range, both among the studies he reviews and other studies examined by the Commission (see, for example, the Australian studies of McKnight 1982, Truong and Hensher 1985, Hensher 1989).

Estimates of travel time values vary fairly consistently between trip purposes. They appear to be higher for business travel (as part of work) than for commuter travel, and higher for commuter travel than for non-work related travel (Hensher 1989 and Tretvik 1993).

In addition, out-of-vehicle time is usually found to be valued two to three times more highly than in-vehicle time. In other words, people would generally be willing to spend proportionately much more to reduce walking and waiting time than to reduce in-vehicle time by the same amount. Modal differences in values of time have also been estimated. Apparently, Sydney commuters are on average more averse to spending time driving a car than aboard public transport (see Groenhout el al 1986 and Hensher 1989). The same preference was discerned among San Francisco commuters in the study by Train (1978), who attributed this to desirable aspects of riding transit, such as the opportunity to read and not having to cope with traffic.

Typical estimates of values of time suggest that time cost far outweighs money cost for commuting in Australian cities. The Commission has calculated that time cost averages at least three times the money cost, using Sydney-based estimates from Hensher (1986, 1989). This accords with the standard finding that the demand for travel is more sensitive to changes in times than to changes in money costs (see above discussion of elasticities). Basically, they are different ways of saying the same thing.

Finally, a point about the use of time values in evaluations of transport projects. In reality, how people value a given saving in travel time will depend on how much time they currently spend travelling. Someone might for instance, value a ten minute time saving more highly if they currently commute one hour as opposed to fifteen minutes. Thus, since the marginal value of time may not be constant, the average value of time used for project appraisals should depend on the magnitude of the time savings the project would realise. Intriguingly, many appraisals of American projects use an industry guide that has vastly different average values of time for different levels of time savings. Small (1992) observes that these differences are not based on solid evidence, but that more defensible patterns can be derived from econometric analysis. However, many econometric studies of mode choice, such as that of Groenhout et al (1986), have assumed a constant marginal value of time.

Evidence on trip scheduling

Models of trip scheduling lend support to common-sense propositions, but have not progressed much further. Small (1982) analysed the scheduling of morning work trips in San Francisco and found that, on average, people are willing to arrive one minute early at work if they can save at least 0.7 minutes travel time (by avoiding the traffic peak). Predictably enough, he found that people are much less willing to arrive late: that at least a two minute saving in travel time is usually required before they would arrive one minute late. Simulations of the effects on trip scheduling of congestion pricing and other policies would be more relevant to transport planning than such estimates of rates of substitution, but few have been reported. Hendrickson and Plank (1984) simulated the effects of a peak period auto charge on the scheduling of morning work trips in Pittsburgh. The assumed charge amounted to between one- and two-thirds of baseline costs for illustrative auto commuters driving alone. The predicted impacts on the departure times of car drivers were comparatively small, with only about ten per cent fewer commuters leaving during the previous peak period (from 7.20 to 7.40 am). Whether the impact would have been this small is made questionable by several limitations of the model. In particular, like the other trip scheduling models examined, it takes as given each individual's scheduled starting time for work, whereas some adjustment to work schedules could be expected after a congestion charge is introduced.[7]

Flexible working hours are often advocated as a means of reducing traffic congestion. The introduction of ‘flexitime’ to government offices in Ottawa reduced peak travel by more than 50 per cent, more through an increase in early arrivals than in late arrivals (Jones et al 1986). American evidence confirms that workers on standard daytime schedules come in earlier on average when allowed greater choice of hours (Ott et al 1980; Moore et al 1984).

Evidence from other ‘before-after’ evaluations suggest that trip scheduling is sensitive to travel times. Traffic congestion in the peak period often fails to reduce significantly following major additions to network capacity. In part, this is because people take advantage of any initial reduction in congestion to reschedule their trips closer toward the peak. So, while the peak period shortens the level of congestion during the peak changes little. This is what happened, for example, in San Francisco after the opening of a light rail system that attracted 8,000 trips previously made by car (evidence in Serret 1975) as reported in Small 1992).

Singapore’s experience with congestion pricing, as described in Toh (1977), also sheds light on trip scheduling. The Area Licensing Scheme (ALS) introduced in 1975 imposed a charge on most types of private vehicles entering central Singapore City between 7.30 am and 9.30 am (high-occupancy vehicles were exempt). Four weeks after the scheme’s introduction, the number of vehicles entering the area had fallen by 45 per cent during the chargeable period and by 22 per cent during the entire morning. These changes were due to people cancelling or rescheduling trips, rerouting their trips around the central city and relying more on car-pooling or public transport. Evidence of rescheduling is the 15 per cent increase in the number of vehicles entering the central city in the half hour before and the hour after the chargeable period. Adjustments in work hours were facilitated by the introduction of flexitime for many Singapore city workers shortly before the ALS took effect. The ALS could have had larger or smaller effects on trip scheduling over the longer run than during the four weeks after the scheme’s introduction, the period to which the above data relate. (See to chapter A9 for additional discussion of congestion charges.)

7 Abkowitz (1981) and Wilson (1989) also estimate models of trip scheduling.

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APPENDIX C

Modelling the effects of urban transport reforms

APPENDIX C MODELLING THE EFFECTS OF URBAN TRANSPORT REFORMS

Reforms to urban transport will affect patterns of land use, but these impacts have not been adequately investigated with Australian models. The Commission has collaborated with Dr. Mark Horridge of Monash University in developing a spatial equilibrium model of Melbourne to analyse patterns of land use and commuting. The model is used in this appendix to simulate the impacts of three reform scenarios: reforms to public transport resulting in a large fare increase and a small reduction in travel times; a surcharge on central Melbourne car parking; and a revenue-neutral restructuring of public transport fares to make fares proportional to distance travelled. In each simulation, employment disperses away from central Melbourne to outlying areas, but the associated decline in importance of the centre is stemmed by a reverse movement in population. Changes in land prices are key to explaining these findings. Predicted impacts on employment and population outside the centre vary across the zones distinguished in the model, and depend on the scenario being modelled. The demand for public transport is predicted to change significantly in the simulation where fares are increased overall. Yet there is no evidence from the simulations that air pollution from commuter travel would abate appreciably.

C.1 Introduction

The terms of reference for this inquiry ask the Commission to report on the 'role of transport infrastructure in shaping the nature and pace of urban development'. Pursuant to this request, the Commission has been collaborating with Dr Horridge of Monash University in developing a modelling framework known as the Model of Urban Land use and Transport Interaction (MULTI). The framework extends a model which Dr Horridge had previously created to analyse land use and transport patterns in Melbourne. MULTI requires considerably more data than its predecessor, and only the Melbourne database has been developed thus far. This appendix describes the MULTI model of Melbourne and uses it to analyse the effect of hypothetical reforms to public transport and parking charges. However, some background on models of urban land use is provided first.

C.2 Models of urban land use

Models of urban land use came into prominence in the 1960s and 1970s and were designed to capture the two-way linkages between land use patterns and the transport system. By contrast, conventional urban transport planning (UTP) models are unidirectional in this regard. Such models relate the demand for transport to the spatial distributions of population and economic activity, features of the transport system and demographic factors. However, they do not incorporate the feedbacks from transport costs to the location decisions of households and producers. The continuing dominance of these conventional models reflects common failings among full-fledged models of transport and land use interactions. These include: lack of transparency, which has earned them a 'black box' reputation; patchy realism, as exemplified by the frequent absence of any role for land prices; and parameter values that are frequently unsupported by econometric evidence. The contrast between these shortcomings and the heady optimism of some early proponents of the interactive models contributed to the disappointment of urban planners.[1]

The interactive models fell from favour during the over-reaction of the 1980s, and it is only recently that planners are coming to a balanced assessment of their potential. Although the changes in land use patterns cannot be precisely estimated, orders of magnitude are often possible and the robustness of findings can be checked by varying assumptions and parameter values. Equally importantly, they can highlight economic mechanisms that escape casual intuition: some of these may be second-round effects that countervail the aim of government policies. Moreover, while no model can capture all the relevant mechanisms, transparency can make plain the omissions and allow some assessment of resulting biases.

The recent rise in the standing of transport/land use models has spurred new research. In Australia, Professor Young and several of his colleagues at Monash

[1] This is exemplified by a study of land-use impacts of a proposed ring road around Melbourne. The Melbourne Metropolitan Board of Works conducted the study with the assistance of a consultant and commissioned a post-study evaluation by Loder and Bayly (1980). The evaluer rightly argued that land-use impacts had been under-estimated because the study took as given the levels and locations of 'basic' employment - that is, employment in industries like manufacturing which sell most of their output outside the region. This treatment of basic employment is common among models of urban land use. Webster et al (1988) discuss the history of these models and their features, and compare simulation results across nine models based in seven countries.

University have been developing a model called LAND, which appears to complement the Dr Horridge/Commission effort (see Gu et al 1992). However, applications of LAND have yet to be published. The only other extant models of transport and land use interaction in Australia are RJ Nairn and Partners' TRANSTEP and the TOPAZ model of Melbourne created by CSIRO.[2] The latter is currently being updated and recalibrated using 1991 data (Sub. 264, p. 1). TRANSTEP has been implemented for most capital cities, including recently for Melbourne. In common with other UTP models developed for Australia, TRANSTEP omits consideration of commercial transport, for which data are quite limited. It does, however, include a wealth of detail on the transport network and on how demand for household travel is determined. In addition, it goes beyond the conventional UTP models by incorporating two-way interactions between land use and transport. However, it does not recognise the role of land prices in guiding location decisions. Moreover, the component of TRANSTEP that seeks to explain land use patterns has been 'switched off' in many applications of the model.

MULTI is in the 'sketch planning' tradition, as it sacrifices geographic detail of the standard often found in UTP models. Yet it is the framework for the case study in this appendix since its advantages more than offset this. These include transparency and a rigorous paradigm of location choices that takes land prices into account. The prices of land are allowed to vary by location and category of use (due to zoning), and are explained by the interaction of supply and demand. While Dr Horridge's original model contained many conjectural parameter estimates and failed to distinguish modes of commuting, the MULTI model of Melbourne, which is discussed in the next section of this appendix, goes much of the way toward resolving these problems.

C.3 The MULTI model of Melbourne

The model divides Melbourne into nine zones (see figure C.1), and considers the decisions of households about where to live and work, mode of commuting and how much land to live on. It assumes away many hard-to-model phenomena, including households with multiple jobs, but includes enough realism to be of value. The determinants of household decisions that are pre-eminent in the 'monocentric' models – land rentals, incomes and commuting costs – are also captured in MULTI, along with zonal wage levels and the intrinsic attractiveness of different zones. Land 'rentals' are the annualised costs corresponding to land prices.

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2 See RJ Nairn and Partners (1986) and Brotchie et al (1980), respectively, for descriptions of TRANSTEP and TOPAZ.

Commuting options

The MULTI model distinguishes two modes of commuting — car and public transport — and defines a ‘generalised’ cost for each combination of mode and origin-destination pair. The generalised cost combines time and money components, assuming certain dollar values for travel time. The money costs in this formula are those actually borne by travellers and their households, or ‘private’ costs. The social costs of providing transport services are the resource costs to society, and can differ in the model from private costs. The deviation between private and social cost is a mode-specific tax or subsidy, the revenue from which is equally shared by households as a lump sum transfer. For each mode, the social cost of a trip is assumed proportional to distance travelled. Absent from the model are endogenous traffic congestion and transport for non-commuting purposes.

Demographic stratification

Households are divided between landowners and landless, assumed to form ‘rich’ and ‘poor’ halves of the population. Horridge (1991) observes that insufficient data were available to support an occupational stratification, which is more conventional in models of land use; he also contends that the property distinction is more relevant. Housing demand, Dr Horridge argues, depends more on accumulated wealth than on human capital because of borrowing constraints. In the absence of adequate data on wealth, he uses land rental income (including imputed rents) as a proxy.

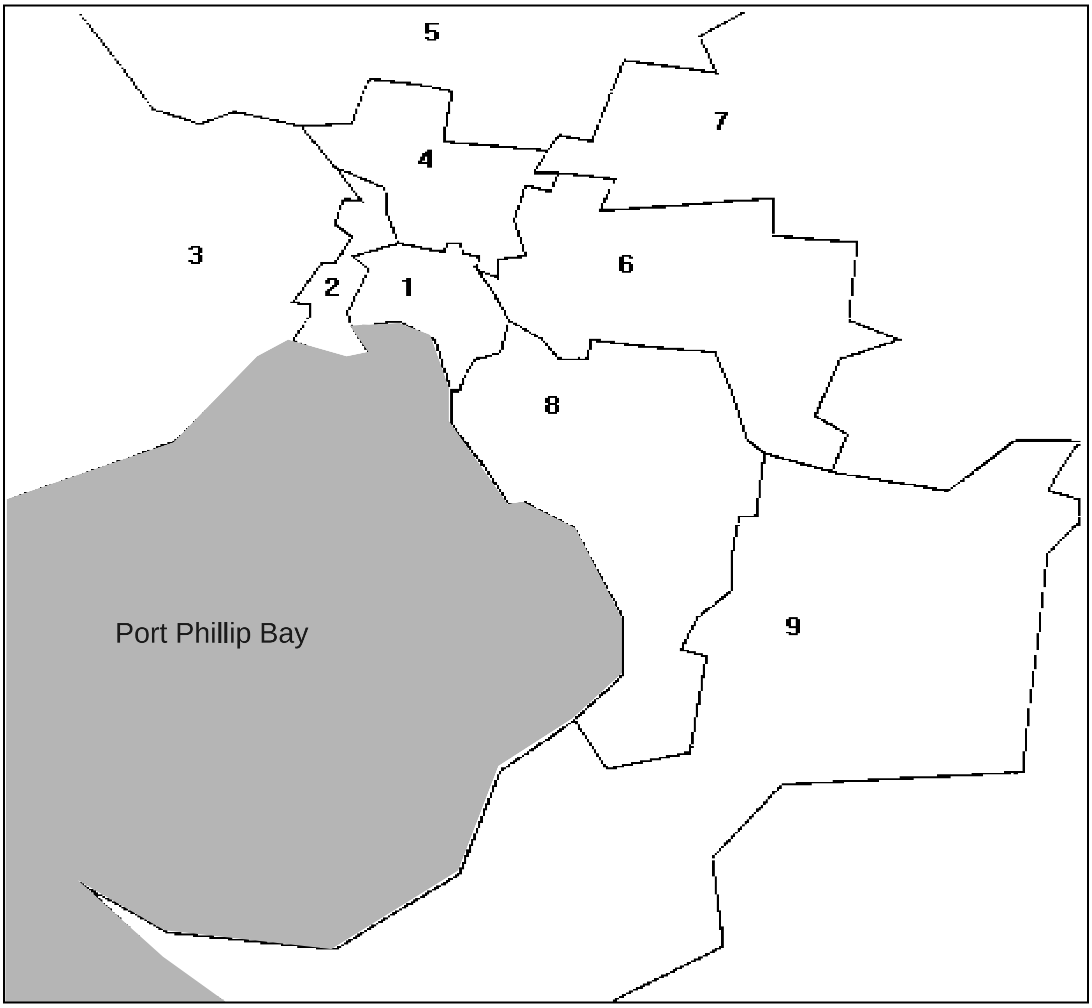
Labour markets

The model abstracts from occupation and other skill attributes and thus treats labour as a homogeneous input. In concept, it allows wages to differ between local labour markets because of competitive pressures. An example of such pressures is the high cost of commuting to remote locations, which might require premium wages to attract workers. In practice, the model assumes that wages are currently uniform since estimates by locality are not available. However, it allows differentials to arise in the future.

Household choices

The categories of dwellings in the model are ‘flats’ and ‘houses’. Within each zone, a house is assumed to occupy twice the area of a flat. However, the site area per house varies (positively) with distance from the city centre and with direction.

Figure C.1: **Zones of the Melbourne region**



Source: Horridge 1991

Zone	**Local Government Areas (LGA)**
1: *Central:*	Collingwood, Fitzroy, Melbourne, Prahran, Port Melbourne, Richmond, St Kilda, South Melbourne.
2: *Inner West:*	Essendon, Footscray, Williamstown.
3: *Outer West:*	Altona, Keilor, Melton, Sunshine, Werribee.
4: *Inner North:*	Broadmeadows, Brunswick, Coburg, Northcote, Preston.
5: *Outer North:*	Bulla, Whittlesea.
6: *Inner East:*	Box Hill, Camberwell, Croydon, Doncaster, Hawthorn, Heidleberg, Kew, Knox, Nunawading, Ringwood.
7: *Outer East:*	Diamond Valley, Eltham, Healesville, Lillydale, Sherbrooke.
8: *Inner South:*	Brighton, Caulfield, Chelsea, Dandenong, Frankston, Malvern, Moorabbin, Mordialloc, Oakleigh, Sandringham, Springvale, Waverley.
9: *Outer South:*	Berwick, Cranbourne, Flinders, Hastings, Mornington, Pakenham.

Households choose among 324 options defined by locations of home and workplace, type of dwelling and mode of commuting (9 zones x 9 zones x 2 densities x 2 modes). For each population stratum (rich and poor), the distribution of households between options is derived in a utility-maximising framework. The determinants of choices include wage rates and income from land, commuting costs and land prices, and intrinsic attractiveness of different zones. The effects of unobserved variation in household tastes are captured through the use of a multinomial logit model.

The attractiveness of each zone is summarised by an index that is treated exogenously (that is, determined outside the model). Hence, the model abstracts from externalities associated with pollution, congestion and other factors. In reality, influx of population to a neighbourhood may add to local traffic congestion, thereby detracting from neighbourhood appeal. Likewise for pollution. However, in MULTI, as in many other models of urban land use, changes in the pattern of settlement do not feed back to neighbourhood attractiveness.

Estimates of parameters of household preferences

Dr Horridge's original model contained purely conjectural values for the parameters that describe household preferences. MULTI calibrates some of these parameters to estimated own-price elasticities of demand. For residential land, the demand elasticity comes out at -0.13 when evaluated with the MULTI model and database, which is the estimate the Commission obtained in its econometric analysis of Melbourne data (IC 1993). Alignment is also close for public transport demand: a fare elasticity of -0.26 from the model and database versus a ballpark econometric estimate of -0.30 based on the findings reported at appendix B. Elasticities of demand for work and home locations cannot be similarly benchmarked, due to the absence of econometric estimates. Since this leaves a key parameter in the model as yet arbitrarily valued, the simulations that are reported need to be carefully interpreted.[3] However, while the magnitudes of some estimated effects, particularly location shifts, could be wide of the mark, the directions of the effects are probably robust.

3 With current parameter values, location demands are fairly elastic with respect to localised incomes. To illustrate, suppose that commuting costs decline for a particular combination of home and work zone, thereby adding one per cent to the disposable incomes of persons choosing that combination. MULTI indicates that the number of such persons would typically increase by nine per cent, assuming no changes in other variables affecting location choices.

The production sector

Two outputs are distinguished, transport services and ‘other goods’. These are produced using cost-minimising combinations of the two inputs, land and labour. The model omits commercial transport, along with all other material and service inputs. In addition, capital stocks are not explicitly represented.

Zonal indices allow some zones to be intrinsically more productive than others. This could be seen as a way of allowing for natural features of the environment – for example, if we think of ‘outdoor recreation’ as a product, the productivity of land and other inputs should be higher in scenic areas. More persuasively, the indices can be interpreted as proxies for ‘agglomeration economies’ which are absent from MULTI – the savings in transport and communication costs which producers and consumers derive from spatial clustering of certain activities.

These can show up in aggregated data as higher productivity in areas of concentrated production. In line with this, the index of productivity is highest in the Central zone (including the CBD), being almost 10 per cent higher there than in the other four outer zones. The magnitude of this advantage is not precisely estimated, however, as it is very much dependent on the assumption that, initially, wages are the same in all zones.

As with the indices of zonal attractiveness to residents, the exogenous treatment of the productivity indices is not without problems. Under the agglomeration economy interpretation, the productivity of a zone can be seen both as cause and consequence of the pattern of settlement.

Within each zone, all producers operate with the same technology that features constant returns to scale and a constant rate of trade-off between the two outputs. The substitution elasticity between land and labour has been set at a constant value of 1.0, which implies fairly easy substitution between these inputs. In this ‘Cobb-Douglas’ case, each input has an output-constant elasticity of -1.0 with respect to its own price and +1.0 with respect to the price of its substitute. Whilst the Commission has found no empirical study on land-labour substitution in urban production, evidence is available on substitution between land and structures, which, in a long run sense, are akin to embodied labour. McDonald (1983) reports estimates of the land-structures substitution elasticity from his own analysis with Melbourne data and from a few overseas studies. For the office sector, the estimates are close to 1.0, suggesting that land can be readily economised by occupying taller buildings. For the manufacturing and commercial sectors, where the choice of building height is more constrained, Dr McDonald reports somewhat smaller estimates. Overall, the estimates he cites imply significant scope for replacement between land and other factors in urban production, consistent with the assumption in MULTI.

Zoning

The model distinguishes three categories of land use: residential, industrial, and other (non-market uses such as parks). Zoning policies are represented through area or price constraints, which may discriminate by dwelling type. Land rentals can thus differ between residential and industrial land, and between houses and flats.

Greenhouse gas emissions

The Commission has incorporated an approximate measure of carbon dioxide emissions from commuter transport into the MULTI model of Melbourne. Carbon dioxide is one of the principal ‘greenhouse’ gases that are the subject of much environmental concern at present (see discussion in Chapter A10). The Commission has assumed emission rates of 0.24 for car and 0.08 for public transport, in kilograms per passenger kilometre. These figures are based on information in RJ Nairn and Partners (1992) and discussions with the Victorian Public Transport Corporation, and are comparable to estimates in the 1991 Industry Commission report on greenhouse gas emissions (IC 1991).[4]

Since the only emissions measured in MULTI are those from commuting, the predominance of other sources of carbon dioxide should be borne in mind when interpreting the model’s findings. One indication of this predominance is that car travel accounts for only 14 per cent of carbon dioxide arising non-naturally in Australia (BTCE 1991). Excluding non-commuting trips would reduce this figure considerably, while factoring in public transport commuting should raise it only slightly, given the overwhelming dominance of commuting by car.

Market equilibrium

Equilibrium in MULTI requires all markets to clear, with supply equal to demand. The prices which producers receive for each commodity are equated with average costs, which is the break-even implication of perfect competition and constant returns. The prices of labour and land can vary across zones in equilibrium, but the overall cost of production is equalised. Thus, producers are left indifferent to where they operate, unlike households, which have distinct preferences for where they live and work. The reason for this asymmetry is that

[4] They differ somewhat from figures presented in chapter A10 of this report (see table A10.2), which relate to passenger travel in general, rather than commuter trips in Melbourne. For car travel, the emission rate per passenger kilometre is higher in the MULTI database than in table A10.2, consistent with lower fuel efficiency during peak commuting periods. The reverse is true for public transport, consistent with higher vehicle occupancy rates during the peak periods.

the model assumes heterogeneous tastes among households and uniform technology among producers. Given the passive role of producers, imagining all workers to be self-employed would assist interpretation of the model. Patterns of land use can then be seen as outcomes of worker choices without reference to location choices of other agents known as ‘employers’. This corresponds to what happens in the model. Under this interpretation, wages are the returns to self-employment.

Another noteworthy feature of the equilibrium is the treatment of transport supply. In reality, the configuration of the transport system, including the land area occupied by roads, is quasi-fixed in the short run. By contrast, MULTI treats all inputs into transport, including land area, as changing in pace with demand. This favours a long run interpretation of the equilibrium this model describes.

MULTI cannot trace out a time path of year-by-year changes, as it tells no story about investment in fixed capital. It is designed for comparative static analyses that simulate the impacts of specific ‘shocks’ to the urban form. Under a very long run interpretation of the market equilibrium, estimates from the simulations are indications of the ultimate effects when all adjustments to the hypothesised event are completed. For example, if an improvement in transport productivity is estimated to raise the demand for transport by five per cent, this means that in the long run, demand will be five per cent higher than if the improvement had not occurred. Such estimates are not forecasts of changes over time, which depend on many influences apart from the particular shock being modelled.

Horridge (1992) has simulated the following scenarios with his original model: a 30 per cent increase in Melbourne’s population; a 20 per cent transport tax; changes in zoning rules that favour urban consolidation; and construction of a harbour bridge that reduces road distance. Apart from the analysis of urban consolidation, the simulations made the same assumptions about the zoning environment.

The simulations assumed, firstly, that the degree of price discrimination resulting from zoning would not vary. Thus, for each zone, land rental prices were held in constant ratio between market uses — industrial, houses and flats. However, the division of land between these categories was endogenous (that is, determined within the model), being demand-determined. In other respects, assumptions differed between the inner zones of Melbourne and the outer zones around its perimeter. The five inner zones are said to be effectively ‘built-out’, so land area for market use is assumed exogenous. Market clearing in this case means that changes in demand for land lead to changes in rental prices. In the outer zones, land is more available for development, and is assumed to be released from ‘other’ use in sufficient quantities to meet demand at a target price.

The allowance for re-allocation of land in the inner zones between houses, flats and industry reinforces the long run interpretation of equilibrium. (In the short run, the division of land between these uses is largely determined by past investment.) However, as Dr Horridge has noted, the assumption of a fixed target price for land in the outer zones imparts a short run element to his model, since increased demand in the outer zones should lead to higher land prices in the longer-run. A similar bias results from the population of Melbourne being treated exogenously. This precludes the feedback from wage levels to the population that occurs in the long run through migration. Despite these ambiguities about the time frame, it is preferable to give a fairly long run interpretation to any simulations.

Database

The database for the model describes travel and land use patterns, land prices and other aspects of the Melbourne spatial economy as of the mid to late 1980’s (see table C.2). These conditions are recent enough to be called ‘current’ and form the baseline for the simulations. Aspects of the database that have not already been covered are discussed below.

The 1986 Census provided data on the numbers of commuters by home and work zones (see table C.1) and mode (see figure C.2), and on the number of households by dwelling type and zone. As the ABS had not publicly released the 1991 Census data in time, we are unable to incorporate it into the model as hoped in the draft report.

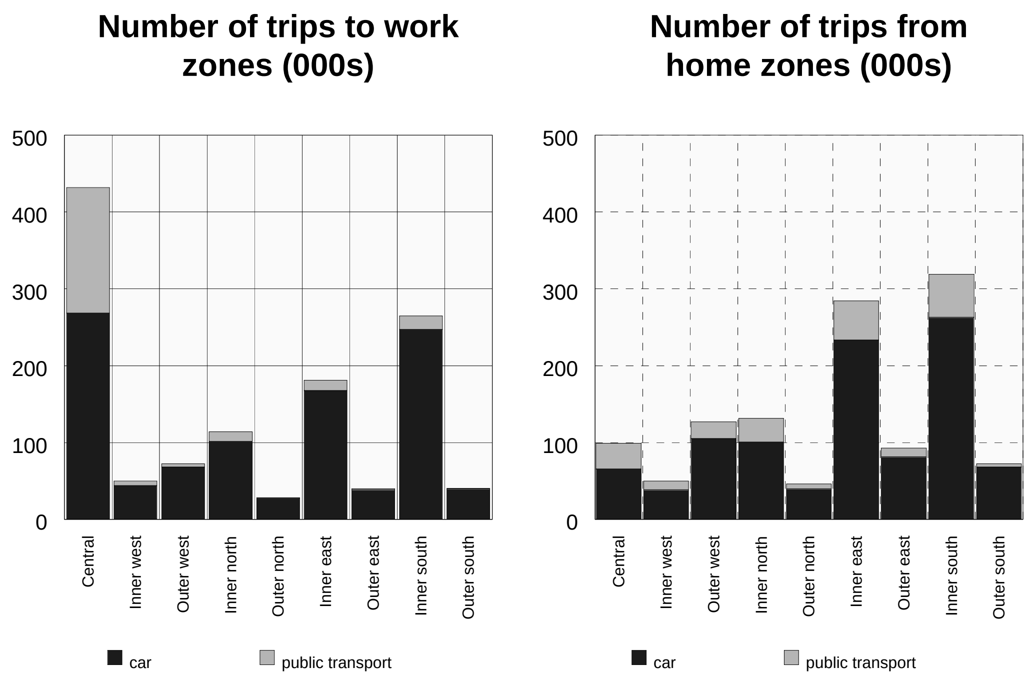
Distance travelled, which relates proportionally in the model to the social cost of transport services, is measured by the shortest road distance between zones. Road distance was used for both modes, although it would have been desirable to have a separate distance measure for public transport. Based on data supplied by RJ Nairn and Partners for the late 1980s, the private cost of car travel is set to 15 cents per kilometre. Much higher estimates from other sources include costs that many people would perceive as independent of their commuting decisions, such as obsolescence and registration fees, given that they would still own their car for other travel even if they used public transport for commuting. Hence, the Commission has chosen the lower figure supplied by RJ Nairn and Partners that does not incorporate all these costs, but which nevertheless exceeds petrol costs by a comfortable margin. The Commission has added to the distance-based cost a parking charge of $10 per day for car trips to central Melbourne; parking elsewhere is assumed to be free. Formally, the model represents the parking charge as a tax that generates revenue shared equally by Melbourne residents.

Table C.1: **Trip numbers from home zones to work zones**

	Home zone									
Work zone	*Central*	*Inner west*	*Outer west*	*Inner north*	*Outer north*	*Inner east*	*Outer east*	*Inner south*	*Outer south*	*All regions*
					(000's)					
Central	73.9	20.1	42.4	48.7	13.1	101.9	22.1	101.3	8.1	431.6
Inner west	2.5	14.7	20.5	4.9	1.2	2.7	0.6	2.4	0.2	49.7
Outer west	2.2	7.8	49.7	5.0	1.6	2.6	0.7	2.5	0.2	72.3
Inner north	4.9	4.4	8.1	56.2	13.6	14.7	8.3	3.4	0.3	113.9
Outer north	0.7	1.0	2.5	6.4	11.8	2.4	2.8	0.6	0.1	28.3
Inner east	5.3	0.9	1.5	6.4	2.6	118.6	23.9	19.0	2.9	181.1
Outer east	0.4	0.1	0.3	1.5	1.6	8.1	26.5	1.2	0.4	40.1
Inner south	8.7	1.0	1.8	2.3	0.6	31.6	7.3	180.4	30.8	264.5
Outer south	0.3	0.1	0.2	0.2	0.1	1.4	0.7	8.3	29.2	40.5
All regions	98.9	50.1	127.0	131.6	46.2	284.0	92.9	319.1	72.2	1222.0

Source: Commission estimates using ABS Census data supplied by Dr Horridge (ABS 1989)

Figure C.2: **Number and composition of trips to work zones and from home zones**



Source: Commission estimates based on ABS Census data supplied by Dr Horridge (ABS 1989)

Table C.2: **Summary statistics — MULTI database**

	Central	*Inner west*	*Outer west*	*Inner north*	*Outer north*	*Inner east*	*Outer east*	*Inner south*	*Outer south*	*All Regions*
Number of resident commuters	98 888	50 041	126 995	131 639	46 163	284 162	92 886	319 040	72 248	1 222 061
Employment	431 653	49 708	72 422	114 112	28 186	180 992	39 963	264 630	40 394	1 222 061
Proportion of trips by public transport (%):										
from home zones	35	23	17	23	14	17	12	16	6	18
to work zones	38	12	6	11	4	8	4	7	2	18
Average commute distance per trip (km):										
public transport	16.4	25.6	43.3	27.2	54.4	39.4	65.3	44.0	82.7	37.5
car	20.8	24.1	34.5	25.6	40.9	32.1	45.0	31.8	44.5	32.8
Average travelling times per trip (minutes):										
public transport	19.0	35.3	46.4	30.1	40.5	36.7	44.3	36.5	65.3	34.9
car	20.8	19.1	21.3	17.3	24.6	18.0	23.8	17.0	23.0	19.3
Average transport expenditure per trip ($):										
public transport	1.2	1.2	1.6	1.5	1.6	1.6	1.9	1.5	1.8	1.5
car	4.9	3.2	3.6	3.2	3.9	3.6	4.0	3.4	3.5	3.6
Land use (hectares):										
residential	3 649	3 463	14 630	9 373	5 429	26 711	10 868	19 876	8 280	102 278
industrial	3 420	899	2 967	2 465	805	2 706	953	2 618	1 124	17 960
other	1 396	1 140	116 046	3 072	95 863	12 288	111 350	21 413	129 574	492 142
Total area	8 465	5 502	133 643	14 910	102 097	41 706	123 171	43 908	138 978	612 380

The database assumes that car commuters, through fuel taxes and other government charges, cover the full annualised cost of the road services they consume. That is, in the absence of conclusive evidence to the contrary, the social and private costs of car travel are assumed equal (as of the mid to late 1980s). For commuting by public transport, the database records private costs amounting to only 23 per cent of the social costs in aggregate.[5] The private costs for each trip were approximated from published fare tables, and the rate of cost recovery varies around the average of 23 per cent, being smaller for long distance trips.

RJ Nairn and Partners supplied estimates of travel times from their 1988 TRANSTEP database for Melbourne. These are measures of in-vehicle time equivalents that assign weights greater than one to components of out-of-vehicle time. (This conforms with econometric evidence that people are relatively averse to the travel time spent walking and waiting.) The Commission has valued in-vehicle time at $8 per hour in estimating the generalised trip costs in MULTI, based on Nairn's assessment from the value-of-time literature. The estimates indicate that, on average, time costs comprise 76 per cent of the generalised cost for public transport. This implies that it would take a comparatively small reduction in travel time to compensate commuters for a fare increase: for example, a 3.3 per cent reduction in travel time combined with a 10 per cent fare increase would typically preserve the competitiveness of public transport. Time costs comprise a smaller share of estimated generalised costs for car travel (42 per cent) than for public transport, reflecting that car travel is faster but more expensive in money terms.

C.4 Illustrative simulations with MULTI

The Commission conducted three simulations with MULTI to explore the effects of possible transport reforms under the assumptions described above. The simulations represent the following reforms:

- increasing fares and productivity in public transport;
- increasing parking charges in central Melbourne; and
- making fares for public transport proportional to distance travelled.

5 This percentage was taken from the report of the Victorian Commission of Audit (1993). Presumably, it relates to all public transport trips, and somewhat exaggerates the subsidy for commuting trips. Although a smaller subsidy rate might be appropriate for the MULTI model, this is not critical to the simulations reported here.

The findings from these simulations are only broad indications of how land use and travel patterns might change, and the directions of location shifts are more reliably estimated than their magnitudes. In addition, as the total population and employment within the model are assumed to be unchanged, the focus of the simulations is on the spatial distribution of these totals within the city.

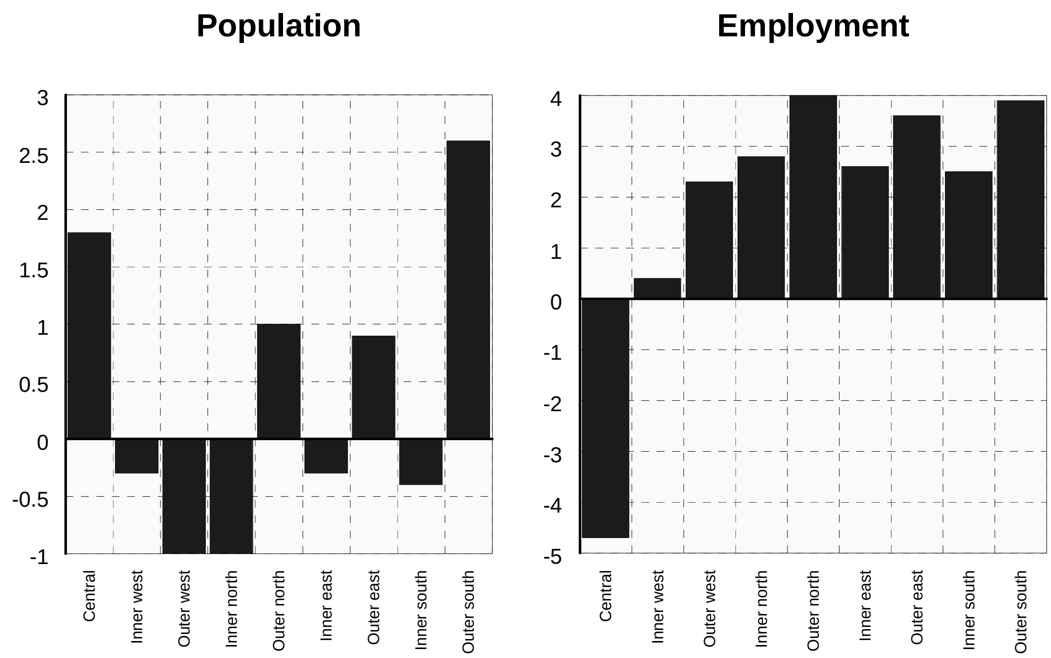
Reforms to public transport

The doubling of fares across-the board that occurs in this scenario would reduce the huge operating deficit for public transport substantially — by about 30 per cent, if patronage remained unaffected. The scenario also assumes that increased productivity in public transport results in a uniform 5 per cent reduction in travel times — or, under a more general interpretation of the model, an improvement in various attributes of service that equates in commuters' calculations to a 5 per cent reduction in travel times. It follows from the above discussion of the database that, in the model, such a reduction in travel time has an impact on peoples mode choices equivalent to about a 16 per cent reduction in fares. So, effectively, fares increase 84 per cent in the scenario being modelled, given that actual fares increase 100 per cent.

This increase in combined money and time cost would reduce commuter demand for public transport significantly. The simulations indicate declines of 25 per cent in passengers (see table C.3) and 28 per cent in passenger-kilometres. The difference in these numbers reflects a projected decline of 3 per cent in the average distance for public transport commutes. In other words, commuters who remain on public transport would adjust the locations of their homes or workplaces to bring them closer together on average, thereby offsetting the impact of higher fares on their travel costs. However, notwithstanding this shift from long- to short-distance commuting, the number of public transport commuters is projected to decline for all combinations of home and work locations. This switch from public transport to cars would increase carbon dioxide emissions from commuter travel by a predicted 3.1 per cent.

The hypothetical reforms to public transport would reduce employment in central Melbourne by an estimated 4.7 per cent, but are projected to increase employment in the city's other zones (see figure C.3). Commuters to the Central zone are currently much more dependent on public transport than commuters to other work locations (see table C.2): according to 1986 Census data for Melbourne (ABS Census 1989), public transport accounts for 38 per cent of work trips to the Central zone, as compared with 12 per cent or less for other work trips. Accordingly, the assumed increase in public transport fares (net of the reduction in time cost) encourages employment to shift out of the Central zone, much like a tax on Central zone employment. Increases in employment of up to 4 per cent are predicted for other zones, with the largest gains indicated for the outer zones excluding the west. Workplaces in these favoured zones are currently the least dependent on public transport for serving their workers. Hence, the increase in fares makes these work locations significantly more attractive relative to the Central zone.

Figure C.3: **Effects of a hypothetical public transport reform package (100 per cent increase in fares and 5 per cent reduction in travel times), by MULTI zone of residence and employment (percentage change)**



Source: Commission estimates using the MULTI model of Melbourne.

With employment and production in the Central zone thus reduced, local land prices would decline by an estimated 2.0 per cent, due to the fall in demand. Since the simulation assumes that within each zone, residential and industrial land prices change in equal proportion, it predicts that the Central zone would become a cheaper place to live. This explains the predicted 1.8 per cent increase in the Central zone's population. Land prices are predicted to change only slightly in the surrounding inner zones and, by assumption, would remain stable in the outer zones. The inner zones together with the Outer West are the sources of the population influx to the Central zone, and are predicted to experience losses in population of up to one per cent. The outer zones to the north, south and east are predicted to gain residents, consistent with their favourable employment outcomes. The estimated increase in population is proportionally largest for the Outer South zone (2.6 per cent).

An increase in parking charges in the Central zone

This simulation assumes that parking charges for Central zone workers increase 20 per cent (or $2.00 per day). The increased incentive to use public transport for commutes to the Centre accounts for the projections of a 7.7 per cent increase in public transport patronage and a 1.7 per cent decrease in the number of car trips (see table C.4). Due to the switch from car travel to public transport, carbon dioxide emissions from commuter travel would decline by an estimated 2.3 per cent.

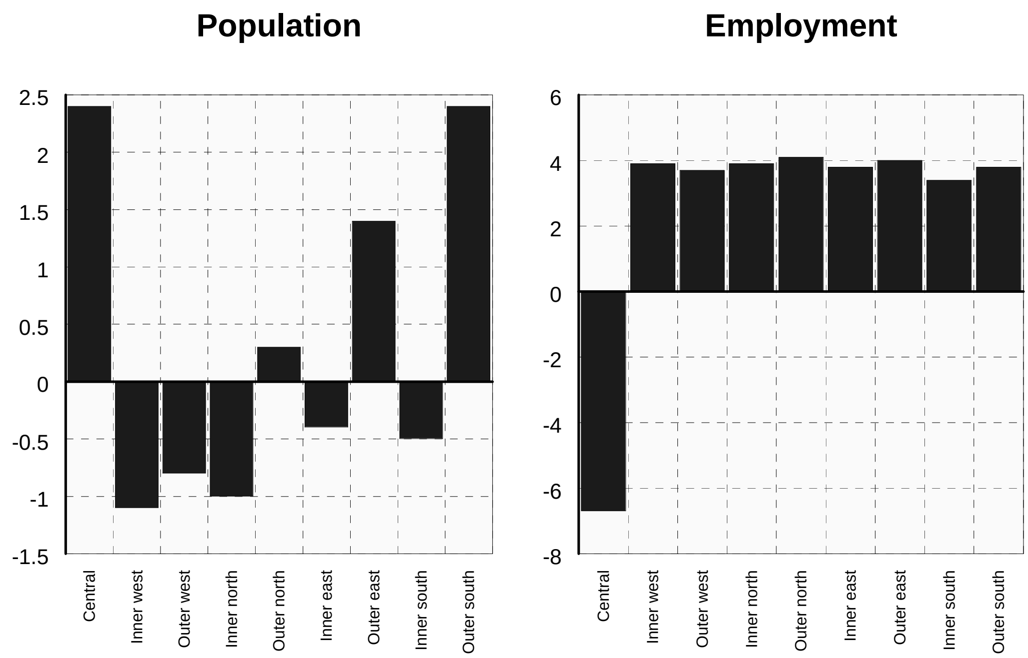
The predicted shifts in population exhibit a more complex pattern (see figure C.4). For the remaining workforce in the Central zone, some would avoid the parking charge by switching to public transport, and thus seek a home location where access to work by public transport is relatively convenient. This contributes to the predicted increase of over 2 per cent in the Central zone's population. Also contributing to this result is the predicted decline in Central area land prices of almost 3 per cent, arising from reduced demand for industrial land as jobs and production move outward from the centre. Since residential land prices are assumed in the simulation to move in line with industrial land prices, this makes the Central zone a cheaper place to live. The residents attracted by the cheaper housing would include, in addition to public transport users, car travellers who commute from the Centre to other zones ('reverse commuters' who mostly go against the flow of peak period traffic).

Predicted location shifts follow the same patterns as in the above simulation of public transport reform. As most commuters to the Central zone currently go by car, the increase in parking charges resembles a tax on Central zone employment even more closely than does an increase in public transport fares. The increase in parking charges is predicted to reduce employment in the Central zone by almost 7 per cent and to increase employment in other zones by 3 to 4 per cent (see figure C.4).

Population outside the Central zone is predicted to decline in the surrounding inner zones, but to increase in most outer zones. The difference reflects, in a sense, the localisation of labour markets. Because of their relative proximity to the Centre, residents of the surrounding inner zones are closely tied in to the Central zone job market. Hence, the increase in parking charges in the Centre makes these suburbs a less attractive place to live. The outer zones are economically more autonomous than the Central zone, so the increase in parking charges is predicted to attract both jobs and residents to these zones.

The predicted changes in population outside the Central zone range from a decline of about 1 per cent to an increase of over 2 per cent.

Figure C.4: **Effects of a hypothetical 20 per cent increase in car parking charges in the central zone, by MULTI zone of residence and employment (percentage change)**



Source: Commission estimates using the MULTI model of Melbourne

The total use of cars for commuting, as measured by distance travelled, is predicted to decline in somewhat greater proportion than the number of trips, since average distance per trip would decline by an estimated 1.5 per cent (see table C.4).

Distance based public transport fares

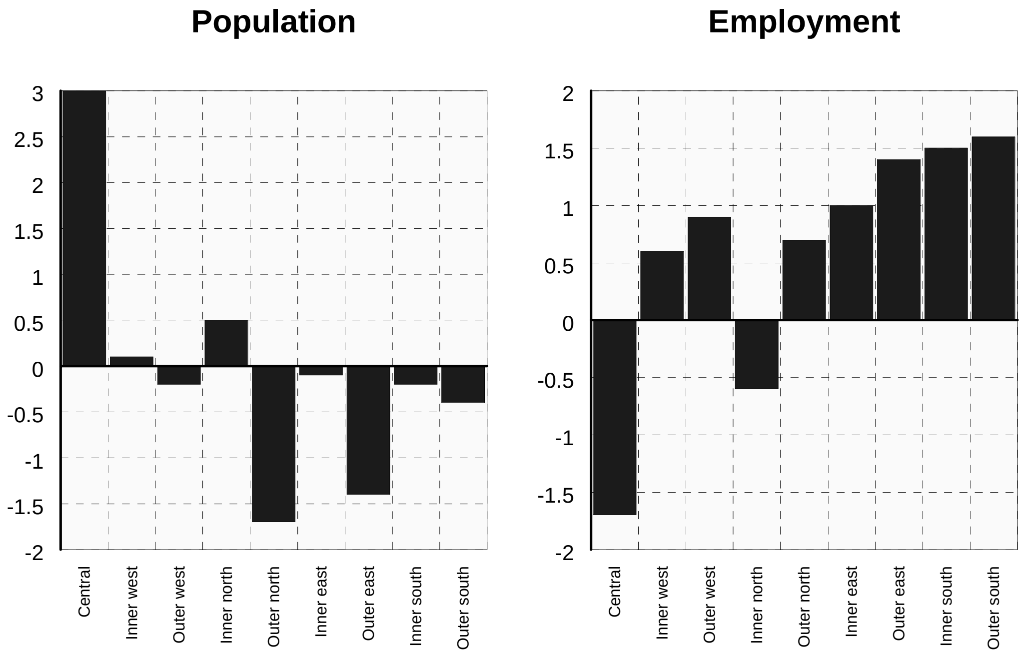
It is often argued that fares for public transport should be more distance-based than at present. Accordingly, the Commission has simulated with MULTI the effects of making fares in Melbourne proportional to distance travelled. The hypothetical charge per kilometre has been chosen to maintain total fare collections from commuters at 'current' levels (in the simulations, those as of the mid to late 1980s). Hence, while fares for short distance trips would decline by up to half under the new system, those on longer routes would increase. For quite long distance trips, such as going from the Outer South to the Outer West, fares are estimated to increase by up to threefold; however, very few commuters currently make such trips by public transport.

Simulated effects of replacing the current fare structure with the simple distance based charges are indicated in table C.5. Commuter demand for public transport, measured in passenger-kilometres, would decline by an estimated 9 per cent, reflecting the reduced demand for long distance trips. The fewer passenger-kilometres that would need to be served would, in turn, reduce the production cost of public transport authorities, at the same time that their revenue from commuters would be maintained (under the simulation’s assumptions). The total subsidy to public transport commuters (revenue minus production cost) would thus decline by an estimated 12 per cent.

The predicted effects of the fare restructuring on population by zone can be understood from patterns of commuting. The Central zone is the dominant workplace among public transport commuters, with about a 75 per cent share (see table C.1). According to the simulation, it would remain so after the fare restructuring. Hence, when changes in fares encourage shorter distance commuting, public transport commuters will generally move their homes closer to the Central zone. The simulation thus predicts a 3 per cent increase in population in the Central zone, and smaller increases for the Inner North and West zones, which are only a short distance from the Centre (see figures C.1 and C.5). Population decreases are predicted for other zones.

The inflow of residents into the Central zone would increase the local demand for residential land, and with it, residential and industrial land prices. In the model, the higher industrial land prices would necessitate a cut in local wages for the Central zone to remain a competitive location for production. And with wages lower, it is predicted that 1.7 per cent fewer people would choose to work there. More modest changes in the same direction are indicated for the Inner North. Elsewhere, employment is predicted to increase by up to 1.6 per cent (see figure C.5).

Figure C.5: **Effects of hypothetical introduction of distance based public transport fares in a revenue neutral manner, by MULTI zone of residence and employment (percentage change)**



Source: Commission estimates using the MULTI model of Melbourne

Table C.3: **Regional effects of reforms to public transport in Melbourne**[c]

	Central	*Inner west*	*Outer west*	*Inner north*	*Outer north*	*Inner east*	*Outer east*	*Inner south*	*Outer south*	*All regions*
					(%)					
Total residents	1.8	-0.3	-1.0	-1.0	1.0	-0.3	0.9	-0.4	2.6	a
Total employment	-4.7	0.4	2.3	2.8	4.0	2.6	3.6	2.5	3.9	a
Industrial output	-4.6	0.4	2.3	2.9	4.0	2.5	3.6	2.5	3.9	0.1
Wages	0.1	b	b	b	b	b	b	b	b	b
Average commuting distance of residents:										
public transport	-1.9	-0.2	-1.2	-2.4	-2.1	-1.9	-2.1	-2.4	-1.7	-3.3
car	-0.6	0.4	0.6	0.3	0.4	0.4	0.4	0.6	0.5	0.2
Average commuting time of residents:										
public transport	-6.7	-5.0	-5.6	-6.4	-5.4	-5.7	-5.3	-5.4	-5.5	-6.6
car	-0.5	0.3	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.2
Total transport expenditure by residents:										
public transport	63.3	59.1	44.1	45.6	45.0	46.0	36.1	46.7	43.8	47.9
car	12.7	6.9	5.9	7.7	6.4	6.2	6.2	5.8	5.3	6.7
Total number of trips by residents										
public transport	-17.8	-19.8	-27.0	-25.2	-25.9	-25.8	-30.9	-25.4	-27.3	-24.5
car	12.3	5.5	4.4	6.3	5.3	5.1	5.3	4.5	4.5	5.4
Proportion of trips by public transport	-19.2	-19.6	-26.3	-24.4	-26.7	-25.5	-31.6	-25.1	-29.2	-24.5
Land use:										
residential	2.5	-0.1	-1.0	-0.9	1.1	-0.2	0.9	-0.3	2.6	0.1
industrial	-2.7	0.6	2.3	3.6	4.0	2.4	3.6	2.2	3.9	1.7
other	a	a	0.1	a	-0.1	a	-0.1	a	-0.2	-0.1
Land rentals	-2.0	-0.2	a	-0.6	a	0.2	a	0.3	a	b

a denotes that variables have been exogenously set equal to zero.

b denotes percentage change between -0.05 and 0.05.

c hypothetical public transport reform package: 100 per cent increase in fares and 5 per cent reduction in travelling times.

Source: Commission estimates using the MULTI model of Melbourne

Table C.4: **Regional effects of a car parking surcharge in Melbourne**[c]

	Central	*Inner west*	*Outer west*	*Inner north*	*Outer north*	*Inner east*	*Outer east*	*Inner south*	*Outer south*	*All regions*
					(%)					
Total residents	2.4	-1.1	-0.8	-1.0	0.3	-0.4	1.4	-0.5	2.4	a
Total employment	-6.7	3.9	3.7	3.9	4.1	3.8	4.0	3.4	3.8	a
Industrial output	-6.5	3.9	3.7	3.9	4.1	3.7	4.0	3.4	3.8	0.2
Wages	0.2	b	b	b	b	b	b	b	b	0.1
Average commuting distance of residents:										
public transport	-0.5	0.1	0.3	0.3	0.3	0.3	0.4	0.5	0.7	-0.4
car	6.4	-0.6	-2.0	-1.0	-2.0	-1.9	-2.2	-2.8	-2	-1.5
Average commuting time of residents:										
public transport	-0.4	0.2	0.2	0.1	b	0.1	b	b	0.2	-0.5
car	5.7	0.2	-0.7	-0.6	-0.9	0.1	-0.8	-0.2	-0.6	0.2
Total transport expenditure by residents:										
public transport	14.9	6.3	6.6	6.2	7.0	7.0	7.2	6.4	7.0	7.7
car	4.5	-3.1	-3.6	-3.4	-2.0	-2.2	-0.9	-2.9	0.3	-1.8
Total number of trips by residents										
public transport	15.1	6.4	6.4	5.8	6.6	6.7	7.0	6.0	6.7	7.7
car	-4.4	-3.3	-2.3	-3.1	-0.6	-1.9	0.6	-1.8	2.2	-1.7
Proportion of trips by public transport	12.3	7.6	7.2	6.9	6.3	7.1	5.5	6.5	4.2	7.7
Land use:										
residential	3.6	-1.0	-0.8	-1.0	0.4	-0.4	1.4	-0.4	2.4	0.1
industrial	-3.8	4.0	3.7	3.9	4.1	3.6	4.0	3.1	3.8	2.2
other	a	a	b	a	-0.1	a	-0.2	a	-0.2	-0.1
Land rentals	-2.9	b	a	b	a	0.2	a	0.3	a	0.1

a denotes that variables have been exogenously set equal to zero.

b denotes percentage change between -0.05 and 0.05.

c hypothetical 20 per cent increase in parking charges in the Central zone.

Source: Commission estimates using the MULTI model of Melbourne

Table C.5: **Regional effects of introducing distance based public transport fares in Melbourne**[a]

	Central	*Inner west*	*Outer west*	*Inner north*	*Outer north*	*Inner east*	*Outer east*	*Inner south*	*Outer south*	*All regions*
					(% change)					
Total residents	3.0	0.1	-0.2	0.5	-1.7	-0.1	-1.4	-0.2	-0.4	b
Total employment	-1.7	0.6	0.9	-0.6	0.7	1.0	1.4	1.5	1.6	b
Industrial output	-1.8	0.5	0.9	-0.7	0.7	1.0	1.4	1.5	1.6	c
Wages	-0.1	-0.1	c	-0.1	c	c	c	c	c	c
Average commuting distance of residents:										
public transport	-2.5	-3.0	-2.0	-0.4	-2.0	-0.8	-4.4	-2.8	-13	-6.2
car	0.3	0.1	c	0.2	c	c	-0.1	-0.1	c	0.2
Average commuting time of residents:										
public transport	-2.1	-2.0	-1.2	-0.6	-0.7	-0.3	-0.1	-0.6	-4.4	-3.4
car	0.2	0.1	c	0.2	0.1	c	c	c	c	0.1
Total transport expenditure by residents:										
public transport	-35.1	-8.7	7.6	-13.7	20.3	5.6	13.7	11.6	13.3	b
car	-2.1	-0.7	1.0	-1.3	1.2	0.7	1.6	1.3	1.7	0.6
Total number of trips by residents										
public transport	12.3	2.5	-7.0	6.7	-20.8	-4.3	-23.6	-9.3	-34.8	-3.3
car	-2.0	-0.6	1.2	-1.4	1.3	0.8	1.7	1.5	1.8	0.7
Proportion of trips by public transport	9.1	2.4	-6.8	6.2	-19.4	-4.3	-22.5	-9.1	-34.6	-3.3
Land use:										
residential	2.7	0.1	-0.2	0.5	-1.7	-0.1	-1.4	-0.2	-0.4	-0.2
industrial	-2.9	-0.2	0.9	-1.7	0.7	0.7	1.4	1.4	1.6	-0.1
other	b	b	c	b	0.1	b	0.1	b	c	c
Land rentals	1.2	0.7	b	1.1	b	0.2	b	0.1	b	c

a Hypothetical introduction of distance based public transport fares in a revenue neutral manner.

b Denotes that variables have been exogenously set equal to zero.

c Denotes percentage change between -0.05 and 0.05.

Source: Commission estimates using the MULTI model of Melbourne

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APPENDIX D

A comparison of the productivity of urban passenger transport systems

APPENDIX D PRODUCTIVITY OF URBAN PASSENGER TRANSPORT SYSTEMS

This appendix reports on a comparison of multilateral total factor productivity between the Public Transport Corporation of Victoria (PTC), the State Transport Authority of South Australia (STA) and Transperth in Western Australia. These comparisons are for entire organisations and different modes over time. Other organisations were invited to participate, but were unable to do so. Factors external to the organisations, such as congestion and pollution, are not included in the analysis.

Transperth is the most technically efficient organisation in providing services. However, its services are not as well used as those of the STA. STA's higher load factors (passenger kilometres per seat kilometre) allow it to have a lower cost per passenger kilometre, making its services more cost effective. This demonstrates that technical efficiency in providing services does not necessarily translate into an overall superior level of productivity.

For the STA and Transperth the study also finds that buses are more efficient in providing urban public transport than rail. For the load factors observed, buses have a higher level of demand side productivity. They also have a higher supply side productivity. They are therefore more cost effective and cost efficient in providing urban passenger services for these two organisations. The study shows that as Transperth has increased its use of rail relative to bus, its overall productivity has declined and is now lower than that of the STA. This may have longer term implications for its overall cost of service and operating deficit, though it will be several more years before the full effect of recent changes to the system become evident.

The PTC has a lower level of supply side productivity than the STA and Transperth. It is likely that Melbourne's large population enables the PTC to have better utilisation of services than the STA and Transperth so that its demand side productivity is closer to that of the STA and Transperth.

D.1 Introduction

Productivity is measured by expressing output as a ratio of inputs. Multilateral total factor productivity (TFP) divides an *aggregate* index of output by an *aggregate* index of input to produce a measure of productivity that is suitable for comparing both *absolute* and *relative* levels of productivity. In this study, the term ‘productivity’ refers to productivity measured using the multilateral total factor productivity methodology. A multilateral total factor productivity study allows a comparison of productivity to be done between systems, modes, and modes by system.

This measure of productivity is different to the commonly used partial productivity indicators, such as output per employee, in that it takes into account the use of many factors, not just a single factor. The process of calculating multilateral total factor productivity also provides partial productivity indexes for each input. As noted by the ACTU (Sub. 271, p. 9), most organisations have increased their labour productivity over recent years. This study finds this to be true for most of the modes within the organisations considered. However, partial productivity trends for other inputs also vary considerably.

In urban transport, factors other than labour, in particular capital, are very important (see chapter A7). Further, it is possible for labour productivity improvements to be offset by falling productivity in the use of capital (infrastructure and other assets). This study uses total factor productivity to examine the productivity of all inputs in generating output rather than partial measures.[1] A more detailed discussion of total factor productivity is contained in the attachment to this appendix.

To calculate productivity indexes requires consistent time series data for each output and input used by the organisation; and for this study, by each mode of public transport operated by an organisation. The PTC, STA and Transperth made their asset registers available to the Industry Commission and provided the consistent data necessary to undertake this study. The period of the study was from 1986-87 to 1992-93 for STA and Transperth, and from 1990-91 to 1992-93 for the PTC. Other transport providers, including Cityrail (Sydney) and Citytrain (Brisbane), were also invited to participate and had expressed an interest in doing so. However, as they were in the process of establishing new financial management procedures and systems, they were unable to provide the required data.

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1 Steering Committee on National Performance Monitoring of Government Trading Enterprises (1992, p. 4) provides an explanation of why total factor productivity is preferred to partial productivity in measuring overall performance.

Central to any measure of productivity is the definition of output. In this study, two alternative definitions of output are used: passenger kilometres and seat kilometres. To distinguish between these two measures, the productivity index with output measured in passenger kilometres is referred to as ‘demand side’ and that with output measured in seat kilometres is referred to as ‘supply side’.

Using seat kilometres as a measure of output provides an indicator of productivity in providing a level of service that is independent of its use. This is a measure of technical efficiency.

The level of productivity using passenger kilometres as a measure of output is influenced by both the productivity of service provision (seat kilometres) and the use of the service (passenger kilometre per seat kilometre, which in this study is called ‘load factor’). This is a measure of cost effectiveness, as discussed by Hensher and Daniels (1993).

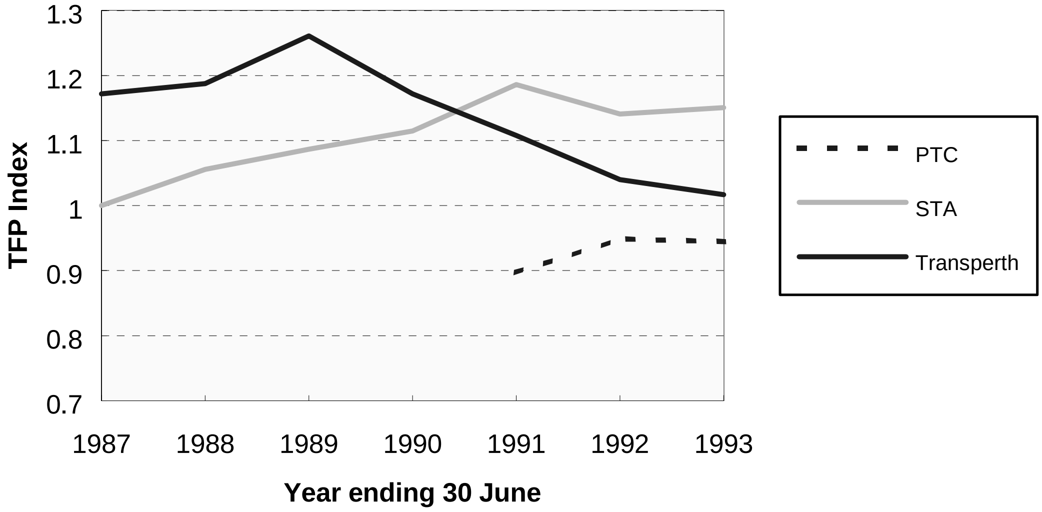
A second fundamental issue relates to the definition of inputs. In this study, four input classes are used to derive an aggregate index input. These are labour (measured by the number of employees), energy (mega-joules), materials (implicit quantity) and capital stock (implicit quantity). The study only includes organisational data. It excludes the cost and quantity of externalities, such as congestion, pollution, service quality and the use of road infrastructure by buses.

This appendix begins by comparing productivity at the organisational level for the PTC, STA and Transperth, and then between these organisations for each mode. Finally, the productivity of modes within each organisation are analysed over time. In addition to the discussion of the concept of productivity, the attachment to this appendix contains some key operating statistics for the PTC, STA and Transperth.

D.2 Organisational total factor productivity

Demand and supply side productivity indexes for the PTC, STA and Transperth are presented in figures D.1 and D.2. These indexes have been normalised around the STA value for 1986-87. They provide an indication of the overall relative efficiency of the three organisations in providing their total services (that is, across all their modes).

Figure D.1: **Demand side organisational total factor productivity**



Source: Industry Commission estimates

Figure D.1 shows that Transperth's demand side productivity was initially 16 per cent higher than that of STA.[2] However, Transperth's productivity began decreasing in 1989-90. Part of this likely to be due to the restructuring of its transport system; first, by replacing its diesel urban passenger rail system with an electric system and second, by building the northern rail link. This required a large increase in capital and caused a temporary fall in the total number of passenger kilometres during 1989-90 and 1990-91. When the first stages of the northern rail line commenced operating in 1992-93, rail productivity recovered to its earlier levels. However, bus productivity has declined as passengers now prefer to travel by train rather than bus. The net result has been an overall fall in productivity. Over the period of this study, Transperth has experienced a 14 per cent fall in demand side productivity (see table D.1), and by 1992-93 was 12 per cent less productive than STA.

By comparison, STA achieved demand side productivity growth of 14 per cent over the same period. Until 1990-91 STA's productivity rose due to increased passenger kilometres and reduced use of inputs. Since then productivity has stabilised due to a simultaneous decline in passenger kilometres and inputs.

The PTC has the lowest overall productivity, primarily due to the low productivity of its trams and buses.[3] In 1992-93, the PTC's productivity level was 20 per cent lower than that of the STA. Since 1990-91 the PTC experienced

2 Percentage difference in TFP between Transperth and STA in 1987 is calculated as the percentage change in the *log* of each organisation's TFP level in 1987.

3 While the PTC's labour productivity is in many instances comparable with that of the other organisations, it has lower productivity in its use of other inputs.

5 per cent productivity growth, primarily in 1991-92 when passenger kilometres increased and inputs decreased. However, changes since June 1993, such as bus services being contracted out and the rationalisation of excess tram rolling stock, should improve the PTC's productivity.

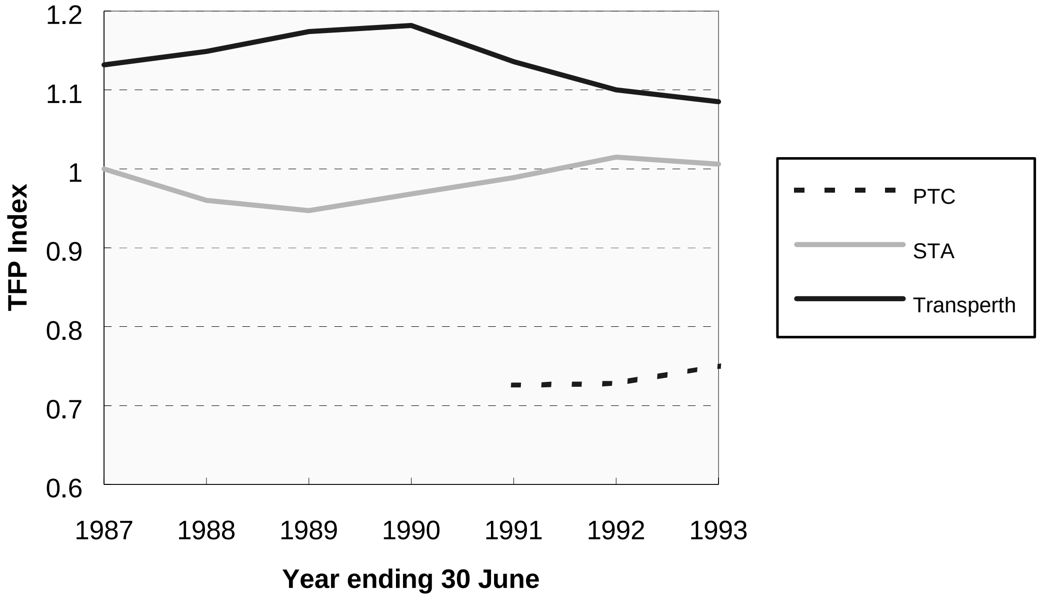
Table D.1: **Annual growth rates in demand side total factor productivity**

Organisation	*Measure*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1988-93*
					(%)			
PTC	TFP					5.6	-0.5	5.1
	Inputs					-2.9	-4.8	-7.7
	Output					2.7	-5.3	-2.6
STA	TFP	5.5	2.9	2.5	6.1	-3.9	0.9	14.0
	Inputs	-1.7	-1.3	0.7	-2.1	-1.5	-6.3	-12.2
	Output	3.8	1.6	3.2	4.0	-5.4	-5.4	1.8
Transperth	TFP	1.3	6.0	-7.3	-5.6	-6.3	-2.3	-14.2
	Inputs	-0.6	-0.2	3.7	3.7	6.9	8.6	22.1
	Output	0.7	5.8	-3.6	-1.9	0.6	6.3	7.9

Source: Industry Commission estimates

The supply side measure of organisational productivity (see figure D.2) shows that Transperth is more efficient in providing services than either the STA or the PTC. Average productivity scores over the appropriate periods are 1.1 for Transperth, 1.0 for STA and 0.7 for the PTC. The PTC and STA have reduced seat kilometres since 1990-91 and 1986-87 respectively. However, both have reduced inputs even more, generating productivity growth over the respective periods. In contrast, Transperth has increased its supply of services, but with proportionately more inputs, resulting in a level of productivity which was 4 per cent lower in 1992-93 than it was 6 years earlier (see table D.2).

Figure D.2: **Supply side organisational total factor productivity**



Source: Industry Commission estimates

Table D.2: **Annual growth rates in supply side total factor productivity**

Organisation	*Measure*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1988-93*
					(%)			
PTC	TFP					0.2	3.0	3.2
	Inputs					-2.9	-4.8	-7.7
	Output					-2.7	-1.8	-4.5
STA	TFP	-4.1	-1.3	2.2	2.1	2.6	-0.9	0.6
	Inputs	-1.7	-1.3	0.7	-2.1	-1.5	-6.3	-12.2
	Output	-5.8	-2.6	2.9	0.0	1.1	-7.2	-11.6
Transperth	TFP	1.5	2.1	0.7	-4.0	-3.2	-1.4	-4.3
	Inputs	-0.6	-0.2	3.7	3.7	6.9	8.6	22.1
	Output	0.9	1.9	4.4	-0.3	3.7	7.2	17.8

Source: Industry Commission estimates

One source of difference between demand and supply side productivity for each organisation is differing load factors. Load factor is a measure of the utilisation of the services provided and is defined here as the number of passenger kilometres divided by the number of seat kilometres (see table D.3). Transperth has the lowest load factor in every year except 1986-87. As noted earlier, the PTC has a much lower supply side productivity than the STA and Transperth.

However, its higher load factors help narrow the gap in demand side productivity. Similarly, the STA has lower supply side productivity than Transperth, but its higher load factors since 1988-89 have enabled it to achieve higher demand side productivity than Transperth. Further, in the last few years, Transperth has experienced both declining supply side productivity and gradually declining load factors. These combine to reduce demand side productivity. It is likely that these trends for Transperth are associated with the restructuring of its public transport system, with its increasing emphasis on rail.

Table D.3: **Average organisational load factor**

Organisation	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*
			(passenger kilometres per seat kilometre)				
PTC	na	na	na	na	0.29	0.30	0.29
STA	0.23	0.25	0.27	0.27	0.28	0.26	0.26
Transperth	0.24	0.24	0.25	0.23	0.23	0.22	0.22

na not available

Source: Industry Commission estimates

Differences in the levels and trends in productivity between organisations are also reflected in the average cost of service, which is defined as total cost divided by passenger kilometres or seat kilometres.[4] Table D.4 shows the average cost of service for each organisation in each year from 1990-91 to 1992-93. Over this period, STA has the lowest cost per passenger kilometre, being 2 cents (6 per cent) lower than Transperth and 9 cents (21 per cent) lower than the PTC. Transperth exhibits the lowest cost per seat kilometre being 1 cent (9 per cent) lower than the STA and 4 cents (35 per cent) lower than the PTC. The PTC's high cost of service reflects its relatively low supply side (technical) productivity.

Although Transperth has the greatest supply side productivity and can provide its services at a lower cost than both the STA and the PTC, its services are not as well patronised as those of the other organisations. Since 1990-91, the STA has had considerably higher load factors, with only slightly higher costs per seat kilometre than Transperth, making its service more cost effective. The PTC has a very high cost of service due to its lower supply side productivity. However its higher load factors enhance its demand side productivity cost effectiveness.

4 Total cost here is defined as the economic cost and is different from the accounting cost reported in the audited annual reports. The primary difference between the accounting and economic cost is that accounting depreciation, interest and capital lease expenses have been replaced with annual user charges. See the attachment for a definition of annual user charges.

These results demonstrate that high productivity in providing services does not necessarily translate into an overall superior level of productivity, if the services are not being patronised. It also illustrates that low supply side productivity may be offset by high load factors.

Table D.4: **A comparison of the real cost of service between organisations**[a]

	Organisation	*1991*	*1992*	*1993*
Cost of service	PTC	44.64	39.05	41.60
(cents per passenger kilometre)	STA	31.97	33.52	32.97
	Transperth	32.52	35.64	36.65
Cost of service	PTC	12.77	11.79	12.13
(cents per seat kilometre)	STA	8.88	8.72	8.73
	Transperth	7.35	7.80	7.95

a Cost includes annual user charge of capital. Expressed in terms of 1993 cents.

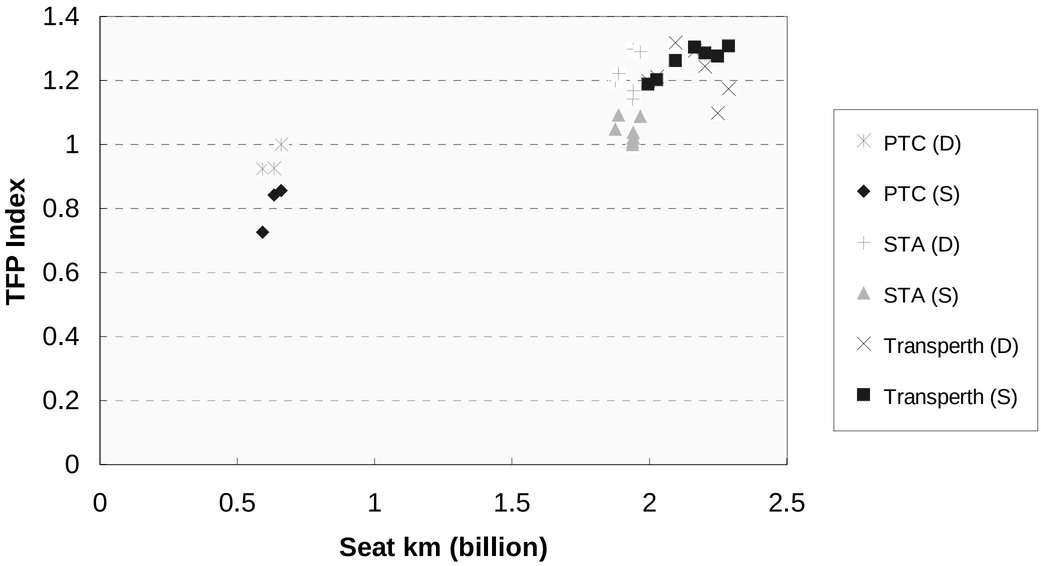
Source: Industry Commission estimates

D.3 An analysis of modes by organisation

In the draft report it was suggested that bus was the more productive mode for the two organisations being studied. This still appears to be the case. However, in the case of the PTC, for which data on buses and trams have since been added, it appears that the rail service is as productive as the bus service. The PTC provides the smallest bus service (it contracts out many bus services to private operators) and the largest rail service of the three organisations. This might suggest that the size of the service, among other factors, influences productivity.

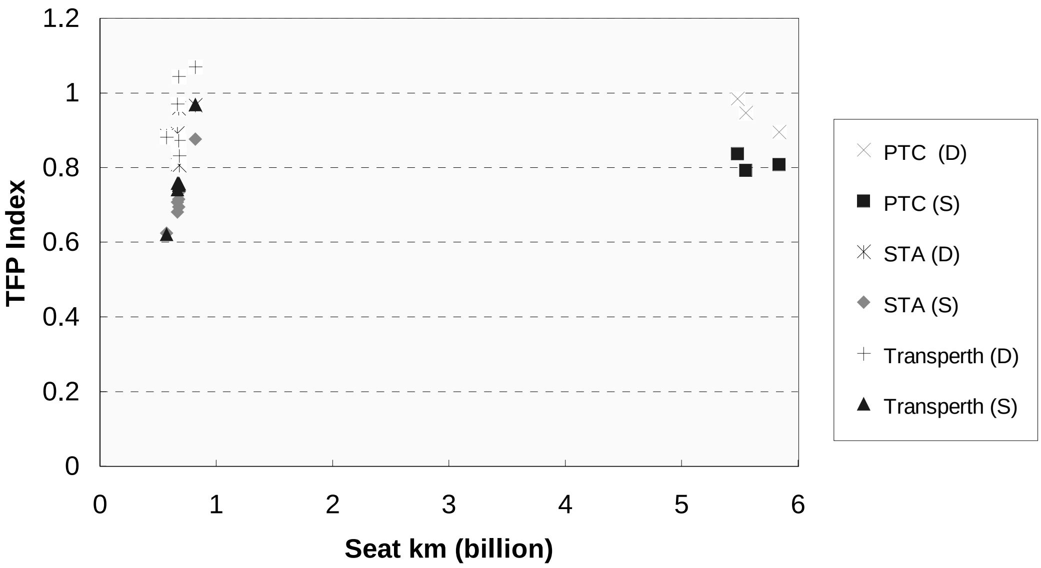
However, there is insufficient data available to determine whether size is a factor. Scatter plots showing productivity scores versus seat kilometres for bus and rail are shown in figures D.3 and D.4. A simple regression of productivity scores versus seat kilometres provides a positive correlation between productivity and the level of service. However, the correlation would be essentially based on two clusters of data, one for the STA and Transperth and the other for the PTC. It is not possible to strongly conclude whether it is the level of service or some other characteristic (for example, congestion) which makes the PTC's rail relatively more and bus relatively less productive.

Figure D.3: **Relationship between bus seat kilometres and productivity**



Source: Industry Commission estimates

Figure D.4: **Relationship between rail seat kilometres and productivity**



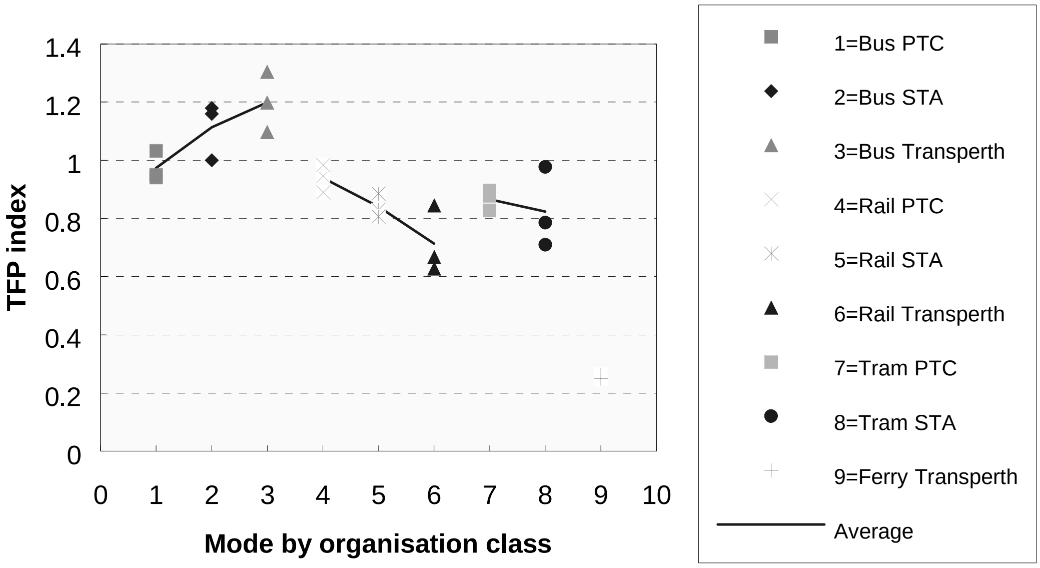
Source: Industry Commission estimates

Accordingly, the productivity of different modes is now discussed on an organisational basis. In comparing modes by organisation, the period has been restricted to 1990-91 to 1992-93, for which data was available for all three organisations.

To determine whether there are significant differences in productivity between organisations for each mode, a statistical analysis of the mean productivity scores for each mode in each organisation has been undertaken. A multiple regression model is used to perform a one-way analysis of variance to test whether the mean productivity scores for each mode in each organisation are statistically different (see Wonnacott and Wonnacott 1972, Kmenta 1971). This is done by regressing the productivity scores on a set of binary (dummy) variables representing each mode in each organisation. The estimated parameter for each binary variable is the mean productivity score for that mode in the organisation. Statistical tests are then performed on pair-wise combinations of organisations for each mode to determine whether the means are statistically different. This is to infer whether the two organisations have significantly different levels of productivity in the provision of passenger kilometres and seat kilometres for the modes considered. The tests for the difference in the mean productivity level between each mode and the results of the regression analysis are presented in table D.21 in the attachment to this appendix. While it has been possible to test whether there are differences in productivity between organisations for each mode, it has not been possible (due to the small number observations) to determine the factors, both within and outside the control of management, which explain the observed differences.

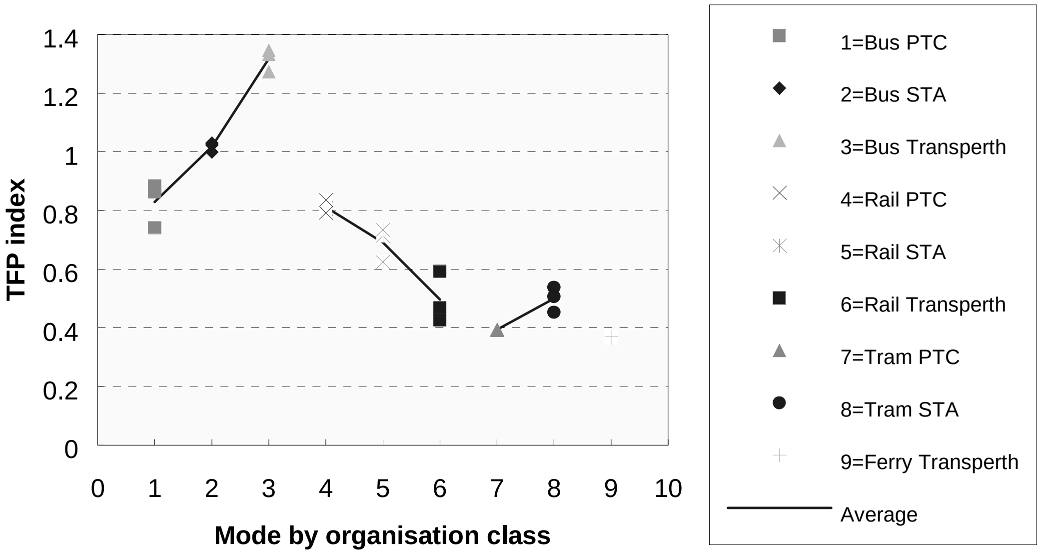
To illustrate the differences in demand and supply side productivity, productivity indexes are presented in figures D.5 and D.6. These productivity indexes are normalised around the STA bus value for 1986-87 (which is not included in the figures).

Figure D.5: **Demand side productivity of organisations by mode, 1991-1993**



Source: Industry Commission estimates

Figure D.6: **Supply side productivity of organisations by mode, 1991-1993**



Source: Industry Commission estimates

Of the three authorities covered in this study, Transperth is the only one operating ferries. While ferries have the lowest level of productivity, they are only a small proportion of Transperth's overall services.

Bus

On average over the last three years, Transperth has had the highest level of demand side productivity (1.3), which is just over 8 per cent higher than the STA's (but not statistically different) and 34 per cent higher than the PTC's. In terms of supply side productivity, Transperth has the highest (1.3), with the STA being 17 per cent lower and the PTC 37 per cent lower.

The mean real cost of service per passenger kilometre and per seat kilometre are shown in table D.5.

Table D.5: **Real cost of service and load factor for buses from 1990-91 to 1992-93**

	PTC	*STA*	*Transperth*
Passenger kilometres (cents)	41	28	31
Seat kilometres (cents)	11	8	6
Load factor	0.26	0.26	0.20

Source: Industry Commission estimates

The ranking in terms of cost of service is broadly consistent with that for productivity. The STA has the lowest cost of service per passenger kilometre, with Transperth being 3 cents (11 per cent) higher and the PTC being 13 cents (46 per cent) higher. A one-way analysis of variance was also undertaken of the cost of service (see table D.22 in the attachment to this appendix). It was not possible to conclude that the real cost per passenger kilometre was significantly different between the organisations.

The ranking in terms of real cost per seat kilometre is consistent with that for supply side productivity. Transperth has the lowest cost per seat kilometre, with the STA being two cents (33 per cent) and the PTC being 5 cents (83 per cent) higher. The statistical analysis shows that the PTC has significantly higher seat kilometre costs than the STA and Transperth. This further supports the conclusion that PTC buses are less technically efficient than those of the STA and Transperth. As discussed in the previous section, load factors explain the difference between the supply side and demand side measures. Transperth has the highest supply side productivity, but its services are not as well utilised, causing its demand side results to be around the same as those of the STA. While the PTC has a load factor similar to the STA's, it is insufficient to overcome the low technical efficiency of its service.

Rail

In contrast to the bus mode, the PTC has the highest level of rail productivity in both the demand and supply side measures. Its demand side productivity is 0.9, with the STA and Transperth being 11 and 24 per cent lower respectively. The one-way analysis of variance shows that the productivity levels are significantly different.

The PTC also has the highest supply side productivity (0.8). The STA and Transperth's rail services are 16 and 38 per cent lower respectively. The one-way analysis of variance shows that these are significantly different. The difference between the organisations is greater for supply side productivity than it is for demand side productivity. The mean real cost of service per passenger kilometre and seat kilometre and load factors are shown in table D.6.

Table D.6: **Real cost of service and load factors for rail from 1990-91 to 1992-93**

	PTC	*STA*	*Transperth*
Passenger kilometre (cents)	43	44	48
Seat kilometre (cents)	11	12	16
Load factor	0.26	0.27	0.32

Source: Industry Commission estimates

The PTC and the STA have similar costs of service and similar load factors. Transperth has a higher load factor which helps improve its relative cost per passenger kilometre by comparison with its cost per seat kilometre. There is no significant difference in cost of service per passenger kilometre. However, Transperth's cost per seat kilometre is significantly higher than the PTC and the STA.

Tram

Only the PTC and the STA operate tram services. The PTC trams are higher in demand side productivity and significantly lower (by 22 per cent) in supply side productivity. The real cost of service and load factors are shown in table D.7. Although the cost per seat kilometre is similar, the PTC's cost per passenger kilometre is lower (although not significantly) due to its higher load factor.

Table D.7: **Real cost of service and load factors for tram from 1990-91 to 1992-93**

	PTC	*STA*
Passenger kilometre (cents)	40	50
Seat kilometre (cents)	19	18
Load factor	0.48	0.36

Source: Industry Commission estimates

D.4 An analysis of productivity by mode and organisation over time

This section analyses the performance of each mode in a particular organisation over time and attempts to identify factors giving rise to variations in productivity over time.

Public Transport Corporation

Figure D.7 shows the demand and supply side productivity indexes for the PTC's bus, rail and tram services for the period 1990-91 to 1992-93. Table D.8 shows the rates of productivity growth over time. It is not possible to formally identify factors that may explain variation in productivity with annual data over such a short period.

Regression results (see table D.24) reveal that the PTC's bus and rail services do not differ significantly in their demand or supply side productivity. Since 1990-91, demand side rail productivity has grown by 10 per cent, while supply side productivity grew by 4 per cent. In 1992-93, demand side output fell, but inputs (particularly labour and materials) decreased by a greater amount, resulting in an overall productivity improvement.

The PTC directly operates only a small bus service, with most of its services being contracted out.[5] During the last 2 years, demand side bus productivity increased only marginally. In contrast, supply side productivity for buses has improved by 15 per cent. Use of all inputs decreased in 1991-92, and the use of labour decreased further in 1992-93. The improvement in supply side productivity has not translated into a similar improvement in demand side productivity. While the supply side output (seat kilometres) increased by 7 per cent, the demand side output (passenger kilometres) decreased by 7 per cent. That is, the increase in services was not matched by an increase in demand, as

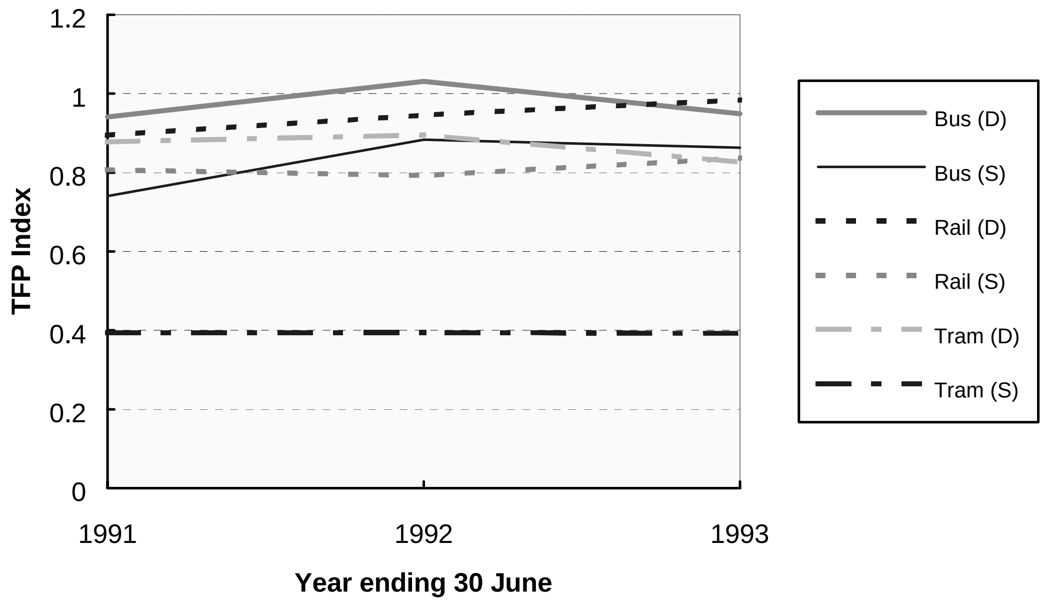
5 For an analysis of the productivity of the private bus operators see appendix E.

reflected in the declining load factor shown in table D.9. One possible explanation is that bus patronage has been affected by the recession. In an effort to improve the productivity of its bus services, the PTC now tenders for the provision of services in competition with private contractors.

Trams are the PTC's least productive service. The average demand side productivity score for trams over the last 3 years is 10 per cent less than that for bus. Trams are much less productive on the supply side, being on average 50 per cent below that for bus. The use of labour has decreased over the period but capital inputs have increased. As a result, the aggregate input index has changed little, unable to offset the reduction in passenger and seat kilometres. However, as trams have much higher load factors than trains and buses, its demand side productivity approaches that for rail and buses. In recent years the government has had a policy of retaining W-class trams for heritage reasons, even after the purchase of new trams by the PTC. This resulted in excess rolling stock, a problem which the PTC is now in the process of resolving.

The three modes appear to have similar average cost of service per passenger kilometre, as shown in table D.10. Compared to rail and bus, tram has a much higher cost per seat kilometre, but its higher load factor means that its cost per passenger kilometre is similar to the other modes.

Figure D.7: **PTC's demand and supply side productivity**



Source: Industry Commission estimates

Table D.8: **Growth rates for productivity, inputs and output for PTC**

Mode	*Measure*	*1992*	*1993*	*Over full period*[a]
			(%)	
Bus	TFP (demand)	9.2	-8.3	0.9
	TFP (supply)	17.7	-2.4	15.3
	Inputs	-6.8	-1.5	-8.3
	Output (demand)	2.4	-9.8	-7.5
	Output (supply)	10.9	-3.9	7.0
Rail	TFP (demand)	5.5	4.0	9.5
	TFP (supply)	-1.8	5.4	3.6
	Inputs	-3.3	-6.7	-10.0
	Output (demand)	2.3	-2.7	-0.4
	Output (supply)	-5.1	-1.3	-6.4
Tram	TFP (demand)	2.0	-8.0	-6.0
	TFP (supply)	0.1	-0.7	-0.6
	Inputs	2.0	-2.7	-0.7
	Output (demand)	4.0	-10.7	-6.6
	Output (supply)	2.2	-3.4	-1.2

a Growth over period might vary from sum of each year's growth due to rounding.
Source: Industry Commission estimates

Table D.9: **Load factor for PTC**

Mode	*1991*	*1992*	*1993*
		(passenger kilometres per seat kilometre)	
Rail	0.25	0.26	0.26
Bus	0.28	0.26	0.24
Tram	0.49	0.50	0.47

Source: Industry Commission estimates

Table D.10: **Real cost of service for PTC**[a]

	Mode	*1990-91*	*1991-92*	*1992-93*	*Average*
			(1993 cents per kilometre)		
Passenger kilometre	Rail	44.9	40.8	40.6	42.6
	Bus	41.3	37.1	43.1	41.0
	Tram	40.1	34.1	43.8	39.8
Seat-kilometre	Rail	11.0	10.8	10.6	11.0
	Bus	11.7	9.6	10.5	10.7
	Tram	19.8	17.2	20.5	19.4

a Cost includes annual user charge of capital.

Source: Industry Commission estimates

State Transport Authority

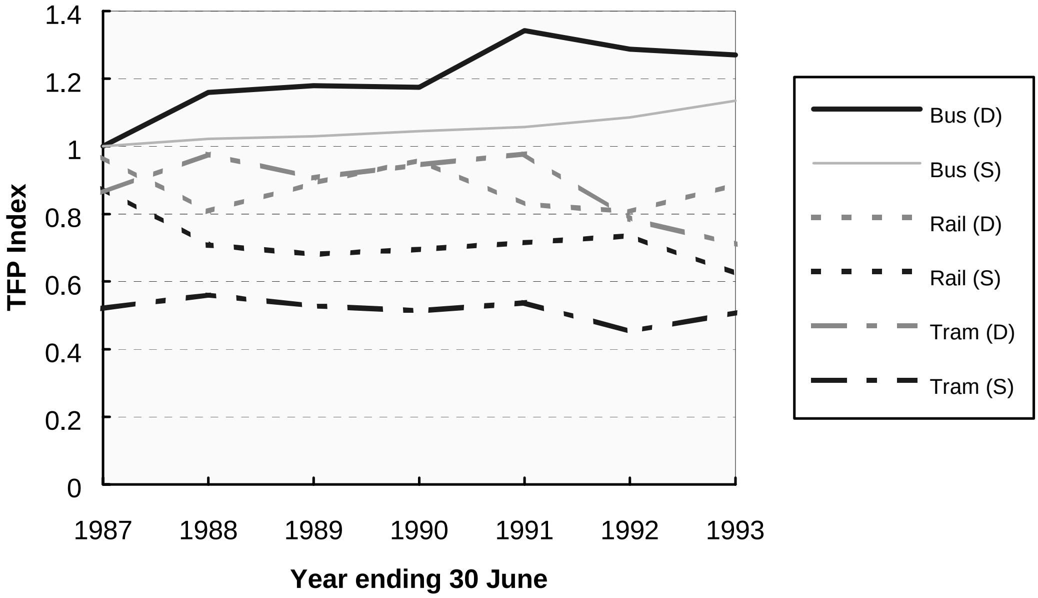
Bus is the STA's most productive mode of transport, followed by train and tram (see figure D.8) on the basis of demand and supply side productivity measures. The STA bus service is significantly more productive than its rail and tram services (see table D.23).

In 1986-87, all three modes had similar levels of demand side productivity. Since then, the bus mode has improved its productivity by 24 per cent, while rail and tram productivity decreased by 9 and 20 per cent respectively.

The performance of the bus mode can be divided into two periods. In the first, from 1986-87 to 1990-91, demand side productivity generally improved. During this period supply side productivity also improved, but at a slower rate. Demand side productivity increased markedly in 1987-88 and 1990-91 due to increases in load factors (see table D.12). As outlined below, policy changes to rail in 1987-88 may have forced some patrons to switch from rail to bus, thereby improving the bus load factor. Then in January 1990, the government introduced free travel for students, which may also explain the rise in load factors for 1990-91. The steady improvement in supply side productivity is primarily due to improvements in labour and materials partial productivity.

In the second period, from 1991-92 to 1992-93, demand side productivity decreased, even though supply side productivity continued to improve, due to a reduction in the load factor. The STA attributes most of this decline to the recession (STA 1993). It could also be associated with the withdrawal, in January 1992, of the government's policy of free travel for students.

Figure D.8: **STA's demand and supply side productivity**



Source: Industry Commission estimates

For STA rail, demand and supply side productivity have decreased over the study period by 9 and 34 per cent respectively. This can be attributed to a number of policy changes. In 1987-88, the STA implemented many policy changes, including the closure of some routes, rationalisation of timetables and fare increases. These may explain the decrease in rail productivity from 1986-87 to 1987-88. The impact of shedding services with low load factors is that the average system load factor rose (see table D.12). During this period there was a reduction in the supply side output index (seat kilometres) of 21 per cent (see table D.11). The decrease in demand side productivity was lower (18 per cent) due to improving load factors.

The STA reports that between 1988-89 and 1990-91, patronage increased by 5.4 per cent, principally as a result of increases in school student and other concessionary travel (STA 1991, p. 7). This may explain the increase in the load for factor for rail during these years. Rail supply side productivity decreased in 1993, partly due to a 17 per cent reduction in seat kilometres. In 1992-93, the STA reduced its rail services provided during weekends and nights (STA 1993, p. 20). The withdrawal of services with low load factors resulted in a significant rise in the average system load factor, as shown in table D.12.

Table D.11: **Growth rates for STA (SA)**

Mode	*Measure*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*Over full period*[a]
					(%)			
Bus	TFP (demand)	14.8	1.7	-0.4	13.3	-4.2	-1.3	23.9
	TFP (supply)	2.2	0.7	1.4	1.2	2.6	4.5	12.7
	Inputs	-2.2	-4.0	2.0	-1.2	-1.3	-8.6	-15.4
	Output (demand)	12.6	-2.3	1.6	12.1	-5.5	-10.0	8.6
	Output (supply)	0.0	-3.3	3.4	0.0	1.3	-4.2	-2.7
Rail	TFP (demand)	-17.9	9.8	7.3	-14.5	-2.7	9.4	-8.7
	TFP (supply)	-21.2	-4.0	2.1	2.7	2.8	-16.4	-33.9
	Inputs	0.1	3.8	-0.1	-3.0	-1.6	-1.0	-1.9
	Output (demand)	-17.9	13.5	7.2	-17.5	-4.4	8.4	-10.6
	Output (supply)	-21.1	-0.2	2.0	-0.3	1.2	-17.4	-35.8
Tram	TFP (demand)	12.3	-7.4	4.1	3.4	-21.9	-10.0	-19.6
	TFP (supply)	7.5	-6.0	-2.8	4.6	-17.1	11.4	-2.5
	Inputs	-12.5	-2.9	-0.3	-3.5	7.7	-4.5	-15.9
	Output (demand)	-0.2	-10.3	3.9	-0.1	-14.2	-14.5	-35.5
	Output (supply)	-5.0	-8.9	-3.1	1.1	-9.4	6.9	-18.4

a Growth over period might vary from sum of each year's growth due to rounding.
Source: Industry Commission estimates

Table D.12: **Load factor for STA**

Mode	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*
			(passenger kilometres per seat kilometre)				
Bus	0.22	0.25	0.25	0.25	0.28	0.26	0.25
Rail	0.24	0.25	0.29	0.31	0.26	0.24	0.32
Tram	0.37	0.39	0.38	0.41	0.40	0.38	0.31

Source: Industry Commission estimates

The STA has only one tram line that runs from the CBD to Glenelg. Over the period studied, demand side productivity for STA trams decreased by 20 per cent while supply side productivity decreased by only 3 per cent, associated with an overall decrease in load factor. In 1992-93, passenger kilometres decreased by 15 per cent with a smaller reduction in the input index, generating a demand side productivity reduction of 10 per cent. During this year, the load factor also decreased.It is useful to try and formally identify the influence of particular factors and trends in productivity over time. In the case of demand side productivity, this is achieved by regressing productivity on load factor,

Table D.13: **Regression analysis of productivity trends over time for STA's bus, rail and tram**

Demand Side

Mode	*Variable*	*Parameter estimate*	*Probability level (t test)*
Bus	Constant	0.116	0.1583
	Load factor	0.039	0.0002
	Time trend	0.026	0.0005
Rail	Constant	0.160	0.1535
	Binary for:		
	-route closure in 1986-87	0.188	0.0111
	-reduction in weekend and night services in 1992-93	-0.102	0.0462
	Load factor	0.025	0.0090
	Time trend	0.006	0.2727
Tram	Constant	-0.063	0.8423
	Load factor	0.026	0.0223
	Time trend	-0.013	0.3321
System weighted R-squared	0.99		

Supply Side

Mode	*Variable*	*Parameter estimate*	*Probability level (t test)*
Bus	Constant	0.974	0.0001
	Time trend	0.020	0.0007
Rail	Constant	0.669	0.0001
	Binary for:		
	-route closure in 1986-87	0.193	0.0041
	-reduction in weekend and night services in 1992-93	-0.122	0.0152
	Time trend	0.010	0.1620
Tram	Constant for 1987 to 1991	0.552	0.0001
	Time trend	-0.009	0.1845
System weighted R-squared	0.95		

Source: Industry Commission estimates

binary variables indicating qualitative changes and time trend variables. In the case of supply side productivity, binary and time trend variables are used. Three regression equations, one for each mode, are estimated jointly using the seemingly Unrelated Regression (SUR) procedure (Judge et al 1988 and Kmenta 1971). The SUR procedure is used because each equation's error terms are likely to be contemporaneously correlated due to the fact that some data for each mode are derived by allocating aggregate organisation data to each mode. For example, tickets may be used on any mode and the agency needs to estimate the proportion of tickets used and the length of journey on each mode. Also, some overhead cost data is allocated to each mode. Variation in estimation and allocation procedures simultaneously affects the data for all modes.

The results of the regression analysis for the STA for both demand and supply side productivity are shown in table D.**Error! Bookmark not defined.**. For the bus mode, load factor and the time trend are significant in explaining the variation in productivity. The time trends indicate that both demand and supply side productivity have been increasing by around 0.02 units per year.

For rail, 1987-88 and 1992-93 policy changes reduced both demand and supply productivity by around 0.2 and 0.1 units respectively. Load factor is also a significant factor affecting demand side productivity. There does not appear to be any underlying time trend in both demand and supply side productivity that is not already explained by the factors referred to above.

The demand and supply side productivity of trams has been constant, except for the variation in demand side productivity, due to changes in the load factor.

The real costs of service for the three modes are shown in table D.14. In terms of cost per passenger kilometre, buses are the STA's least costly mode, being around 32 per cent lower than the cost of rail and tram. Rail and tram have similar costs of service per passenger kilometre. However, trams are more expensive per seat kilometre, but have had higher load factors until 1992-93.

Table D.14: **Real cost of service for STA**[a]

	Mode	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*Average*
					(1993 cents per kilometre)				
Passenger kilometre	Rail	39.2	48.6	44.7	41.7	47.1	45.7	40.1	43.9
	Bus	34.4	30.3	30.3	30.2	26.9	29.0	29.4	30.1
	Tram	38.9	38.0	42.3	40.6	38.9	53.1	58.6	44.3
Seat kilometre	Rail	9.6	12.3	13.0	12.8	12.1	11.1	12.6	11.9
	Bus	7.6	7.8	7.8	7.6	7.6	7.6	7.2	7.6
	Tram	14.3	14.7	16.1	16.6	15.7	20.4	18.2	16.6

a Cost includes annual user charge of capital.

Source: Industry Commission estimates

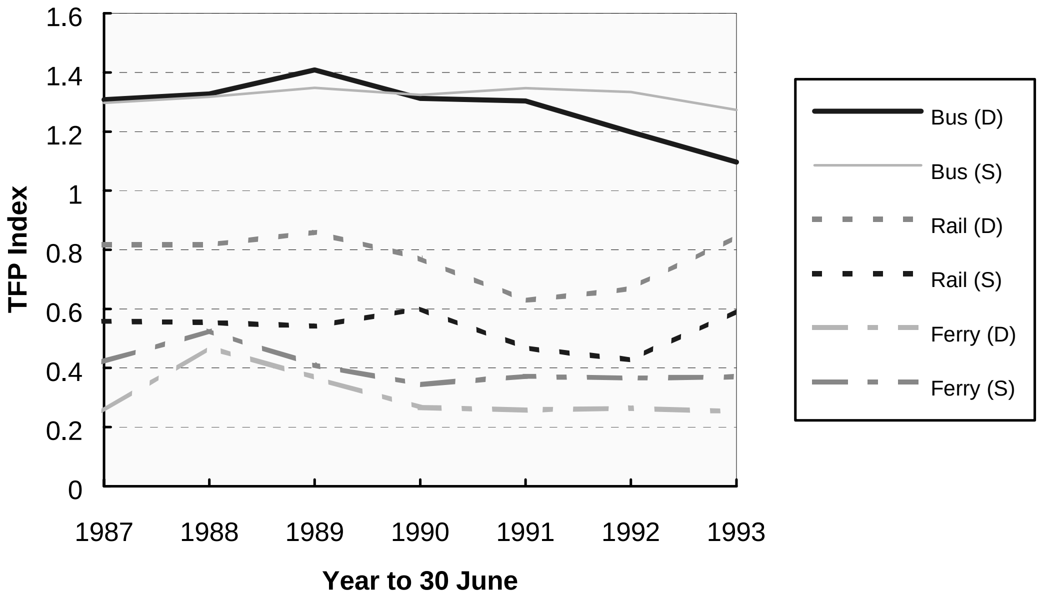
Transperth

Bus has been Transperth's most productive mode over the period studied, both in terms of demand and supply side productivity. Rail has been the second most productive, followed by ferry. All modes have significantly different levels of demand and supply side productivity (see table D.23).

While buses have the highest level of productivity, their demand side productivity has been decreasing since 1988-89 (see figure D.9 and table D.15). Over the entire study period, bus demand side productivity has decreased by 18 per cent, even though supply side productivity has only decreased by 2 per cent, due to declining load factors (see table D.16). The electrification of the rail system and the introduction of the northern rail link are most likely to have caused bus patrons to transfer to the rail service. The new electric trains offer a superior quality of service (for example, air conditioning, which is attractive during Perth summers).

Ferry productivity has generally been constant, except for a temporary increase in 1987-88.

Figure D.9: **Transperth's demand and supply side productivity**



Source: Industry Commission estimates

Table D.15: **Growth rates for Transperth**

Mode	*Measure*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*Over full period* [a]
					(%)			
Bus	TFP (demand)	1.4	5.9	-7.1	-0.6	-8.4	-8.9	-17.6
	TFP (supply)	1.5	2.3	-1.8	1.6	-1.0	-4.6	-1.8
	Inputs	0.1	0.9	5.1	0.1	4.8	2.9	13.9
	Output (demand)	1.6	6.8	-2.1	-0.5	-3.6	-6.0	-3.8
	Output (supply)	1.6	3.2	3.3	1.7	3.9	-1.8	12.0
Rail	TFP (demand)	0.0	5.1	-10.7	-20.6	6.3	23.4	3.3
	TFP (supply)	-0.8	-2.1	10.4	-25.0	-9.1	32.8	6.0
	Inputs	-2.5	-3.4	0.7	12.3	11.5	19.2	37.8
	Output (demand)	-2.5	1.7	-10.0	-8.3	17.8	42.6	41.2
	Output (supply)	-3.3	-5.5	11.1	-12.7	2.4	52.0	43.8
Ferry	TFP (demand)	61.0	-24.6	-32.1	-3.0	2.2	-4.2	-0.8
	TFP (supply)	22.0	-24.7	-17.3	7.6	-1.7	1.3	-12.9
	Inputs	-20.6	24.8	4.7	-8.9	2.4	-0.5	1.9
	Output (demand)	40.4	0.2	-27.4	-11.9	4.5	-4.7	1.1
	Output (supply)	1.4	0.1	-12.6	-1.3	0.7	0.8	-11.0

a Growth over period might vary from sum of each year's growth due to rounding.
Source: Industry Commission estimates

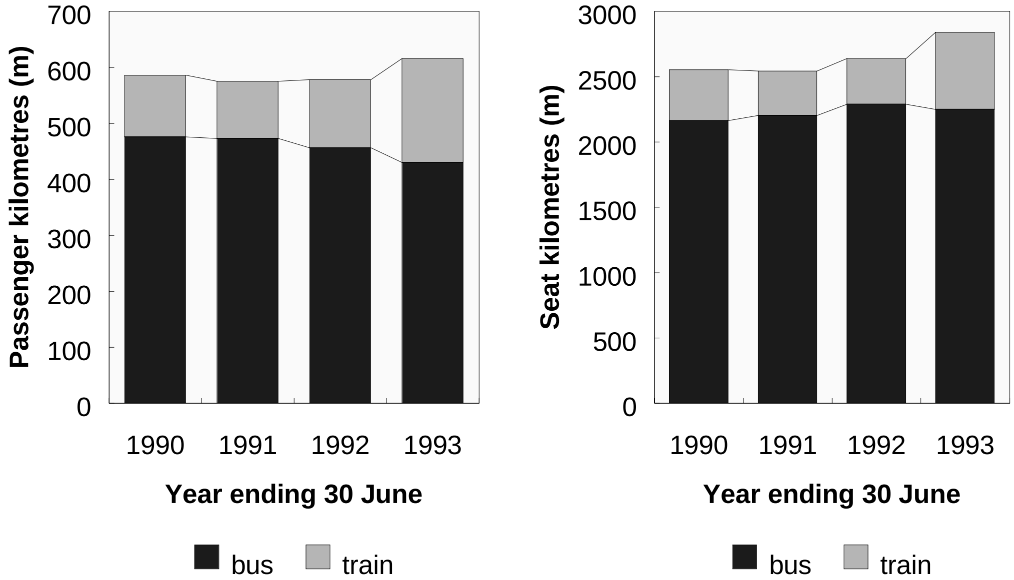
Bus patronage fell by 17 and 27 million passenger kilometres in 1991-92 and 1992-93 respectively (4 and 6 per cent). During the same years, rail patronage rose by 20 and 65 million passenger kilometres (18 and 43 per cent) (see figure D10). These figures suggest that part of the decline in bus patronage may result from the switching of bus passengers to rail travel. In addition, 38 million new public transport passenger kilometres were generated, representing a 6.5 per cent increase on 1991-92. It is likely that most of these were car travellers attracted by the opening of the northern rail line and the electrification of the rail system.[6]

Rail demand and supply side productivity decreased temporarily during the construction phase of the electric rail system and the northern rail link. During the entire study period, rail demand side productivity grew by only 3 per cent, despite the large increase in rail patronage (see figure D.10). This is because the increase in service required a large increase in inputs (38 per cent), particularly capital. So, even though the new rail service has attracted passengers, rail productivity has not yet improved much beyond the level of the late eighties

6 Few, if any of these would have previously been ferry travellers, as the new rail services do not duplicate ferry routes.

because extra resources were required to deliver the service. The full effect will not be evident until the northern rail line project has been completed and the system stabilised.

Figure D.10: **Transperth's rail and bus passenger and seat kilometres**



Source: Industry Commission estimates

Table D.16: **Load factor for Transperth**

Mode	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*
				(passenger kilometres per seat kilometre)			
Bus	0.22	0.22	0.23	0.22	0.21	0.20	0.19
Train	0.32	0.33	0.35	0.28	0.30	0.35	0.32
Ferry	0.13	0.20	0.20	0.17	0.15	0.16	0.15

Source: Industry Commission estimates

In a manner similar to that for the STA, three regression equations, one for each mode, are jointly estimated using the SUR procedure discussed above. The results of the regression analysis of Transperth are shown in table D.17.

Load factor is significant in explaining the variation in demand side productivity for all 3 modes. There appears to be no underlying time trend in demand or supply side productivity for any mode. Demand and supply side productivity for rail were significantly affected by the changes to the rail system during 1990-91 and 1991-92.

Table D.17: **Regression analysis of productivity trends over time for Transperth's bus, rail and ferry**

		Demand Side	
Mode	*Variable*	*Parameter estimate*	*Probability level (t test)*
Bus	Constant	-0.6993	0.0341
	Load factor	0.0890	0.0007
	Time trend	0.0164	0.0608
Rail	Constant	0.4841	0.0028
	Binary for electrification and construction 1990-91 to 1991-92	-0.1801	0.0003
	Load factor	0.0100	0.0082
	Time trend	0.0048	0.1689
Ferry	Constant	0.0638	0.9171
	Binary for 1987-88	0.1141	0.0131
	Load factor	0.0184	0.0113
	Time trend	-0.0061	0.2370
System weighted R-square	0.9898		

		Supply Side	
Mode	*Variable*	*Parameter estimate*	*Probability level (t test)*
Bus	Constant	1.3258	0.0001
	Time trend	-0.0014	0.8075
Rail	Constant	0.5485	0.0001
	Binary for electrification and construction 1990-91 and 1991-92	-0.1288	0.0017
	Time trend	0.0058	0.3215
Ferry	Constant	0.4248	0.0001
	Binary for 1987-88	0.1151	0.0038
	Time trend	-0.0100	0.0935
System weighted R-square	0.9270		

Source: Industry Commission estimates

The real cost of service for Transperth's three modes is presented in table D.18. In terms of cost per passenger kilometre, the bus mode is much more cost effective than rail, with a cost per passenger kilometre which is 37 per cent lower than for rail. In addition, bus also has a lower cost per seat kilometre.

Table D.18: **Real cost of service for Transperth**[a]

	Mode	1986	1987	1988	1989	1990	1991	1992	Average
					(1993 cents per kilometre)				
Passenger kilometre	Rail	43.3	45.4	44.0	46.5	52.8	51.6	41.1	46.4
	Bus	26.7	27.0	26.1	28.0	28.0	31.3	34.6	28.8
	Ferry	167.9	114.0	131.7	170.5	170.9	136.0	134.7	146.5
Seat kilometre	Rail	14.1	14.8	15.5	13.2	15.7	17.9	13.0	14.9
	Bus	6.0	6.0	6.1	6.2	6.0	6.2	6.6	6.2
	Ferry	22.6	22.6	26.2	29.3	26.4	21.8	20.4	24.2

a Cost includes annual user charge of capital.

Source: Industry Commission estimates

D.5 Conclusion

Transperth is the most technically efficient organisation in providing services, while the STA provides its services in a more cost-effective manner. This difference is due primarily to higher load factors in Adelaide. For the STA and Transperth the study also finds that buses are more efficient in providing urban public transport than rail for the load factors observed. In addition, as Transperth has increased its use of rail relative to bus, its overall productivity has fallen to below that of the STA. Whether this remains the case after the system has completely settled is uncertain. The PTC generally has a lower level of supply side productivity than the STA and Transperth. While the PTC has made some partial productivity gains, principally due to reductions in the use of labour, there appears to be scope for the PTC to improve its overall supply side productivity (technical efficiency), particularly its tram and bus services. The PTC recognises the need for improvement and in 1993-94 is implementing a number of reforms to improve productivity.

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Attachment to appendix D

Introduction to total factor productivity

In practice, productivity measures the amount of output per unit of input. There are two types of productivity measures: total factor productivity (TFP) and partial factor productivity. TFP is an aggregate output index divided by an aggregate input index, where as a partial productivity indicator is the ratio of a single output to a single input (for example passenger kilometres per employee).

Partial productivity measures are widely used because they are relatively easy to calculate. However, they need to be interpreted with caution. For example, passenger kilometres per employee may be improved by using larger buses with a higher seating capacity. However, the overall productivity improvement is likely to be less than that indicated by the partial labour productivity indicator because the reduction in the labour requirement and savings in wages has been offset by an increase in the use of capital and the additional costs of depreciation and return on the investment. As TFP takes into account all inputs used, it is superior to partial productivity measures.

TFP uses index number procedures to aggregate multiple outputs and multiple inputs into single aggregate output and input indexes. The outputs are aggregated using revenue shares as weights, and the inputs are aggregated using cost shares as weights. There are two basic index procedures used to measure TFP. The first involves measuring productivity for an individual organisation, such as a government trading enterprise, relative to a specific point in time using the Tornqvist index procedure (see Steering Committee on National Performance Monitoring of Government Trading Enterprises 1992). This methodology is unsuitable for comparing the absolute levels of productivity between modes and systems. The second method, first proposed by Caves et al (1982), is referred to as multilateral TFP and is suitable for comparisons of both absolute levels of productivity between systems and modes, and the relative productivity of individual systems and modes over time. This study uses the second method. For a more detailed discussion of multilateral TFP, see Hensher and Daniels 1993.

It should be noted that the methodology used to calculate the level of capital stock and the annual user charges are different to that used in previous productivity studies undertaken by the Commission and that published by the Steering Committee on National Performance Monitoring of Government Trading Enterprises (1992). The availability of detailed data on individual assets has enabled the methodology of calculating capital stocks and annual user charges to be refined. Here, the quantity of capital stock for each individual asset included in the aggregate capital stock is defined as its undepreciated cost in constant dollars (year). This leads to the implicit quantity of the asset being constant over its life. This contrasts with the methodology published by the Steering Committee on National Performance Monitoring of Government Trading Enterprises (1992), where the implied quantity of an asset is its written down value, expressed in constant dollars. In their case, the implied quantity of each asset, such as a bus or train, is declining over time in accordance with its depreciation schedule. This may lead to an over estimation of productivity improvements over time for assets which are replaced infrequently, such as railway tunnels, tracks, bridges, and bus depots. The methodology used here is consistent with that being used elsewhere in this report (see appendix E).

In this study, the annual user charges (cost of using assets in each year) are calculated by converting the replacement cost (in current dollars) to an annuity using a capital recovery factor based on the life of the asset and a 7 per cent target real rate of return. This contrasts with the methodology outlined by the Steering Committee on National Performance Monitoring of Government Trading Enterprises (1992), where annual user charges are the sum of current year depreciation cost and a 7 per cent target real rate of return on the current year written down value of each asset. The difference between the two methods is that the methodology used here yields annual user charges which are constant in real terms over the life of each asset, whereas as the other methodology results in annual user charges which decline in real terms over the life of the asset. All else being equal, the other methodology leads to declining cost shares for long lived assets. The methodology used here is the same as that used elsewhere in this report (see appendix E) and also Hensher and Daniels (1993). This methodology is considered more appropriate for comparing the productivity of organisations who are at different stages in the life cycle of long lived assets. For example, Transperth replaced its diesel rail system with an electric system during the period studied, whereas other organisations did not change their systems. For a more detailed technical discussion of these issues see Salerian and Kaur (1993).

The data used in this study has been obtained from annual reports, the Commonwealth Grants Commission and the relevant transport authorities. One of the most difficult tasks in productivity studies is valuing the capital stock and calculating annual user charges. To facilitate this study, each organisation has made available its data on individual assets. This has enabled the calculation of annual user charges and capital stocks for each asset in each organisations asset register and for each mode of transport operated.

Key operating statistics

Key statistics were gathered for the three organisations, by mode and year, in order to facilitate interpretation of organisational productivity and modal productivity results. These are presented in tables D.19, D.20 and D.20.

Table D.19: **Key operating statistics for PTC (Victoria)**

	Mode	*1990-91*	*1991-92*	*1992-93*
Pass. Km (‘000)	Tram	560000	583000	524000
	Bus	167000	171000	155000
	Rail	1437000	1470000	1431000
	Total	2164000	2224000	2110000
Seat Km (‘000)	Tram	1134000	1159000	1120000
	Bus	592000	660000	635000
	Rail	5840000	5550000	5480000
	Total	7566000	7369000	7235000
Pass Km / Seat Km (Load factor)	Tram	0.49	0.50	0.47
	Bus	0.28	0.26	0.24
	Rail	0.25	0.26	0.26
Employees (Average no.)	Tram	3878	3767	3535
	Bus	1259	1177	1067
	Rail	6812	6537	5857
	Total	11949	11481	10459
Energy use (GJ)	Tram	202000	205000	202000
	Bus	296000	287000	305000
	Rail	821000	842000	827000
	Total	1319000	1334000	1334000
Capital stock (constant 1993 $’000)	Tram	636295	667468	798646
	Bus	73039	73158	90397
	Rail	2250421	2310563	2355871
	Total	2959755	3051189	3244914

Source: PTC and Industry Commission estimates

Table D.19: **Key operating statistics for STA (South Australia)**

	Mode	*1986-87*	*1987-88*	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*
Pass. Km	Tram	20356	20313	18317	19037	19017	16502	14275
('000)	Bus	430175	488104	476901	484381	546934	517857	468721
	Rail	201712	168729	193154	207531	174195	166752	181374
	Total	652243	677146	688372	710949	740146	701111	664370
Seat Km	Tram	55232	52544	48064	46600	47116	42880	45932
('000)	Bus	1938538	1939492	1876324	1941500	1941441	1967612	1887337
	Rail	823485	666572	665150	678571	676790	684866	575414
	Total	2817255	2658608	2589538	2666671	2665347	2695358	2508683
Vehicle Km	Tram	863	821	751	713	720	688	733
('000)	Bus	39562	39024	37753	38642	40039	38911	38075
	Rail	8696	7039	7024	7160	6730	6537	5972
Route Km	Tram	11	11	11	11	11	11	11
('000)	Bus	1022	1020	1020	1049	1057	1080	1121
	Rail	149	127	128	126	120	120	120
Pass Km /	Tram	23.6	24.7	24.4	26.7	26.4	24.0	19.5
Vehicle Km	Bus	10.9	12.5	12.6	12.5	13.7	13.3	12.3
	Rail	23.2	24.0	27.5	29.0	25.9	25.5	30.4
Seat Km /	Tram	64.0	64.0	64.0	65.4	65.4	62.3	62.7
Vehicle Km	Bus	49.0	49.7	49.7	50.2	48.5	50.6	49.6
	Rail	94.7	94.7	94.7	94.8	100.6	104.8	96.4
Pass Km /	Tram	0.37	0.39	0.38	0.41	0.40	0.38	0.31
Seat Km	Bus	0.22	0.25	0.25	0.25	0.28	0.26	0.25
(load factor)	Rail	0.24	0.25	0.29	0.31	0.26	0.24	0.32
Vehicle Km /	Tram	75.8	72.1	69.5	66.0	66.7	63.7	67.9
Route Km	Bus	38.7	38.3	37.0	36.8	37.9	36.0	34.0
	Rail	58.4	55.4	54.9	56.8	56.1	54.5	49.8
Employees	Tram	129	126	118	121	116	108	106
(No. at 30	Bus	2663	2584	2428	2489	2396	2305	2174
June)	Rail	906	879	826	847	815	782	740
	Total	3699	3589	3372	3457	3327	3195	3020
Energy	Tram	6275	6253	6253	6217	6246	6012	5929
use (GJ)	Bus	684841	682062	663302	659249	674149	613701	657860
	Rail	362724	341880	336746	327521	309186	273867	272786
	Total	1053840	1030195	1006301	992987	989581	893580	936575
Capital stock	Tram	14935	16641	16513	15788	17007	16836	16723
(constant 1993	Bus	340554	345630	338603	352410	381125	380285	314397
$'000)	Rail	293523	333241	394533	371709	381093	380268	405668
	Total	649012	695512	749649	739907	779225	777389	736788

Source: STA and Industry Commission estimates

Table D.20: **Key operating statistics for Transperth (Western Australia)**

	Mode	*1986-87*	*1987-88*	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*
Pass. Km	Ferry	530	794	796	605	537	566	536
('000)	Bus	446400	453400	485500	475600	473200	456500	429800
	Rail	123300	120200	122200	110600	101800	121600	186100
	Total	570230	574394	608496	586805	575537	578666	616436
Seat Km	Ferry	3941	3996	4000	3526	3481	3505	3532
('000)	Bus	1994691	2027502	2094211	2164136	2202123	2289105	2249225
	Rail	379826	367477	347688	388337	341872	350168	588853
	Total	2378458	2398975	2445899	2555999	2547476	2642778	2841610
Vehicle Km	Ferry	39	40	40	35	35	35	35
(‘000)	Bus	46911	46474	47841	47564	48750	49210	49444
	Rail	5729	5511	5230	5815	5543	5648	8830
Route Km	Ferry	2.50	2.50	2.50	1.30	1.30	1.30	1.30
('000)	Bus	1771	1784	1836	1867	1876	1911	1918
	Rail	67	66	66	66	66	66	95
Pass Km /	Ferry	13.5	19.9	19.9	17.1	15.4	16.1	15.2
Vehicle Km	Bus	9.5	9.8	10.1	10.0	9.7	9.3	8.7
	Rail	21.5	21.8	23.4	19.0	18.4	21.5	21.1
Seat Km /	Ferry	100.3	99.9	100.0	99.9	100.0	99.9	100.1
Vehicle Km	Bus	42.5	43.6	43.8	45.5	45.2	46.5	45.5
	Rail	66.3	66.7	66.5	66.8	61.7	62.0	66.7
Pass Km /	Ferry	0.13	0.20	0.20	0.17	0.15	0.16	0.15
Seat Km	Bus	0.22	0.22	0.23	0.22	0.21	0.20	0.19
(load factor)	Rail	0.32	0.33	0.35	0.28	0.30	0.35	0.32
Vehicle Km /	Ferry	15.8	16.0	16.0	27.2	26.8	27.0	27.2
Route Km	Bus	26.5	26.1	26.1	25.5	26.0	25.8	25.8
	Rail	85.5	87.5	83.0	92.3	88.0	89.7	93.2
Employees	Ferry	11	8	9	9	9	9	9
(Average no.)	Bus	2163	2127	2113	2117	2124	2130	2176
	Rail	618	577	554	545	531	526	549
	Total	2745	2673	2662	2717	2455	2538	2734
Energy use	Ferry	2432	2355	2084	2162	1853	1814	1814
(GJ)	Bus	716585	719443	759670	770173	784319	803335	808528
	Rail	179799	193154	203576	207050	194467	180772	134507
	Total	898816	914952	965330	979385	980639	985921	944849
Capital stock	Ferry	2103	2103	3575	3575	3049	3049	3049
(constant 1993	Bus	245145	261548	273475	279382	289928	335851	338721
$'000)	Rail	258023	258023	258023	272833	361642	434474	526397
	Total	505271	521674	535073	555790	654619	773374	868167

Source: Transperth and Industry Commission estimates

Regression results

The following tables present the analysis of variance regression results for TFP and cost of service.

Table D.21: Regression analysis of productivity for each organisation by mode (1990-91 to 1992-93)

	Demand side		*Supply side*	
	Parameter estimate	*Probability level (t test)*	*Parameter estimate*	*Probability level (t test)*
Bus STA	1.20	0.0001	1.09	0.0001
Bus Transperth	1.30	0.0001	1.32	0.0001
Bus PTC	0.97	0.0001	0.83	0.0001
Rail STA	0.84	0.0001	0.69	0.0001
Rail Transperth	0.71	0.0001	0.50	0.0001
Rail PTC	0.94	0.0001	0.81	0.0001
Tram STA	0.82	0.0001	0.50	0.0001
Tram PTC	0.87	0.0001	0.39	0.0001
Ferry Transperth	0.26	0.0001	0.37	0.0001
R-square	0.99		0.99	

Pairwise tests of all combinations of organisation and mode were conducted. Those pairs with coefficients which are not statistically different (at 5 per cent level) are listed below.

Demand side	*Supply side*
STA bus, Transperth bus	STA tram, Transperth rail
STA bus, Transperth rail	PTC bus, PTC rail
STA rail, PTC rail	PTC tram, Transperth ferry
STA rail, PTC tram	
STA rail, STA tram	
STA tram, Transperth rail	
STA tram, PTC rail	
STA tram, PTC tram	
PTC bus, PTC tram	
PTC bus, PTC rail	
PTC rail, PTC tram	

Source: Industry Commission estimates

Table D.22: **Regression analysis of real cost of service for each organisation by mode (1990-91 to 1992-93)**

	Cost per passenger kilometre		*Cost per seat kilometre*	
	Parameter estimate	*Probability level (t test)*	*Parameter estimate*	*Probability level (t test)*
Bus STA	0.28	0.0001	0.08	0.0001
Bus Transperth	0.31	0.0001	0.06	0.0001
Bus PTC	0.41	0.0001	0.11	0.0001
Rail STA	0.44	0.0001	0.12	0.0001
Rail Transperth	0.48	0.0001	0.16	0.0001
Rail PTC	0.43	0.0001	0.11	0.0001
Tram STA	0.50	0.0001	0.18	0.0001
Tram PTC	0.40	0.0001	0.19	0.0001
Ferry Transperth	1.47	0.0001	0.23	0.0001
R-square	0.99		0.99	

Pairwise tests of all combinations of organisation and mode were conducted. Those pairs with coefficients which are not statistically different (at 5 per cent level) are listed below.

Demand side	*Supply side*
STA bus, Transperth bus	STA bus, Transperth bus
STA bus, PTC bus	STA rail, PTC bus
STA bus, PTC rail	STA rail, PTC rail
STA bus, PTC tram	STA tram, Transperth rail
STA rail, STA tram	STA tram, PTC tram
STA rail, Transperth bus	PTC bus, PTC tram
STA rail, Transperth rail	
STA rail, PTC bus	
STA rail, PTC rail	
STA rail, PTC tram	
STA tram, Transperth rail	
STA tram, PTC bus	
STA tram, PTC rail	
STA tram, PTC tram	
Transperth bus, PTC bus	
Transperth bus, PTC rail	
Transperth bus, PTC tram	
Transperth rail, PTC bus	
Transperth rail, PTC rail	
Transperth rail, PTC tram	
PTC bus, PTC rail	
PTC bus, PTC tram	
PTC rail, PTC tram	
PTC rail, PTC tram	

Source: Industry Commission estimates

Table D.23: **Regression analysis of productivity for each organisation by mode (1986-87 to 1992-93)**

	Demand side		*Supply side*	
	Parameter estimate	*Probability level (t test)*	*Parameter estimate*	*Probability level (t test)*
STA bus	1.20	0.0001	1.05	0.0001
STA rail	0.88	0.0001	0.72	0.0001
STA tram	0.88	0.0001	0.52	0.0001
Transperth bus	1.28	0.0001	1.32	0.0001
Transperth rail	0.77	0.0001	0.53	0.0001
Transperth ferry	0.31	0.0001	0.40	0.0001
PTC bus	0.97	0.0001	0.83	0.0001
PTC rail	0.94	0.0001	0.81	0.0001
PTC tram	0.87	0.0001	0.39	0.0001
R-square		0.99		0.99

Pairwise tests of all combinations of organisation and mode were conducted. Those pairs with coefficients which are not statistically different (at 5 per cent level) are listed below.

Demand side	*Supply side*
STA rail, STA tram	STA tram, Transperth rail
STA bus, Transperth bus	Transperth ferry, PTC tram
STA rail, PTC bus	PTC bus, PTC rail
STA rail, PTC rail	
STA rail, PTC tram	
STA tram, PTC bus	
STA tram, PTC tram	
STA tram, PTC rail	
PTC tram, Transperth rail	
PTC bus, PTC tram	
PTC bus, PTC rail	
PTC rail, PTC tram	

Source: Industry Commission estimates

APPENDIX E

Performance measurement in the urban bus sector

APPENDIX E PERFORMANCE MEASUREMENT IN THE URBAN BUS SECTOR

This appendix reproduces the executive summary from a paper by the University of Sydney's Institute of Transport Studies (Prof. David Hensher and Rhonda Daniels) contracted by the Commission as part of this inquiry. The paper is entitled 'Productivity measurement in the urban bus sector: 1991/92'. Copies of the paper are available from the Commission.

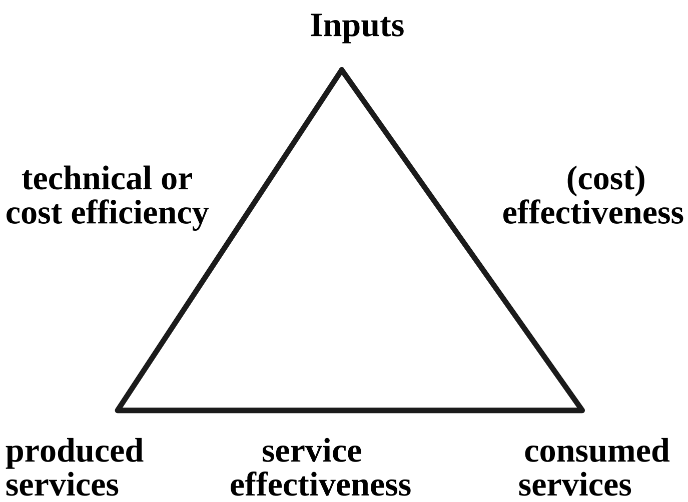
This report investigates the relative performance of urban bus operators in Australia in 1991/92. A new data set has been compiled with the support of 24 private bus operators in Brisbane, Sydney and Melbourne, and the 8 public operators in all the capital cities. A time series data base spanning the period 1980/81 to 1991/92 for public operators only has also been developed, but is not included in this report given the primary emphasis on a comparison across the entire private and public sectors. Further reports by the Institute of Transport Studies will analyse public operator performance over time.

Performance has many dimensions. In broad terms we distinguish between efficiency and effectiveness (figure E1). The efficiency of an enterprise represents the manner in which the physical inputs of labour, energy, maintenance materials, capital and overheads are used to produce the physical (intermediate) services defined by vehicle kilometres of service. Effectiveness has two essential components: (i) cost effectiveness — the relationship between inputs and consumed services (ie. patronage levels), and (ii) service effectiveness — the relationship between produced services (ie. vehicle kilometres) and consumed services (ie. patronage levels). All of these global measures are *relative* measures of different dimensions of performance. *This report studies cost efficiency and cost effectiveness and not service effectiveness.*

A single index which represents either cost efficiency or cost effectiveness is total factor productivity (TFP). A TFP index representing cost efficiency tells us how efficient an operator is in using their inputs to produce vehicle kilometres of service. We call this TFPvkm. A TFP index representing cost effectiveness tells us how effective an operator is in using their inputs to service passengers. We call this TFPpass. Both measures are important interpretations of performance. They must be interpreted at a strategic firm-wide level. They are not designed in this study to provide details of route-specific or depot-specific performance.

The reporting of both a cost efficiency and a cost effectiveness measure of performance is important. The cost efficiency measure is of particular interest to the operator because it relates to service levels to a large extent under their control, given patronage levels. Government regulators and inquiries such as the Industry Commission Inquiry are also interested in how cost effective each operator is in moving passengers, the latter representing the prime purpose for being in business.

Figure E1: **The essential dimensions of performance measurement**



In establishing a quantitative measure of the overall relative productivity of bus operators, it is also important to identify the influences which contribute to explain the differences in overall productivity. The Industry Commission is particularly interested in identifying the influence of broad categories of effects, especially institutional differences (eg. ownership, subsidy arrangements, service delivery conditions). Contextual differences such as the size of the patronage catchment area, fleet utilisation, and work practices can explain some of the differences. Knowing the extent to which sources of difference are under the control of the operator or are the consequence of uncontrollable external factors is important in identifying strategies by the operator and government/regulators which are commensurate with improving productivity.

The main findings from the study are summarised below. In interpreting each statement it is important to recognise that the results apply to one recent year, 1991/92. As such the study's primary objective is to identify differences in the productivity of operators at a point in time. This is a valid interpretation of TFP. Another equally valid interpretation not studied herein is a comparison of changes in productivity over time (ie. productivity growth). The cross-section of 32 operators is a rich description of the different ways in which inputs are related to outputs. The data set also enables us to identify the influences under the control of the operator or outside of their control which explain the differences in productivity between operators. In addition to the TFP measures of overall productivity, we report a number of the most interesting partial measures of productivity (eg. total cost per vehicle kilometre, total cost per vehicle hour, labour cost per vehicle kilometre). It must be understood that partial ratios can be misleading in assessing the *overall* productivity of a bus operator, even though such measures have an inherent appeal to operators.

In any comparison of the rankings of each operator discussed below and in the body of the report it is important to identify the actual level of the TFP index, because some of the operators have indices with very similar values. It does not take a very large change in output or inputs to change the *adjacent* rankings. It is important that the reader of this report recognise this point and allow for some degree of 'grouping' of operators with very similar TFP indices in any interpretation of the findings.

It is also important to recognise that the two measures of output — passengers and vehicle kilometres — are two of a number of possible measures. They are the most commonly used measures in TFP studies. Our preferred measures are passenger kilometres and vehicle seat hours. The former allows for differing trip lengths, the latter allows for the differing operating environments such as traffic congestion and time required for passengers to board and alight. The data on trip lengths required to convert passenger trips to passenger kilometres was deemed to be unreliable — operators tend not to keep such information. Data on vehicle hours is reliable for some operators but not for other operators. In ongoing monitoring of the bus industry we have requested each operator to keep better records on both of these preferred output measures. In opting for reliable data items in the current study it is acknowledged that the TFPpass results tend to favour operators with shorter average trip lengths (which tend to be the public operators). The TFPvkm results tend to favour operators experiencing relatively less traffic congestion; the *suburbanisation* of traffic congestion and greater efforts to provide transit lanes and bus bays in locations closer to the centre of cities has eliminated a sizeable amount of the difference between public and private operators. The greater use of interchanges by public operators has also worked against them on vehicle hours, with a relatively high level of dead running time. Private operators tend to have a much lower percentage of dead running time than public operators. The net effect of using vehicle hours compared to vehicle kilometres is not known. It does not necessarily favour public operators. The partial ratios presented in the text support this view.

The broad findings on productivity differences between the major sectors of private and public operators are valid under these caveats. In making statements below about the relative efficiency and effectiveness of operators, the important comparison is on scale-adjusted gross TFP. The scale-adjusted index takes into account both size and diversity of output. As such, it adjusts for scale and scope of service.

E.1 The main findings

1. Overall, the private bus operators in Sydney are the most productive on TFPpass, followed by the Melbourne private operators, the Brisbane private operators, and then the public operators. On TFPvkm, the private operators across states are on average quite similar, and more efficient than the public operators on average. On average the private operators are 40% more productive on both gross indices of TFP than the public operators before adjusting for scale and scope, and after adjusting for scale and scope they are 67% more productive on TFPpass and 120% more productive on TFPvkm.

   While this difference is broadly valid for comparisons between all public operators and private operators in *each* State for TFPvkm, the difference on TFPpass however is largely due to the relative cost effectiveness of the private Sydney operators. The difference in cost effectiveness on average between the public operators and the Melbourne or Brisbane private operators is negligible.

2. There are however notable differences within each of the four groupings which suggest some overlap in relative productivity between the groups.

3. Within the public operators, the State Transit Authority of NSW scores highest on gross TFP where output is measured by passenger trips (and is number 7 in ranking out of the full 32 operators). Brisbane Transport and Transperth are equally the best performing large public operators (excluding the very small operation of Darwin Buses) on gross TFP where output is measured by vehicle kilometres, although PTC (Victoria) is a major player when gross TFP is adjusted for scale and scope. In contrast Transperth does not perform well when patronage is the measure of output, possibly due to the very large catchment area and low urban densities. Brisbane Transport is consistently good on both TFPpass and TFPvkm.

4. Out of 32 operators, the highest ranking for private Sydney operators is 1 on scale-adjusted TFPpass and 1 on TFPvkm (see table E1). The highest ranking of a private Brisbane operator is 12 on scale-adjusted TFPpass and 5 on scale-adjusted TFPvkm. The highest ranking for private Melbourne operators is 12 on scale-adjusted TFPpass and 5 on scale-adjusted TFPvkm. The highest public operator rank is 7 for the STA (NSW) on scale-adjusted TFPpass, but all other public operators are below 20 with the lowest at 31. On scale-adjusted TFPvkm, the highest ranking public operator is 24.

Table E1: **Quartile incidence of group membership: scale-adjusted TFP pass and scale-adjusted TFPvkm**[a]

Quartile (Q)	*Private Sydney*	*Private Brisbane*	*Private Melbourne*	*Public*
1st Q (1 - 8 rank)	7 (5)	0 (2)	0 (1)	1 (0)
2nd Q (9 - 16 rank)	3 (4)	2 (2)	3 (2)	0 (0)
3rd Q (17 - 24 rank	1 (2)	2 (2)	2 (3)	3 (1)
4th Q (25 - 32 rank)	1 (1)	2 (0)	1 (0)	4 (7)
Total	**12 (12)**	**6 (6)**	**6 (6)**	**8 (8)**

a Scale adjusted TFPvkm appears in brackets.

5. The importance of distinguishing between a final demand measure of output (that is, total annual passenger trips) and an intermediate measure of output (that is, total annual vehicle kilometres) has been clearly demonstrated in this study. Both measures have a role, depending on one’s interest in cost efficiency and/or cost effectiveness. *An operator with a relatively high ranking on TFPvkm but a relatively low ranking on TFPpass should ask themselves whether they are really servicing the appropriate markets, and even over-servicing in existing markets.*

6. The importance of the distinction between cost efficiency and cost effectiveness is best illustrated by the public operator results. The STA (NSW) has a strong performance on TFPpass, largely attributable to the high levels of patronage supported by the benefits of servicing corridors of relatively high density traffic movements in Australia’s largest city. This advantage, in part available to all public operators (noting that some public operators such as Transperth however also service low density outer suburbs), does not appear to assist the other major public operators as demonstrated by the relatively low TFPpass rankings of the other 7 public operators. Unlike the STA (NSW), the other public operators do not demonstrate such a parsimonious use of inputs in the ‘production’ of passenger trips. This passenger-based productivity advantage for the STA (NSW) however does not transfer to the intermediate measure of

productivity TFPvkm. The STA(NSW) is not as cost efficient in the way it uses its inputs to produce vehicle kilometres. Transperth and Brisbane Transport have higher gross and scale-adjusted TFPvkms than the STA(NSW), although all public operators are poor performers on gross and scale-adjusted TFPvkm relative to the private operators.

7. In contrast to the public operators, the private operators have a smaller potential market of passengers, but have managed in general to define a network of services and a set of inputs which reflect a relatively more efficient operation. The private operators appear to make better use of their vehicles and labour out of peak periods through charters and tours, and the employment of casual drivers for school runs than do the public operators.

   If private operators were to supply the equivalent service currently offered by the public operators in the public operators' service area, we might expect a significant improvement in TFPpass, given TFPvkm.

8. A selection of partial indicators (see table E2) are included to highlight some interesting global differences between the private and public operators; as well as to emphasise the difficulties in knowing which partial measures are the appropriate set to use in identifying and monitoring performance. There is the risk that the preferred set of partial indicators will be those which place an interested operator in the best light relative to other operators. Relatively good performance on a selective set of partial ratios does not guarantee a high relative value for cost efficiency and/or cost effectiveness.

9. The scale-adjusted TFP indices are themselves very important measures of cost efficiency and cost effectiveness. It is also useful to have an appreciation of some of the key reasons, additional to size, for differences in productivity between operators. To identify sources of difference in the gross index of TFP, we regressed GTFP against a number of factors, broadly grouped into (i) institutional and regulatory influences, (ii) location and demographic effects, (iii) ownership, and (iv) other contextual influences. The scale-adjusted TFP index was examined to identify reasons for further differences in TFP within the sample which were statistically significant. The residual or unexplained sources of difference produces a residual index of TFP. All three indices (GTFP, scale-adjusted TFP and residual TFP) contain useful information (see table E3).

10. The analysis identified seven primary influences explaining nearly 80 percent of the variation in scale-adjusted TFPpass: (i) a dummy variable representing the private operators in Sydney (SYD) — a positive effect; (ii) the incidence of coach kilometres in the total fleet kilometres (COAKMP) — a negative effect; and (iii) the incidence of patronage from the

catchment area population as a measure of the success in attracting the population to use the bus services (PASSPOP) — a positive effect. Other contributing effects are (iv) the mix of casual and full-time labour (CASP); (v) fleet diversification (amongst private operators) defined by the number of mini vehicles (MINI); (vi) private operator specific dummy variables for the Melbourne operators (MEL) and (vii) the Brisbane operators (BRS), all positive effects.

Table E2: **Private and public bus operations 1991/92 (based on 24 private operators and 8 public operators)**

Partial Performance Indicator	*Private Operators*	*Public Operators*
Total cost per vehicle kilometre	$2.18	$3.31
Labour cost per vehicle kilometre	$1.06	$2.01
Revenue per vehicle kilometre (excl deficit/CSO)	$2.30	$1.48
Revenue per passenger	$1.85	$0.98
Non-labour maintenance cost per kilometre	$0.18	$0.17
Average annual kilometres per vehicle	45,850	48,790
Labour cost per paid hour	$16.98	$17.52
Total cost per passenger	$1.79	$2.40
(Accounting) Capital cost per vehicle kilometre	$0.43	$0.46
Total cost per vehicle hour	$60.74	$76.70
Passengers per vehicle kilometre (service effectiveness)	1.417	1.461
Gross total factor productivity (passengers) best = 100	**50.76**	**36.62**
Gross total factor productivity (vkm) best = 100	**76.61**	**54.00**

11. Six statistically significant sources of variation in scale-adjusted TFPvkm explain nearly 80 percent of the variation in TFP: (i) fleet utilisation defined by annual kilometres per vehicle (KMVEH) — a positive effect; (ii) the proportion of costs which are non-labour overheads (OTH$WK) — a negative effect; (iii) the incidence of coach kilometres in the total fleet kilometres (COAKMP) — a negative effect; (iv) the mix of casual and full-time labour (CASP) — a positive effect; (v) fleet diversification (in private operators) defined by the number of mini vehicles (MINI) — a positive effect; and (vi) the proportion of passengers carried by private operators that are school children (SCHTOTP) — a positive effect.

Table E3: **Summary of GTFP, scale-adjusted GTFP and residual TFP indices, 1991/92**

Operator	*Gross TFPpass*	*Rank*	*Scale-adjusted TFPpass*	*Rank*	*Residual TFPpass*	*Rank*	*Gross TFPvkm*	*Rank*	*Scale-adjusted TFPvkm*	*Rank*	*Residual TFPvkm*	*Rank*
NSW:												
Sl	1.647	6	1.516	5	0.267	12	1.691	6	1.437	6	0.539	7
S2	1.488	9	1.342	9	0.042	21	1.427	15	1.147	15	0.210	21
S3	0.626	31	0.540	28	-0.053	26	0.952	30	0.760	25	0.211	20
S4	1.039	15	0.954	15	0.431	6	1.085	23	0.933	23	0.226	19
S5	1.805	4	1.698	4	0.187	15	1.884	1	1.683	1	0.848	1
S6	1.960	3	1.805	3	0.150	18	1.646	8	1.360	9	0.550	6
S7	2.429	1	2.275	1	0.768	2	1.674	7	1.409	7	0.198	22
S8	2.307	2	2.167	2	0.777	1	1.511	10	1.284	12	0.248	17
S9	1.584	7	1.478	6	0.085	29	1.697	4	1.495	4	0.610	5
S10	0.930	18	0.805	19	0.276	31	1.468	13	1.185	14	0.084	25
S11	1.023	16	0.954	16	0.172	30	1.735	2	1.571	2	0.803	2
S12	1.552	8	1.426	8	0.395	7	1.228	19	1.011	18	0.349	13
Av. Syd	**1.615**	**-**	**1.413**	**-**	**0.226**	**-**	**1.596**	**-**	**1.273**	**-**	**0.444**	**-**
Qld:												
B1	1.144	13	1.144	12	0.304	10	1.486	12	1.379	8	0.772	4
B2	0.673	27	0.604	26	0.094	20	1.490	11	1.299	10	0.745	3
B3	0.810	23	0.698	20	0.318	9	1.732	3	1.450	5	0.233	18
B4	0.626	30	0.545	27	0.166	17	1.208	20	1.000	19	0.186	23
B5	0.726	26	0.628	24	0.433	5	1.271	17	1.038	17	0.469	10
B6	1.186	12	1.056	13	0.244	13	1.570	9	1.294	11	0.307	16
Av. Bris	**0.861**	**-**	**0.779**	**-**	**0.260**	**-**	**1.460**	**-**	**1.243**	**-**	**0.452**	**-**

Table E3 cont/d:

Operator	*Gross TFPpass*	*Rank*	*Scale-adjusted TFPpass*	*Rank*	*Residual TFPpass*	*Rank*	*Gross TFPvkm*	*Rank*	*Scale-adjusted TFPvkm*	*Rank*	*Residual TFPvkm*	*Rank*
Vic:												
M1	1.378	10	1.301	10	0.595	3	1.252	18	1.132	16	0.468	11
M2	0.906	19	0.824	18	0.146	19	1.443	14	1.254	13	0.418	12
M3	1.255	11	1.184	11	-0.071	25	1.074	24	0.973	20	0.328	14
M4	1.014	17	0.852	17	0.186	16	1.318	16	0.973	21	0.141	24
M5	0.370	32	0.325	32	0.212	14	1.105	22	0.937	22	0.508	9
M6	1.111	14	1.038	14	0.491	4	1.695	5	1.530	3	0.517	8
Av. Melb	**1.006**	**-**	**0.921**	**-**	**0.270**	**-**	**1.315**	**-**	**1.133**	**-**	**0.397**	**-**
Av. Private	**1.233**	**-**	**1.132**	**-**	**0.234**	**-**	**1.443**	**-**	**1.231**	**-**	**0.415**	**-**
PUBLIC:												
STA	1.735 [1]	5	1.435 [1]	7	0.033 [3]	22	1.034 [4]	27	0.458 [7]	31	-0.30 [4]	28
ACTION	0.735 [6]	25	0.527 [6]	29	-0.500 [8]	32	0.955 [6]	29	0.506 [6]	30	-0.19 [2]	26
PTC	0.844 [4]	22	0.635 [3]	22	0.361 [1]	8	1.020 [5]	28	0.578 [2]	26	-0.33 [7]	29
BCC	0.899 [2]	20	0.666 [2]	21	0.033 [4]	23	1.064 [2]	25	0.566 [3]	27	-0.37 [5]	30
STSSA	0.866 [3]	21	0.617 [5]	25	0.004 [5]	24	0.944 [7]	31	0.422 [8]	32	-0.56 [8]	32
TRANSP	0.638 [8]	29	0.399 [8]	31	-0.057 [6]	27	1.056 [3]	26	0.513 [5]	29	-0.41 [6]	31
METRO	0.654 [7]	28	0.477 [7]	30	-0.084 [7]	28	0.930 [8]	32	0.542 [4]	28	-0.19 [2]	26
DBS	0.744 [5]	24	0.635 [4]	23	0.290 [4]	11	1.136 [1]	**21**	**0.889 [1]**	**24**	**0.31[1]**	**15**
Av. Public	**0.889**	**-**	**0.674**	**-**	**0.010**	**-**	**1.017**	**-**	**0.559**	**-**	**-0.254**	**-**
Av. All	**1.147**	**-**	**1.018**	**-**	**0.178**	**-**	**1.337**	**-**	**1.063**	**-**	**0.248**	**-**

Note In making statements about the relative efficiency and effectiveness of operators, the important comparison is **scale-adjusted TFP**.
[ ] = rankings within public operators.

12. The distinction between GTFP or scale-adjusted TFP and residual TFP is very important. Where an operator has a relatively high GTFP or scale-adjusted TFP but a relatively low residual TFP, we have captured a substantial amount of the explanation for the relative scale-adjusted or GTFP level. A low residual TFP relative to the original GTFP must not be interpreted to mean poor productivity. It simply says that *relative to the GTFP index,* that there are few remaining unexplained influences on TFP. All absolute values of residual TFP are substantially smaller than the GTFP (see table E3). What is however of greater interest is the adjusted ranking. If the ranking drops substantially it indicates that the observed influences operate in favour of other operators relative to the operator being evaluated. A preserved high ranking indicates that there are a number of unobserved influences on relative productivity which favour an operator relative to other operators.

13. When adjusting the gross TFPpass for scale and scope, the public operators become relatively less cost effective, with the private Brisbane operators improving their ranking. However the impact on the ranking of the Sydney and Melbourne operators is negligible. The same finding applies to TFPvkm except for the Metro in Tasmania which improves its ranking quite significantly. When evaluating the residual TFP rankings, some operators' comparative advantage has been explained predominantly by the set of variables in paragraphs 10 and 11 above. For TFPpass, this applies particularly to S2, S4, S9, S10, S11, B3, B4, B5, M3, STA(NSW), PTC, and the Darwin Bus Service. For TFPvkm, it applies especially to S3, S7, S10, B1, B2, B3, B5, M5, and the Darwin Bus Service.

14. The impact of institutional and regulatory influences are best represented by ownership (by location) dummy variables, and access to casual labour (the latter denied to public operators). After allowing for scale and contextual sources of variation in GTFP, the ownership (by location) specific variables represent differences due to contractual obligation and ex ante subsidy arrangements. The Sydney private operators are given no explicit operating or capital subsidy per se, in contrast to the Brisbane operators who receive subsidy support equivalent to 30-40% of the gross fare plus an interest subsidy on vehicle purchases. The Melbourne private operators are on cost-only contracts for school and local scheduled services with no revenue return except on charters and tours.

15. Public and private operators have agreed to participate in an ongoing annual survey. In future surveys we will seek more information in areas where there is a need for further elaboration and context. Amongst these are the extent of contracting out, the existence of loss-making service

provision 'chosen' by the operator (compared to that imposed by the government/regulator), special activities which need explicit recognition (eg. Nightride contracts in Sydney, BCC contracts in Brisbane, active involvement in inquiries, associations and Ministerial requests), greater disaggregation of revenue to identify fully all sources of subsidy and more detail on fleet composition. Vehicle hours of service and passenger trip lengths will be given more attention to enable us to use passenger kilometres and vehicle seat hours as measures of output.

APPENDIX F

Urban bus operations: productive efficiency and regulatory reform - international experience

APPENDIX F URBAN BUS OPERATIONS: PRODUCTIVE EFFICIENCY AND REGULATORY REFORM — INTERNATIONAL EXPERIENCE

The appendix reproduces the executive summary of a paper by Travers Morgan (NZ) Ltd contracted by the Industry Commission as part of this inquiry. The paper is entitled 'Urban Bus Operations: Productive Efficiency and Regulatory Reform — International Experience'. Copies of the paper are available from the Commission.

F.1 Introduction

The Report reviews the experience with regulatory reform of the urban bus sectors in Great Britain (1986) and in New Zealand (1991) and its potential relevance to the Australian urban bus sector. In particular it reviews the effects of the reforms on technical efficiency: the review covers unit costs, labour productivity levels and operational/working practices for a range of operators in the two countries.

The report covers technical efficiency aspects only. It does not attempt to recommend a preferred model for regulatory reform in Australia, but does comment on some of the likely implications for reform in Australia of Great Britain and New Zealand reform experience.

F.2 The pre-reform situation

Industry structures

Prior to regulatory reform, the urban bus industry structures in Great Britain and New Zealand had considerable similarities.

In Great Britain (ie. England, Scotland and Wales), operators could be considered in three broad groupings:

- Publicly owned Passenger Transport Companies (PTCs);

  — in London, in 7 metropolitan counties and in about 40 district councils. This group operated the majority of urban services and were generally the highest cost group of operators.

- The National Bus Company (NBC) in many parts of England and Wales, and the Scottish Bus Group (SBG) in Scotland; and
- Independent operators, in the private sector. These were mostly very small companies with only a minor share of local bus operations (mainly in rural areas).

In New Zealand also, there were three main groups of operators:

- 'Municipal' operators — comprising 10 operators who accounted for about two-thirds of total urban route services;
- NZ Rail — provided bus services in 7 regions, accounting for about 10 per cent of total urban route services. These were in the process of being divested to the private sector; and
- Private operators — comprising a large number of generally small operators, together accounting for about one-quarter of total urban route services. (The New Zealand private sector was substantially stronger than that in Great Britain, but not as strong as in New South Wales and Victoria.)

Industry trends and background factors

Prior to regulatory reform in both countries, the urban bus sector had been characterised for some years by falling patronage, increasing subsidy levels and very little innovation in terms of better serving the customers.

In Great Britain the previous nationwide labour arrangements in the bus industry started being replaced by local agreements in the mid-1980s. Assisted by this, operators started to introduce mini-buses (from 1984), generally being driven by drivers on lower than standard wages.

Somewhat similarly, in New Zealand national awards started being replaced by local agreements in the late 1980s. This process was hastened by the 1990 Employment Contracts Act: this introduced considerably greater flexibility in labour negotiations, at the individual enterprise level or even at the individual employee level.

Given these various factors, it might be seen both that the urban bus industry in the two countries was ripe for reform, and that reforms would stand a good chance of being successful.

Reasons for regulatory reform

The reasons for regulatory reform in the urban bus industry were broadly similar in the two countries, although the importance of different factors could be argued. In summary these reasons were:

- To introduce or increase competition, as a means of increasing technical efficiency of service provision and hence of cutting public subsidy levels;
- To increase innovation and improve market responsiveness in the urban bus sector, which was expected to lead to an increase in patronage and reduced subsidy requirements; and
- To separate public transport policy issues from transport operations, and get the public sector out of operating buses: this would be achieved by privatisation and corporatisation of the public operators.

F.3 The regulatory reforms

Great Britain (excluding London)

The 1985 Transport Act introduced ‘deregulation’ of local bus services in Great Britain (excluding London) from October 1986. Salient features of the legislation were:

- The previous quantity-based route licensing system was abolished;
- Operators were able to register any service they wished to provide on a commercial basis;
- Any additional services required were specified by local authorities and were to be subject to a competitive tendering procedure;
- There was to be no price control on commercial services;
- Operators of all services would be compensated for concessionary fares for specified groups, principally pensioners;
- The National Bus Company was to be split up and privatised (1986-88), followed by similar treatment for the Scottish Bus Group (1991); and
- More recently, privatisation of a number of passenger transport companies (PTCs) is proceeding.

London

The ‘deregulation’ legislation in the rest of the country was not applied to London. In London a system of progressively tendering out services on a route-by-route basis was introduced in 1985. Features of the London reforms include the following:

- Services were to be tendered on a route-by-route basis, using gross cost contracts and hence enabling the integrated fares system to be retained;
- About 5 per cent of services have been tendered per year with now about 40per cent of all services being tendered;
- London Buses Ltd (LBL) was split into 12 separate operating companies, which were able to compete with each other for tenders;
- The individual LBL operating companies are now being progressively privatised; and
- The UK Government has announced its intention to deregulate services in London, but action on this has been continually delayed and the precise form it will take is still not clear. The earliest expected date for deregulation is 1995. The House of Commons Transport Committee has recently issued a report suggesting any deregulation should be postponed and further examination of the merits of different types of regulatory reform should be undertaken.

New Zealand

Regulatory reform of the New Zealand bus system was introduced in July 1991. The new regulatory system is based very broadly on the British 1985 Transport Act and is sometimes referred to as deregulation. However it is substantially different from the form of deregulation introduced in Great Britain and we refer to it here as Transport Law Reform (TLR). Important features of the new system include:

- It covers all local transport modes, not just buses;
- It involves a clear separation of policy responsibility from public transport operations, including corporatisation or privatisation of all ex-municipal operators;
- As in Great Britain, the route licensing system was abolished and replaced by a system of registration of commercial services and a ‘topping-up’ of the services through a competitive tendering process (the competitive tendering process was subject to a set of guidelines known as Competitive Pricing Procedures in New Zealand);

- Regional councils were given more power than in Great Britain to achieve their desired services and fares, if necessary through contracting over registered commercial services; and
- Depending on regional council policy, the result in some areas could thus be a high fare/low service level situation with most or all services being provided commercially; whereas in other areas it could be a low fare/high service level situation with all services tendered.

Some comments

In Great Britain pre-deregulation the average cost recovery on local bus services was 80-85 per cent. In this situation, the great majority (about 85 per cent) of previous services were offered commercially, aided by universal concessionary fares reimbursement. The competitive tendering procedures were then used to provide the remaining 15 per cent of services through a ‘gap-filling’ process.

In New Zealand the average cost recovery prior to regulatory reform was around 50-55 per cent. Given this, and given that regional councils tended to discourage substantial fare increases, it is not surprising that only around 20 per cent of previous services are now being offered commercially. The great majority (around 80 per cent) of previous services are now being provided through the tendering process.

These differences have resulted in a very different balance between commercial services (which are essentially planned by the operators) and the tendered services (planned by the local authorities) in the two countries. In Great Britain, the local authorities play an essentially gap-filling role in terms of tendered services and tend to follow the prevailing commercial fares: most of the service and fare planning is done by commercial operators. In New Zealand, the regional councils continue to play the major role in service planning, and tend to be dominant in determining fare levels and structures.

In Australia, with even lower cost recovery in the main centres than was the case in New Zealand, adoption of a deregulated approach would be likely to result in a very small proportion of truly commercial services unless fares were allowed to rise dramatically.

F.4 Impacts on technical efficiency

Overview

For Great Britain, the main report presents analyses of changes in technical efficiency and its components before and after deregulation, principally comparing 1991/92 with 1985/86. For New Zealand, the main comparisons are between 1992/93 or 1991/92 and 1989/90. Obviously ascribing cause and effect to the various changes is often difficult, given other changes that were affecting the bus industry and the national economy in each country over the period. However the broad trends are clear.

Very broadly, in terms of technical efficiency, what has happened in both countries is that there was previously a wide range of efficiency levels in the industry; and this range has been considerably narrowed, by the previously less efficient (public sector) operators adopting practices and cost levels closer to those of the more efficient (private sector) operators.

This section gives a brief summary of what has happened first to overall unit costs, and then to the main components of these costs.

Unit costs

In Great Britain excluding London, there was an overall reduction in real operating cost per bus kilometre of 36 per cent (from 1985/86 – 1991/92).

However, this is an over-estimate of the real efficiency gain associated with deregulation, principally because of effects of increased use of mini-buses and the fall in fuel prices over the period. After adjusting for these effects, the average unit cost reduction was about 25 per cent.

While complete data is not available, the reductions have been greater than this (around 30 per cent) among those operator types which were previously the least efficient.

Most of the unit cost reduction occurred in the period leading up to deregulation and in the first one or two years thereafter, although there have been some further reductions since then.

In New Zealand, for the three municipal operators for which data is available, average unit costs fell about 30 per cent in money terms and over 35 per cent in real terms (1989/90 - 1992/93). Most of this fall was in the year leading up to and the year immediately following Transport Law Reform.

For New Zealand private operators, there has been little change in unit costs and only limited changes in work practices or award conditions over this period.

Components of unit cost changes

Labour costs typically account for 70-75 per cent of total working expenses; and it is virtually impossible to achieve significant unit cost reductions in some of the non-labour items (for example, fuel). Hence it is inevitable that most of the cost reductions achieved have been in the labour cost areas.

Cost savings in the labour areas have been made through a combination of:

- reductions in base wage rates;
- reductions in labour on-costs; and
- improvements in output per person hour employed (ie. efficiency gains).

A summary of the impacts of regulatory reform in each of these areas is now given.

Base wage rates

Previously in both countries, national awards applied in most cases and there was an inevitable tendency for rates paid in the bus industry to be based on rates in other industries in the higher cost areas. With the move away from national awards and the regulatory reforms in the bus industry, significant pay rate differences between areas and operators emerged, generally resulting in real wage reductions.

In Great Britain in particular, much more flexibility in driver pay rates and pay structures has emerged: for instance, within an individual company there might be rate differences between older and younger drivers, mini-bus and standard bus drivers, and between newly-recruited and longer-serving drivers. Further comment is given below on some of the ways in which the awards have been restructured. On average in Great Britain, bus driver earnings fell 9 per cent (in real terms) between 1986 and 1992, while average pay rates for male manual workers as a whole increased by 8 per cent over this period. In New Zealand also, pay rates with most operators have fallen in real terms over the 1989-1992 period, by in the order of 10 per cent.

Labour on-cost reductions

This heading refers to direct wage and salary on-costs such as superannuation, workers' compensation, leave allowances, training expenses etc. These costs have tended to increase as the proportion of wages over the last 10 years, in both Great Britain and New Zealand (and also in Australia), particularly for public sector operators. In award renegotiations in Great Britain and New Zealand, there have been moves to reduce on-costs back towards levels pertaining in the private sector.

Mention should also be made here of absenteeism, whether for sickness, annual leave or other reasons. This had again been tending to increase over time: new award negotiations resulted in less generous provisions for absenteeism in the public sector with greater incentives to actually attend work.

Overall changes in labour productivity

Improvements in labour productivity account for the largest component of the cost reductions reported in both countries. In Great Britain, the overall growth in productivity (per staff member) was around 35-40 per cent over the period 1985/86 - 1991/92, indicating that around 30 per cent fewer staff were needed to provide a given service. In New Zealand, the staff productivity were even greater than this for two of the three municipal operators assessed.

In both countries, greatest productivity improvements have been among engineering/maintenance staff, followed by administration/other staff, with lesser improvements in driver productivity.

In the engineering/maintenance area, the following measures have contributed towards improvements in labour productivity:

- closure of central workshops, with activities either being transferred to local depots or being contracted out;
- improvements in management/supervisory practices and in maintenance procedures; and
- reductions in unnecessary overtime and in absenteeism.

In the administration/general overheads area, the following measures have contributed in improvements in labour productivity:

- reductions in head office staff, with devolution of management responsibility to the depot level;
- reductions in activities of a marginal nature (for example, inspectors); and
- improved service and timetable planning.

Driver awards have been extensively restructured to achieve labour productivity gains. Changes made include:

- shorter sign-on and sign-off times;

- shorter (sometimes unpaid) meal breaks, with greater flexibility on the timing and location;
- less restrictive limits on shift lengths;
- introduction/extension of part-time staff;
- cut-backs in absenteeism (usually through changes in award provisions) and reductions in stand-by shifts; and
- more flexible bus garaging arrangements, to reduce positioning time.

Comparisons between London and other parts of Great Britain

A leading questions is whether the competitive tendering system introduced in London has been more successful or less successful in producing technical efficiency improvements than the deregulated system introduced in the rest of Great Britain. This is a hypothetical question and practically unanswerable. There were and are major differences in the industry structure and the operating environment between London and other areas. However some comments might usefully be made.

To an extent, the rest of Britain led the way in rationalisation of work practices, introduction of cost reduction measures, introduction of more flexible labour agreements and wider deployment of mini-buses, and some of these innovations did indicate changes that might be followed and in many cases were adopted later in London. Had the deregulated system adopted elsewhere been also introduced in London, then changes of these types might have occurred more rapidly in the capital and wage reductions might have occurred earlier. However, there is little evidence to suggest that the cost and labour productivity now being achieved in London would have been significantly lower under a deregulated regime.

F.5 Some comparisons and implications for the Australian situation

Labour efficiency comparisons

While there are difficulties in making useful comparisons in unit costs between countries, labour productivity levels may be more usefully compared.

The main report compares labour productivity levels (staff per bus kilometre and staff per bus hour) for a range of operator types in Great Britain and New Zealand (before and after regulatory reform), and in Australia.

A number of important conclusions emerge:

- The best performing operators in all three countries have similar productivity performance: there is no evidence of significant differences between the overall labour productivity of efficient operators in the three countries;
- In Great Britain and New Zealand, regulatory reform has basically brought the less efficient operators towards the productivity performance of the more efficient operators. This change has been particularly pronounced in New Zealand; and
- The present Australian urban bus industry is characterised by substantial differences in labour productivity between public and private sector operators; typically private sector operators provide a given transport task with around 40 per cent fewer staff. This gives a measure of the size of the gap that needs to be bridged for the Australian public sector operators to achieve the efficiency levels of good private sector operators. Based on the British and New Zealand experience, appropriate regulatory reform should enable this gap to be bridged.

Types of regulatory reform

There is little evidence to show that any of the three models of regulatory reform examined (London, rest of Great Britain, New Zealand) is intrinsically better than any other in terms of encouraging improved technical efficiency. (Of course, it would not be appropriate to assess any regulatory model on this criterion alone.)

The major reason for the current poor performance in the Australian public sector, and in the British and New Zealand public sector prior to regulatory reform, is the relative weakness of commercial incentives to efficient operation. (Such incentives are present in the Australian private sector, through the profit motive of owners.)

Any successful regulatory reform model will need to introduce appropriate commercial incentives. To an extent these might be introduced by privatisation alone. However, this is not essential — but in its absence some form of contestability is a principal requirement. If an adequate degree of contestability is present, then the New Zealand experience (in particular) would suggest that ownership is not necessarily of great importance in influencing technical efficiency.

APPENDIX G

Urban transport systems in other countries

APPENDIX G URBAN TRANSPORT SYSTEMS IN OTHER COUNTRIES

The terms of reference for the inquiry require the Commission to report on the gains to be achieved from adopting international best practice in the provision of urban transport infrastructure and services.

During the initial round of hearings, many participants opined that Australia could benefit from adopting the policies and practices applied to urban transport in a number of cities overseas. The cities most frequently nominated by participants were located in Canada, Germany and Switzerland. The Commission's own preliminary work in this area confirmed that cities in these countries were among the more promising places for further investigation.

Accordingly, the Commission contacted and interviewed a range of organisations with an interest in urban transport in selected cities in other countries. These organisations included government ministries and operating agencies, private operators and their industry organisations, as well as consumer, community and environmental groups.

The cities selected for further examination were: Leeds and Newcastle upon Tyne in the United Kingdom, Munich in Germany, Toronto and Vancouver in Canada, Washington DC in the United States, Zurich in Switzerland, and Singapore. They were selected because they are broadly comparable to the larger Australian cities in terms of the population of the conurbation and most of the countries concerned share a federal system of government with Australia (with the exceptions of the United Kingdom and Singapore).

G.1 Leeds

Leeds is the largest city and regional centre of West Yorkshire. It houses about a quarter of the 2.1 million people in the conurbation, which covers an area of 780 square miles and consists of six major cities, several smaller towns and an extensive rural hinterland.

Background to transport policy in the UK

In the conurbations of England outside London (eg, Birmingham, Leeds, Liverpool, Manchester, Newcastle upon Tyne), Passenger Transport Executives (PTEs) are responsible for planning and financing urban public transport services. The PTEs contract commercially unprofitable but socially necessary route bus services from operators. They also contract local rail passenger services from British Rail (BR); in some cases using the PTE's own rolling stock and infrastructure.

On commercial bus services the operator determines the fare and timetables. On contract bus and local rail services, the fares and timetables are set by the PTE in accordance with policies decided by the Passenger Transport Authority (PTA) for the conurbation. The PTA is a board of elected councillors appointed by the district councils for the conurbation and is responsible for public transport in the conurbation (Tyson 1992). Originally the PTEs were set up as the operating arms of the PTAs and operated extensive bus networks.

BR is the government-owned railway operator. It provides commuter and inter-urban passenger and freight services in Great Britain, and is managed by a board whose members are appointed by the UK Government. BR is organised around a series of business units. In July 1992, the UK Government published a White Paper (UK Department of Transport 1992), which set out its approach to the privatisation of BR. Among other things, its approach involves:

- establishing an authority to franchise passenger services;
- restructuring BR to separate infrastructure from services;
- establishing rights of access for new operators to the rail network; and
- setting up an independent regulator of access to the rail network.

The route franchises in the initial tender round are mostly non-urban ones. Over time, the Government intends to tender all BR's operations, including its urban passenger services. In the interim, rail services will continue to be operated by BR. On most routes private franchisees will be expected to provide specified services for a fixed contractual period. Access may also be provided by an 'open access' arrangement. The franchising authority will tender franchises for individual lines in terms of either a payment to or from the UK Government.

A new organisation, Railtrack, will be responsible for managing the signalling and the track. Franchisees will be required to pay Railtrack for use of its infrastructure. The UK Government will pay Railtrack the difference between the amount Railtrack requires and that which the franchisee is willing to pay. The Government may also provide Railtrack funds for selected investments.

Rail fares will continue to be regulated by the UK Government where the service is considered to be a natural monopoly. All other fares will be left to the franchisees.

Prior to 1986, urban route bus operations in the UK were subject to safety regulations, and operators were required to hold road service licences issued by the UK Traffic Commissioners. These licences had the effect of creating a monopoly right for the particular route. The *Transport Act 1985* combined the removal of road service licensing of local bus services with changes to the government-owned National Bus Company (NBC). The *Act* had specific provisions relating to:

- *Deregulation of entry.* Any supplier able to meet specified standards of competence as an operator was free to offer bus services on whatever routes, at whatever fares, it chose (except in London);
- *Commercialisation.* While local authorities were able to supplement commercial services, they were required to obtain any supplementary services by way of competitive tender; and
- *Privatisation.* The NBC was split into about sixty units and sold to the private sector to provide a large number of competent, independent units which could compete in the market.

To ensure the privatised units of the NBC remained small, initial rules for the sale of the fragmented company did not permit purchase by any other operator in the area of the company being sold. However a number of subsidiaries have now been sold a second time and larger operators are emerging.

Municipally-owned bus operations were reconstituted as commercial entities under the UK companies legislation. Those operations were thereby required to act in a normal commercial manner, prevented from receiving global subsidies from their local authority owners and subjected to the normal commercial risks and penalties of bankruptcy. They have since been gradually privatised, mostly by way of management buy-outs.

The role of government in transport in West Yorkshire

Before the re-organisation of local government, most bus services in West Yorkshire were provided by four municipal undertakings (Leeds, Bradford, Halifax and Huddersfield), four large subsidiaries of the NBC, and a few independent bus operators. British Rail (BR) operated an extensive local rail service and private taxi companies operated throughout the region.

With the establishment of the West Yorkshire PTA and, in 1974, the West Yorkshire Metropolitan County, the West Yorkshire PTE took over the four municipal operations. In the 1980s the NBC companies were commercialised, then privatised in 1986. The largest bus company in the region is now the Yorkshire Rider Group which operates the former municipal services, most of the former West Yorkshire Road Car Company, and some other smaller operators.

As 90 per cent of travel in West Yorkshire is by bus, privatisation of the NBC changed the role of the West Yorkshire PTE from service operator to planner and financier. The West Yorkshire PTE is now responsible for:

- subsidising the supported bus services;
- financing local rail services;
- financing concessionary travel for the young and old;
- funding bus stops, rail stations, bus stations;
- funding comprehensive maps, timetables etc;
- managing the metro card and saver strip integrated tickets;
- providing Accessbus for the disabled; and
- providing special bus services for women.

With the abolition of the metropolitan counties in the UK in early 1986, the municipal authorities became responsible for planning urban transport in their local government areas. Afer considering high technology systems (for example, the VAL system), Leeds opted for a strategy incorporating improved rail and bus services (including guided bus routes), plans for light rail and greater pedestrianisation. A similar strategy was developed for Bradford, though a proposed new trolleybus service was set aside and funds applied to local rail electrification. After 1986 the West Yorkshire PTA directed its attention to rail, building new stations, funding rolling stock and planning a light rail network (Supertram).

The Leeds transport system

Leeds is dominated by the bus services of the Yorkshire Rider Group complemented by other large operators (for example, Yorkshire Buses linking the city with the south and west of the conurbation), local BR rail services, small private bus operators, and taxis.

Yorkshire Rider is a classic example of the US model of an employee share ownership plan (ESOP). An agreed proportion of the company's equity (in Rider's case 49 per cent) is held in a discretionary trust (the Employee Benefit

Trust). Employees with two or more years service qualify for shares. Some 51 per cent of the shares are held by the company's management, giving them control. When it was formed, the Yorkshire Rider ESOP was the biggest in UK, since then other bus operators have adopted the model, including West Midlands, Grampian and Busways.

Performance of the Leeds transport system

Car ownership in West Yorkshire is comparatively low, with almost half the population still dependent on public transport.

Before 1986, the West Yorkshire PTE made savings in its operating costs of about one per cent per annum. With commercialisation this rose to 2.5 per cent per annum and after privatisation, operating costs were cut by five per cent per annum. All this has been achieved with no shrinkage in operations, and no compulsory redundancy. (Staff turnover is still about seven per cent but absenteeism is down.) Yorkshire Rider announced its first dividend in 1992.

Asset replacement suffered in the early years of privatisation. This was due to the cost of servicing the capital cost of the management buyout of £23 million. Interest payments of about £3 million per annum for ten years have had first call on profits. However, new buses are now being ordered, including single deck Scanias capable of being fitted for guided busway operation.

The company's focus has to be the commercial network as the subsidised business is variable and unreliable. Most 7.00 am to 7.00 pm, Monday to Saturday urban services are commercial, with evening and weekend services being tendered as supplementary services. No concession fares are available for adults, however, the company provides an off-peak fare.

The market in which the company operates is variable and relations with other bodies, particularly the local councils, are important. For example, the level of pensioner and children's fares can be changed: the fare for pensioners, who travelled free at one time, is now 10p (25 cents) interpeak, 50 per cent in the peak, and free at other times. Although the company is reimbursed for non-commercial fare concessions, such changes have operational implications. There is little danger of too high a level of service for the supported services, as the council's requirements are held in check by financial constraints.

Financing the Leeds transport system

Although the commercialisation and privatisation policies had different objectives, one of their effects was to make passenger transport take its share in public sector expenditure cuts. As a result of initiatives taken by the UK

Government in 1993, municipal operations are now coming onto the market and railways are being selectively privatised; these changes will save even more in the transport sector. Planning for rail privatisation reinforces the view that rail costs are very high compared to buses. Private bus companies are likely to bid for some of the local rail franchises.

Savings in subsidies of some £250 million were made between 1986 and 1991 in the UK. These were not at the expense of passengers: fares in most cities have held steady in real terms, and there are more buses running more kilometres, chasing a gradually declining number of passengers. Cross-subsidies have ended, except where a service is operated as a commercial loss leader.

More routes have been declared commercial than originally foreseen, with over 70 per cent in Leeds, and about 80 per cent nationally. As a result spending on the services requiring support is lower than expected, with the proportion of expenditures devoted to transport in all areas dropping markedly.

Transport and urban development in Leeds

The major planning achievement in Leeds and West Yorkshire has been the emergence of a close working arrangement between bus operators, the PTE and the local councils since bus deregulation in 1986, albeit after a somewhat shaky start. Integration is better (not worse, as is often asserted) as all parties are equal. In general, mistrust between the councils and the bus companies has been replaced by a new spirit of cooperation. The weakness is that the planning is not formalised, and progress depends on goodwill between the parties.

G.2 Munich

Munich is the capital of the State of Bavaria and the third largest city in Germany. It is a major centre for business and manufacturing. The population of the City of Munich is 1.3 million and in the Munich region of some 5 200 km^2 there are a total of 2.3 million people. Munich is the most densely populated city in Germany.

Background to transport policy in Germany

There are four levels of government in Germany: Federal, State, regional and local. Bavaria has two regional governments: Upper and Lower Bavaria. The City of Munich is located in Upper Bavaria. In general, the states in Germany are responsible for public transport at the local and interurban level and for nonfederal railways. The Federal Government's constitutional responsibilities are restricted to the federal railways.

On 1 January 1994, the former Deutsche Bundesbahn [German Federal Railways] was incorporated under German companies legislation as Deutsche Bahn AG. It is to be divided into separate business units for track, passengers and freight. In about three years' time, each of these business units is expected to be incorporated as an independent company.

On 1 January 1995, Deutsche Bahn's passenger operations will be divided into commercially autonomous business units for long distance and regional passengers. (These changes are, in part, to meet the requirements of Directive 18/93 of the European Union [the successor to the European Community]. This Directive requires all railway operators in the Union to have the right of access to any railway track within it.) At this point financial responsibility for the Deutsche Bahn's commuter rail passenger services (S-Bahn) will be transferred to the German States and Deutsche Bahn's regional corporations; they will set the fares but will have to fully fund the operating deficits, which are collectively running at DM7.7 billion per year. However, there will be scope for the regions to tender out these services to other operators in the European Union.

The German Deregulation Commission has strongly advocated a step-by-step deregulation of public transport in Germany, particularly for bus services (Rothengatter 1992).

The role of government in transport in Munich

Municipal authorities (such as the City of Munich) are responsible for the management of traffic in their urban areas.

The licensing of public transport operators and the terms and conditions of their licences are the responsibility of the regional governments. In Upper Bavaria, licences confer exclusive rights. While they are limited to eight years, there is a presumption that incumbents will have their licences renewed on expiry. However, this is likely to change with implementation of the requirements of the Single European Act of the European Union.

The Munich transport system

In most of the larger German conurbations (for example, Frankfurt, Hannover, Hamburg, and Munich) there is a verkehrsverbund (association of public transport operators) to coordinate public transport fares and services. While this concept originated in Germany, it is not unique to that country. Similar associations are found in cities in other European countries (for example, Stockholm, Vienna and Zurich).

The Munich association is the Münchner Verkehrs- und Tarifverbund GmbH (MVV). The MVV is a limited liability company established by the two major public transport operators in the Munich region to perform the following functions:

- planning public transport and its services;
- setting public transport timetables and fares;
- marketing its integrated fare system; and
- distributing fare revenues to the shareholders.

The MVV does not operate any services as that is done by each of the shareholders in their own right.

The City of Munich and the Deutsche Bahn are the joint shareholders in the Munich Verkehrsverbund. Each holds half of the voting rights in the MVV and a power of veto over decisions of its supervisory board. The supervisory board of the MVV is chaired by the Lord Mayor of the City of Munich and its other members are appointees of the Deutsche Bahn, the Federal Ministry of Transport, the Bavarian Ministries of Finance and of Transport, and the regional local governments outside the City of Munich. The appointees of the regional local governments have neither voting rights nor membership obligations.

Stadtwerke München Verkehrsbetriebe (SMV) is part of the semi-autonomous Public Utilities Division of the City of Munich. (The Division is also responsible for the reticulation of gas, electricity and water throughout the City.) SMV operates the U-Bahn (a metro of 65 route kilometres), as well as the tram (79 route kilometres) and bus services (414 route kilometres) within the city limits. SMV contracts out about one third of all bus route kilometres in the City to private operators; the contracts are for up to five years in length.

The Deutsche Bahn operates the S-Bahn which serves the Munich region. Since it was opened in 1972 for the Munich Olympic Games, the network has been expanded to some 431 route kilometres. The most recent addition to the S-Bahn network involved a 20 kilometre extension to the new Munich airport. The Munich Tunnel Company is responsible for constructing the U-Bahn and the S-Bahn in the region. Its shareholders are the Federal Government, the State of Bavaria, the City of Munich and the Deutsche Bahn.

Regionalverkehr Oberbayern GmbH, a subsidiary company of the Deutsche Bahn and the Deutsche Bundespost (the German Federal Post Office), operates extensive suburban and rural bus services within the Munich region; about 1 900 route kilometres are in the MVV area.

Performance of the Munich transport system

Data and performance indicators on public transport operations in Munich are set out in table G.1.

Table G.1: **Indicators of performance of public transport in Munich**

		Münchner Verkehrs Tarifverbund GmbH (MVV)	
	Units[a]	*1990*	*1991*
Data on Operations			
Operating costs	$ million	794	816
Operating revenue	$ million	425	428
Operating subsidy	$ million	325	344
Total employment	no.	na	na
Vehicle km operated	million	61.3	61.3
Passenger journeys	million	711	730
Performance Indicators			
Cost recovery	%	53.5	52.4
Cost per passenger journey	$	1.1	1.1
Cost per vehicle km operated	$	13.0	13.3
Subsidy per passenger journey	$	0.46	0.47
Revenue per passenger journey	$	0.60	0.59
Revenue per employee	$’000	na	na
Revenue per vehicle km operated	$	6.9	7.0
Passenger journeys per employee	$’000	na	na
Passenger journeys per vehicle km operated	no.	11.6	11.9

na not available

a Local currency amounts converted to $A using average exchange rates.

Source: Data obtained from Deutsche Bahn and MVV 1992
OECD 1993, p. 164

Financing the Munich transport system

Revenue collected by the MVV, after deduction of its own administrative expenses, is shared among its two partners on the basis of an agreed formula. One element in this formula is the weighted share of the total vehicle kilometres performed by each operator.

The operating deficit of the SMV (around 40 per cent of operating costs, including depreciation on capital) is met by the City of Munich. Contributions to financing the operating costs of the bus services are also made by the State of Bavaria and by the governments of the counties surrounding Munich. In the case of the S-Bahn the deficit on operating costs, including depreciation, is about 45 per cent and is funded by the Federal Government. In 1991 the aggregate operating deficit on MVV services was DM444 million (Münchner Verkehrs- und Tarifverbund GmbH 1992). In addition, the Bavarian Government reimburses each public transport operator for the revenue foregone in fare concessions. Payments are in the form of annual lump sums.

The cost of constructing the S-Bahn is shared by the Federal Government (60 per cent) and the State of Bavaria (40 per cent). The Federal Government contributes 60 per cent of eligible capital expenditure on U-Bahn systems, with the State of Bavaria and the City each funding 20 per cent. The Federal funds for these works are raised by a portion of the Government's tax on petrol (3 pfennings per litre). Bavaria's contribution comes from a tax it levies on motor vehicle registrations. The City has to meet the cost of purchasing the rolling stock for the U-Bahn.

Both the Federal and regional governments provide grants to bus operators for the acquisition of new buses. The proportionate size of the grants diminishes as the capital cost increases.

Transport and urban development in Munich

Munich has the reputation of having 'an exceptionally good public transport system' (Walmsley and Perrett 1992). Between the 1950s and the 1970s the city grew rapidly along the axes of the U-Bahn and S-Bahn systems. As a result the spatial separation between residential and employment location increased; manufacturing industry moved to the suburbs.

Extensions to the U-Bahn system totalling 14 kilometres are underway and a further 16 kilometres are being examined; these will, for the first time, extend the system beyond the City boundaries. As the U-Bahn system has been extended, the tram network has been progressively cut back.

G.3 Newcastle upon Tyne

The Tyne and Wear Passenger Transport Executive (PTE) serves a population of about one million people in and around the lower Tyne and Wear valleys of north-east England.

The role of government in transport in Tyne and Wear

As in the other conurbations of the United Kingdom outside London, the Tyne and Wear Passenger Transport Executive (PTE) is responsible for planning and financing urban public transport in its district. It operates the Metro light rail transit service and contracts local rail and non-commercial bus services from British Rail (BR) and bus operators. On contract bus and local rail services, the fares and timetables are set by the PTE in accordance with policies decided by the Tyne and Wear Passenger Transport Authority (PTA). The PTA is a board of elected councillors appointed by the district councils (that is, Newcastle, Gateshead, Sunderland, North Tyneside and South Tyneside) and is responsible for public transport in the Tyne and Wear conurbation.

Tyne and Wear PTE is unique amongst the former PTEs in that it has retained responsibility for operating services on the Metro. This light rail network runs mainly over former BR track with new tunnel sections in the city centre and an extension to Newcastle Airport. (In more recent years other PTEs have developed or are planning light rail operations, for example, in Manchester, Birmingham and Leeds.) Aside from the operation of the Metro, the role of government in Newcastle is similar to that already described for Leeds.

The Tyne and Wear transport system

Commercial bus services in Tyne and Wear account for 80 to 90 per cent of all services in any year with very low direct costs (for example, costs per mile), resulting in lower indirect costs for the PTE. Services in Tyne and Wear are provided by up to 50 operators, of whom three are big and competitive: Busways (ex-PTE), Northumbria (ex-United), and Go Ahead Northern. Contestability is accentuated by the presence of such smaller but dynamic operators as OK, TMS (TWOC), and Wellcome.

The Tyne and Wear PTE developed the integrated bus light rail network and fare system in the 1970s and 1980s. This was eliminated with deregulation and privatisation. However, in recent years the gaps in service, information and fare options have been gradually filled. For example, the Tyne and Wear PTE provides comprehensive information at a cost of £1 million ($A2.5 million) a year and new multi-ride/multi-operator tickets are available.

Commercial bus services are a very high proportion of the total. Accordingly, the services ‘secured’, that is, contracted and subsidised by the Tyne and Wear PTE, are mainly for some school trips, work trips, weekend services, and weekday services in the evenings or very early in the morning.

The operator making the initial sale of multi-ride/multi-operator tickets keeps the revenue. The Tyne and Wear PTE loses out as the busier (more certain) morning peak mainly starts on the feeder buses to Metro. However, the savings in administration costs are considerable, as there are single-ride transfer tickets as well as multi-rides, monthly passes etc.

Performance of the Tyne and Wear transport system

Car ownership in Tyne and Wear is among the lowest in the United Kingdom and public transport serves a very large proportion of trips; 90 per cent until the early 1970s, and still over 70 per cent in the 1990s.

As a result of the United Kingdom’s deregulation and privatisation policies, savings in operating costs have been made and practices such as low fares in South Yorkshire eliminated. Costs are down and fares now more accurately reflect costs.

The Metro has about 14 per cent of the total urban transport market, carrying about 40 million out of the more than 300 million passenger journeys by all modes in 1992-93. Cost recovery is 90 per cent, as fares are comparatively high, and kept high by holding them close to bus fares. This figure compares with the average cost recovery for urban rail in the United Kingdom of 50 per cent. As a result the Metro operating deficit was only £3.7 million ($A8 million) in 1993-94. (The Tyne and Wear PTA is responsible for the Metro’s £70 million outstanding borrowings.)

A notable feature of the Metro is its carriage of 40 million passengers a year on an intensive service with only 681 staff. The conversion from BR to PTE operation was justified on the gains that could be achieved on the industrial side. In comparison Adelaide trains carry only 10 million passengers a year with 800 staff. However, as noted above, North-east England has the lowest levels of car ownership in the United Kingdom, and South Australia very high levels.

Transport and urban development in Tyne and Wear

The loss of centralised planning after privatisation was not the problem it was made out to be by some, because public transport and highway planning in the United Kingdom was never well coordinated. A strong informal network has developed, and most metropolitan districts now submit a joint package of proposals to the UK Department of Transport. The first initiatives came from West Midlands and embraced, inter alia, the Centro LRT, the M6 By-pass, and the Snow Hill Railway. A new lead role for the metropolitan districts and a broader outlook by operators have emerged.

Because the existing Metro operation has proved to be cost-effective, the Tyne and Wear PTA has announced a preference to extend Metro over the existing BR line to Sunderland, after evaluating alternatives such as a new line via Washington, and electrification of the BR route. An extension within Sunderland is also proposed. Capital costs are £27 million ($A70 million) which will be sought from the UK Government and the European Union; operating costs will be similar to the present PTE payment to BR for the local rail services that will be replaced.

Tyne and Wear PTE has a special division of 18 persons administering the three systems providing service to the elderly and those with disabilities. The two main systems are a network of minibuses and a taxi voucher scheme. A small number of special semi-fixed routes are also operated and the Metro is totally accessible. The minibuses have a cost recovery of over 30 per cent. Annually, the taxi voucher scheme costs less than £0.2 million net, as the outlays of £0.5 million are offset by revenue of £0.3 million from sale of vouchers. (The scheme is much less generous than similar schemes in Australia).

To assist its planning, promotion and information roles, the PTE receives copies of the registrations of bus services and has a sideline business in circulating them at a price to all bus operators, another illustration of the cooperation and goodwill that can develop in a competitive environment.

G.4 Singapore

Singapore is a city-state with a population of some 2.6 million. The urbanised area of the island is 290 km^2.

The role of government in transport in Singapore

The Public Transport Council is the government agency responsible for regulating public transport in Singapore. The Council consists of nine government appointees and the chief executive officers of the four major public transport operators (two bus companies, the metro operator and the largest taxi cooperative). The Council is responsible for:

- issuing bus service licences (for up to three years in duration);
- approving bus, taxi and rapid transit fares;

- regulating bus routes; and
- carrying out any other function assigned to it by the Government.

In approving bus service licences, the Council can impose whatever conditions it deems appropriate, including restrictions on timetables, the number of buses used, their carrying capacity, stopping points, etc.

A government authority, the Mass Rapid Transit Corporation, was established in 1983 under the Mass Rapid Transit Act to develop and construct the Singapore metro system, including the rolling stock.

Singapore Mass Rapid Transit Ltd was incorporated in 1987 and was subsequently granted a ten year licence by the Mass Rapid Transit Corporation to operate the metro system. The Corporation holds a Special Rights Preference Share in the operating company. This Share gives the Corporation certain voting rights but no rights to any dividends, profits or assets of the operating company. A Licence and Operating Agreement between the Corporation and the operating company sets out the terms and conditions of the operating licence.

The Registry of Vehicles administers the Area Licensing Scheme to manage road congestion. The Scheme operates during the morning and afternoon peaks in the Central Business District (CBD) of 725 ha. All private and commercial vehicles are required to display a valid area licence (costing S$3 per day or S$60 per month for a private car) before they can enter the CBD. Police are stationed at the various entry points to the CBD to enforce compliance. The Singapore Government is planning to introduce an Electronic Road Pricing (ERP) System to replace the Area Licensing Scheme. The ERP System is expected to be in operation in 1997 or 1998.

In addition to the restrictions under the Area Licensing Scheme, there are other fees and restrictions on car ownership and use administered by the Registry of Vehicles: a Vehicle Quota System which sets a ceiling on total vehicle ownership; Additional Registration Fees (set at 150 per cent of the market value of the vehicle); and a Weekend Car Scheme to allow restricted ownership and use of a private motor vehicle. Revenues from these fees, taxes and levies on vehicle ownership totalled around S$1.8 billion in 1991 (Registry of Vehicles 1991).

The Singapore transport system

Singapore Mass Rapid Transit Ltd operates the metro system under an agreement with the Mass Rapid Transit Corporation. The Corporation completed Phase I of the project (67 kilometres in route length) in 1990, is currently constructing Phase II (of 16 kilometres) and is planning to commence Phase III in 1993.

Most scheduled bus services are provided by two privately-owned bus companies: Singapore Bus Service (SBS) and Trans-Island Bus Services (TIBS). TIBS was established to take over some routes previously held by SBS as a result of government policy to licence a second major operator. The services provided by SBS (2 570 route kilometres) and TIBS are supplemented by peak-hour commuter buses, private hire bus and school bus operators. SBS and TIBS also operate taxis. Since the opening of the metro system, the bus network is being restricted and rationalised to reduce route duplication with and provide feeder services to the metro system.

Singapore Mass Rapid Transit Ltd, SBS and TIBS have formed a joint subsidiary company, Transit Link Pte Ltd, to provide an integrated fare system for the two bus operations and the metro system. Transit Link has introduced a ticketing system based upon a stored-value farecard (similar to the phone cards issued by Telecom for use in public telephones in Australia). The Transit Link innovation is the first of its kind in the world. The farecard gives commuters a rebate for each transfer between metro and bus services or between trunk bus services. Each operator is responsible for its own fare schedule but requires the approval of the Public Transport Council.

Performance of the Singapore transport system

Since introduction of the Area Licensing Scheme in 1975, road congestion has dropped, average vehicle speeds have risen and air quality has improved in Singapore. However, the Scheme is inflexible in terms of time and area of application (it can only be applied in a relatively large zone), and its enforcement is very labour intensive. For these reasons, the Singapore Government is looking to replace the Area Licensing Scheme with an Electronic Road Pricing (ERP) System.

In 1989, eight joint venture contractors were prequalified to tender for the ERP project. Subsequently five proposals were submitted but no contract was awarded by the Government as none of the tenders fully satisfied the tender requirements. Accordingly a second prequalification was held in 1991 and tenders called in 1992. Three of the systems tendered have been short listed for further evaluation. Currently field trials of the three rival systems are in the process of being conducted to demonstrate their effectiveness. Full scale implementation of the selected ERP System is expected by 1997.

Data on performance indicators on public transport operations in Singapore are set out in table G.2.

Table G2: **Indicators of performance of public transport in Singapore**

	Units[a]	*Singapore Mass Rapid Transit*		*Singapore Bus Service*		*Trans-Island Bus Service*		
		1990	*1991*	*1990*	*1991*	*1990*	*1991*	*1992*
Data on Operations								
Operating costs	$million	75.9	83.9	225.9	262.8	35.5	0.8	2.7
Operating revenue	$million	109.6	136.7	237.7	289.6	39.6	11.0	6.2
Operating subsidy	$million	nr	nr	nr	nr	nr	nr	nr
Total Employment	no.	2 242	2 223	7 447	7 276	1 104	1 090	1 000
Vehicle km operated	millions	8.7	8.9	na	na	40	42	38
Passenger journeys	millions	195	202	879	841	141	150	148
Performance Indicators								
Cost recovery	%	144.4	163.0	105.3	110.2	111.8	1293.3	228.7
Cost per passenger journey	$	0.39	0.41	0.26	0.31	0.25	0.01	0.02
Cost per vehicle km operated	$	8.76	9.38	na	na	0.89	0.02	.07
Subsidy per passenger journey	$	nr	nr	nr	nr	nr	nr	nr
Revenue per passenger journey	$	0.56	0.68	0.27	0.34	0.28	0.07	0.04
Revenue per employee	$'000	48.9	61.5	31.9	39.8	35.9	10.1	6.2
Revenue per vehicle km operated	$	12.6	15.3	na	na	1.0	0.3	0.2
Passenger journeys per employee	$'000	86.9	91.0	118.1	115.5	127.7	137.6	148.0
Passenger journeys per vehicle km operated	No.	22	23	na	na	3.5	3.6	3.9

na not available nr not relevant

a Local currency amount converted to $A at average exchange rates.

Sources: Various Annual Reports and Bushells 1993 and OECD 1993, p. 164

Financing the Singapore transport system

The fares for scheduled public transport services were increased by 10 Singaporean cents across-the-board in 1990. Prior to this increase, bus fares were last raised in 1981. All public transport operators, including Singapore Mass Rapid Transit Ltd, are required to recover their costs commercially as no operating subsidies are paid by the government.

Under its operating agreement with the Mass Rapid Transit Corporation, Singapore Mass Rapid Transit Ltd is required to pay the Corporation an annual operating fee and to set aside from its operating profits a reserve for the replacement of operating assets. Singapore Mass Rapid Transit Ltd has been granted exemption from income tax for ten years on its ‘pioneer activities’ but it pays dividends to its shareholders.

G.5 Toronto

Toronto is the primary financial, administrative and service centre of the Province of Ontario and of Canada. The Toronto region covers an area of 8 000 km^2 and is home to 4.5 million inhabitants. Some 2.2 million people live in Metropolitan Toronto which is only 630 km^2 in area. The region contains 2.1 million jobs which represents 20 per cent of total Canadian employment. Regional employment is concentrated in the metropolitan area; 1.4 million of its jobs are to be found there.

As can be seen from table G.3, the Toronto region has a relatively small core with a population density comparable to European cities, and a large periphery with a much lower population density, more akin to the newer cities in the United States. For this reason Toronto has been characterised as ‘Vienna surrounded by Phoenix’ (Sub. 11, p. 24).

Table G.3: **Population and employment in the Toronto region, 1986**

	Area (km^2)	*Population (‘000)*	*Population density (persons/ha)*	*Employment (‘000)*	*Employment density (jobs/ha)*
Central area	20	130	65	412	21
City of Toronto	98	612	62	574	57
Metropolitan Toronto	630	2 193	35	1 350	2.2
Toronto region [a]	1 480	3 735	25	2 079	1.3

a Figures are for the urban area only

The role of government in transport in Toronto

In Canada, the Federal Government is primarily responsible for air, rail and sea transport. Highways, roads and public transport are predominantly in the hands of the Provinces and the two lower levels of government (regional and local).

The Toronto region, the Greater Toronto Area (GTA), consists of Metropolitan Toronto and the adjoining regions of Halton, Peel, York and Durham. Metropolitan Toronto is the core of the region covering five local government areas, including the City of Toronto. Public transport in the Toronto region is the responsibility of 16 transit authorities and the Toronto Area Transit Operating Authority, a statutory corporation of the Ontario Government. Private operators are unable to operate in their own right.

In Metropolitan Toronto, the relevant transit authority is the Toronto Transit Commission (TTC). The TTC is a crown corporation responsible for coordinating all public transport in the metropolitan area (except railways and taxis). It also can construct and operate public transport services. Its Commissioners are selected by the metropolitan government from its elected representatives.

Public transport between the regions of Ontario is provided by the Toronto Area Transit Operating Authority, operating as GO Transit. By agreement with a regional government, GO Transit may also operate services within its region. The board of GO Transit consists of a Chairman appointed by the Ontario Government and, *ex officio*, the chairpersons of the six regional governments served by the Authority. The relationship between GO Transit and the Ontario Government is set out in a Memorandum of Understanding which, among other things, provides for Government approval of GO Transit's corporate plan and budget each year.

The Metropolitan Toronto Transportation Department builds and maintains the major arterial roads and some of the expressways in the metropolitan area. The remaining freeways are the responsibility of the Province of Ontario.

The Ontario Government has created a new agency to facilitate investment in new transport infrastructure. The Ontario Transportation Capital Corporation will be responsible for financing and implementing major new highway and public transport projects which involve novel ways of financing or delivery. In doing so, the Corporation may avail itself of the following options: toll roads; turnkey construction contracts; cost-sharing with project beneficiaries; and private sector participation.

The Toronto transport system

The TTC is the sole operator of the bus (1 220 route kilometres), trolleybus (54 route kilometres), tram (75 route kilometres) and metro (54 route kilometres) services within the Toronto metropolitan area. It also operates an automatic rapid transit service using the Vancouver SkyTrain technology. The Commission is by far the dominant public transport operator in the Toronto region, accounting for over 83 per cent of the total public transport ridership. The rest is carried by GO Transit (5 per cent of total patronage) and the 15 municipal bus systems, some of which are publicly-owned and some owned and operated by private companies under contract to the relevant municipal government (Frisken and McEachern).

GO Transit operates commuter bus and train services along seven corridors within the Toronto region. These involve rail (426 route kilometres) and bus (1 500 route kilometres) services which connect with the TTC and other municipal transit systems. For its rail services, GO Transit specifies the service, sets fares and schedules, but contracts out the operation to two railway operators that run the commuter trains on their own tracks using GO Transit's rolling stock. While originally its bus services were also contracted out, GO Transit now operates all its own buses.

The TTC operates Wheel-Trans, a door-to-door service for the physically disabled unable to use conventional public transport. Wheel-Trans services are characterised by flexible routing and scheduling of specialist vehicles. Wheel-Trans contracts out station wagon services and utilises contract sedan services and taxis to provide its services. The regular services operate at least 16 hours a day, seven days a week and are charged at regular TTC fares. The average operating subsidy is Can$29 per trip and the total subsidy is in excess of Can$19 million per year (Toronto Transit Commission 1989).

Performance of the Toronto transport system

As table G.4, shows, those residents of the Toronto region who live outside the metropolitan area tend to rely more heavily upon their cars and are less inclined to use public transport. As recent population growth has been concentrated in this part of the Toronto region, the net result has been a sharp increase in inter-regional trips, over longer distances between more dispersed origins and destinations. These developments are making it difficult for public transport to compete with the private car and are expected to become more pronounced (Toronto Transit Commission 1991, p. 20).

Table G.4: **Modal shares of trips in the Toronto region, 1986**

	Car	*Public transport*	*Walk/cycle*	*Other*
			(%)	
6am to 9am				
Metropolitan Toronto	57	33	10	0
Rest of region	74	14	10	2
24 hours				
Metropolitan Toronto	64	26	9	1
Rest of region	80	10	9	1

Source: Transportation Tomorrow Survey, Travel Survey Summary for the Greater Toronto Area, June 1989 (based on data collected in 1986 as reported in Toronto Transit Commission 1991b)

Data and performance indicators on public transport operations in Toronto are set out in table G.5.

Financing urban transport in Toronto

Since 1977, the Ontario Government has required that TTC passengers pay for 70 per cent of the operating costs of the system; the balance is equally shared between the Metropolitan and Provincial Governments. Subsequently the operating subsidy target was increased to 32 per cent.

In the case of the municipal transit authorities (including the TTC), the Ontario Government funds 75 per cent of the capital cost of public transport vehicles and infrastructure, including the cost of creating reserved bus lanes.

The Ontario Government expects GO Transit to recover 65 per cent of its operating costs from commercial sources. The Province meets the balance and pays 100 per cent of all capital expenditure.

In the case of municipal roads, the Ontario Government only meets 50 per cent of the capital and maintenance expenditure by municipal governments.

Transport and urban development in Toronto

Population and employment growth in the Toronto region were very high over the 25 years to the middle of the 1980s. Since then both have slowed appreciably and are not expected to recover quickly in the wake of the present recession (Irwin 1990). Over the 1980s population growth has increasingly spilled out of Metropolitan Toronto into the surrounding region. The Metropolitan population remained relatively constant while that in the rest of the Toronto region grew by 34 per cent (Toronto Transit Commission 1991).

Table G.5: **Indicators of performance of public transport in Toronto**

		GO Transit						*Toronto Transit Corporation (TTC)*		
		All Modes		*Suburban Rail*		*Bus*		*Metropolitan*		
	Units[a]	*1990-91*	*1991-92*	*1990-91*	*1991-92*	*1990-91*	*1991-92*	*1990*	*1991*	*1992*
Data on Operations										
Operating costs	$ million	177	188	na	na	na	na	674	725	755
Operating revenue	$ million	na	na	na	na	na	na	446	452	478
Operating subsidy	$ million	73	80	na	na	na	na	216	232	242
Total employment	no.	na	na	na	na	na	na	10 351	10 218	10 051
Vehicle km operated	million	17.8	18.0	2.4	2.4	15.4	15.6	195.2	188.0	183.5
Passenger journeys	million	35.3	35.2	25.0	25.1	10.3	10.1	459.2	424.2	404.3
Financial Ratios										
Cost recovery	%	64.3	63.5	na	na	na	na	66.2	62.4	63.3
Cost per passenger journey	$	5.0	5.4	na	na	na	na	1.5	1.7	1.9
Cost per vehicle km operated	$	10.0	10.5	na	na	na	na	3.5	3.9	4.1
Subsidy per passenger journey	$	2.06	2.29	na	na	na	na	0.47	0.55	0.60
Revenue per passenger journey	$	na	na	na	na	na	na	1.0	1.1	1.2
Revenue per employee	$’000	na	na	na	na	na	na	43.1	44.3	47.5
Revenue per vehicle km operated	$	na	na	na	na	na	na	2.3	2.4	2.6
Passenger journeys per employee	$’000	na	na	na	na	na	na	44.4	41.5	40.2
Passenger journeys per vehicle km operated	no.	1.98	1.95	10.33	10.42	0.67	0.65	2.35	2.26	2.20

na not available

a Local currency amounts converted to $A at average exchange rates.

Sources: Various Annual Reports and OECD 1993, p. 164

With respect to land use planning, the provinces establish the policy guidelines and approve the land use plans which are developed by local government; the latter are then responsible for the implementation of the plans. In the case of the Toronto region, there are five regional governments and 31 local government authorities.

Public transport in Toronto was originally established around a system of horse-drawn trams. The underground metro service was introduced in the 1960s to provide additional capacity on heavily patronised tramlines which had reached capacity and whose service speeds had progressively deteriorated with increasing car traffic. When the first metro line was opened, commercial activity near the stations benefited from the passing traffic. High rise development around the stations followed, and spread with successive extensions of the metro system.

In the three decades to 1984, half of all new apartments in Toronto were constructed within a five minute walk of a metro station, while 90 per cent of all new offices were built adjacent to the three major metro stations in the Central Business District (Walmsley and Perrett 1992). Both developments were undoubtedly due, in part, to sympathetic land use planning, zoning and regulation. The Metropolitan Government actively encouraged high rise development within 1 500 feet of metro stations but restricted it in areas without access to public transport (Toronto Transit Commission 1987). Provincial restrictions on septic tank development during the 1950s also helped to confine residential development within the metropolitan area during a period of rapid population growth.

However, rent controls were in force during this period and they led to an extreme shortage of rental accommodation (Irwin 1989). This may have also helped to artificially contain the migration of population growth from the metropolitan area to the rest of the region.

G.6 Vancouver

Vancouver is the major conurbation of the Province of British Columbia and of Western Canada. The region is British Columbia’s main distribution centre and is home to Canada’s primary air and sea ports on its Pacific coast. The Vancouver region has a population of 1.6 million people.

The role of government in transport in Vancouver

The Canadian Federal Government has primary responsibility for air, rail and sea transport. Responsibility for highways, roads and public transport rest predominantly with Provincial and lower levels of government (regional and local).

The Greater Vancouver Regional District (GVRD) was set up under provincial legislation with few formal powers. It is a voluntary federation of 18 municipalities, including the City of Vancouver, and undertakes those functions (water, sewerage and public transport) delegated to it by its constituent municipalities. The GVRD board is selected by the member councils.

In British Columbia, public transport is the responsibility of BC Transit, a statutory corporation of the Provincial Government. The board of directors of BC Transit is appointed by the Province and includes elected municipal representatives as well as people from the private sector. BC Transit plans and operates public transport services in the metropolitan regions of Vancouver and Victoria, the provincial capital. In other communities in the Province, BC Transit supplies the vehicles, planning, marketing and finance but contracts out provision of the services to private operators.

Because public transport in the Vancouver and Victoria metropolitan regions serve several municipalities, each has a regional transit commission which decides upon fares, service levels and the taxes to meet their share of the costs involved. Locally elected representatives from the municipalities in each region sit on the commissions. The chairpersons of the two commissions are members of the board of BC Transit.

In 1993 the Province of British Columbia established the British Columbia Financing Authority to borrow funds off-budget to finance roads infrastructure. In doing so the Authority will look at the possibility of tolling some major roads.

The Vancouver transport system

In the Vancouver region, some 83 per cent of urban trips are made by private motor vehicle, around 9 per cent by public transport and 8 per cent by bicycle or on foot. In the period since 1985, public transport’s share of urban trips has declined, even though travel has grown faster than population.

BC Transit provides bus and trolleybus (1 293 route kilometres), ferry (3 route kilometres) and SkyTrain (25 route kilometres) services within the Vancouver region. SkyTrain is an automated, driverless, rapid transit system which operates over 24 kilometres of elevated guideway. It links with bus services at many of its stations and with the SeaBus ferry service to North Vancouver.

BC Transit was the first public transport system in Canada to introduce lift-equipped buses. The first such bus was introduced in 1990 and they will progressively replace those without lifts. Each bus takes two wheelchairs. BC Transit also provides a custom transport service, handyDART, for those physically disabled unable to use conventional public transport. HandyDART is a shared ride service operated by private agencies under contract to BC Transit. Service hours vary but are generally between 8.30 am and 5.30 pm. The standard handyDART vehicle is a modified van with a wheelchair lift.

All maintenance of provincial roads is done under contract to the private sector.

Performance of the Vancouver transport system

Data and performance indicators on public transport operations in Vancouver are set out in table G.6.

Table G6: **Indicators of performance of public transport in Vancouver**

		British Columbia Transit	
	Units[a]	*1989-90*	*1990-91*
Data on Operations			
Operating costs	$ million	220	247
Operating revenue	$ million	117	127
Operating subsidy	$ million	154	173
Total employment	no.	3 271	3 441
Vehicle km operated	million	71	70
Passenger journeys	million	188	207
Financial Ratios			
Cost recovery	%	53	52
Cost per passenger journey	$	1.17	1.19
Cost per vehicle km operated	$	3.1	3.5
Subsidy per passenger journey	$	0.82	0.83
Revenue per passenger journey	$	0.62	0.61
Revenue per employee	$'000	35.7	37.0
Revenue per vehicle km operated	$	1.6	1.8
Passenger journeys per employee	$'000	57.3	60.1
Passenger journeys per vehicle km operated	no.	2.6	3.0

a Local currency converted to $A using average exchange rates.

Sources: Data provided by BC Transit
OECD 1993, p. 164

Financing transport in Vancouver

On average, public transport passengers pay around 30 percent of the costs of operating the Vancouver regional transit system, including all the costs of amortising the capital. The rate of recovery varies considerably by mode.

The Province of British Columbia contributes some 46 per cent of the system operating costs while the balance (24 per cent) is met by the Vancouver Transit Commission through its constituent municipalities. The local government contributions are financed by specific taxes on petrol, commercial property and electricity (see table G.7).

The Province of British Columbia funded all of the capital costs of SkyTrain system. The final cost of the project was Can$845 million. The Province will also meet all the capital costs of any extensions to the system.

In the case of roads, the Government of British Columbia meets all of the capital costs of provincial (that is, major) roads. This is about 50 per cent of the capital expenditure on all roads in the Province. The balance is financed by the municipal governments

Table G.7: **Source of subsidies for public transport in the Vancouver region, 1991**

Subsidy	*Paid by*	*Diesel bus*	*Trolley bus*	*SkyTrain*	*SeaBus*	***Total***
				(Canadian $ million)		
Gasoline tax	Car drivers	19.6	9.4	17.8	0.6	**47.4**
Hydro levy	House-holders	5.2	2.5	4.7	0.2	**12.6**
Commercial property tax	Business	9.9	4.8	9.0	0.3	**24.0**
Residential property tax	Home owners	5.8	2.8	5.2	0.2	**14.0**
Provincial Government	Provincial taxpayers	50.0	24.2	120.9	1.7	**196.8**
Total subsidy	**All sources**	**90.5**	**43.7**	**157.6**	**0.3**	**294.8**

Source: Peat Marwick, Stevenson & Kellog 1993

Transport and urban development in Vancouver

SeaBus and SkyTrain have been catalysts for urban development in the Vancouver region. SkyTrain stations have become the focus of commercial development and have contributed to the development of suburban town centres. BC Transit have created a property development unit to negotiate, with private interests, joint development projects based around SkyTrain stations. In addition ambitious land use zoning for high rise and mixed uses has been adopted by the planning authorities to reinforce the integration of transport and land use planning (Walmsley and Perrett 1992).

Road congestion and air quality are considered to be major problems in the Vancouver region. Accordingly, the Regional District Board has initiated a plan to reduce total air emissions from motor vehicles by 50 per cent by the year 2000 (compared to 1985). As part of this plan the District Board is actively promoting improved air quality by discouraging the unnecessary use of the private motor vehicle and encouraging walking, cycling and public transport.

The Regional District Board wishes to promote the concept of regional town centres and cities linked by high capacity public transport. A long range transport plan to support this concept is being jointly developed by the Regional District Board and the Province of British Columbia as part of Transport 2021. Transport 2021 is expected to make its recommendations to the Province, the Regional District Board and its constituent municipalities by the end of 1993.

G.7 Washington, DC

Washington is the capital of the United States of America. It is located in the District of Columbia, which is situated on the northern bank of the Potomac River, between the States of Maryland and Virginia. The national capital region consists of the District of Columbia and the adjacent counties in Virginia and Maryland. The population of the national capital region is 2.9 million.

Background to transport policy in the US

The *Intermodal Surface Transportation Efficiency Act 1991* (ISTEA) authorises Federal funding of about US$155 billion for highways and urban public transport for the fiscal years 1992 to 1997. Among other things, the Act:

- allows State and local governments more flexibility in the application of Federal funding for highways and urban public transport;
- continues discretionary and formula funding for urban public transport; and
- relaxes the restrictions on the use of Federal funding for the construction of toll roads.

The Federal Transit Administration of the Department of Transportation administers the urban public transport programs under the ISTEA. These programs include funding of US$31.5 billion over the six fiscal years of the Act for operating subsidies, new transit projects and the modernisation of existing urban railways (or other tracked urban public transport systems).

The role of government in transport in Washington, DC

The Washington Metropolitan Area Transit Authority (WMATA) was created by an Interstate Compact between the District of Columbia and the States of Maryland and Virginia. The Compact was also approved by the United States Congress. The Washington Transit Authority was set up to construct and operate a public transport system in the District of Columbia, the cities of Alexandria, Falls Church and Fairfax, and the counties of Arlington, Fairfax, and Loudoun in Virginia and the counties of Montgomery and Prince George's in Maryland. The Transit Authority's board is appointed by its three partners; each nominates two members to the board.

The Washington transport system

Washington Transit Authority operates bus (4 580 route kilometres) and metro (126 route kilometres) services. It is in the process of extending its metro system by a further 30 kilometres.

The Transit Authority provides a lift for the disabled at every metro station and a special bus to transport disabled passengers when one of these lifts break down. It is also in the process of replacing its bus fleet with lift-equipped vehicles; about half the fleet now has lifts.

Performance of the Washington transport system

Data and performance indicators on public transport operations in Washington are set out in table G.8.

Financing the Washington transport system

For capital projects, the Federal urban transport programs will meet 80 per cent of approved costs (the same as for highway projects) and 90 per cent for bus-related equipment to meet the requirements of the *Clean Air Act* and the *Americans with Disabilities Act*.

For operating assistance, Federal grants are available for up to 50 per cent of public transport system deficits.

On average, the Washington Transit Authority recovers 53 per cent of its operating costs through fares and other commercial revenue. This leaves an operating deficit of US$325 million at the present time. The metro recovers 74 per cent of its operating costs but the Authority's bus services only 34 per cent. The Authority's operating deficits are funded by subsidies from the eight local jurisdictions which it serves and operating grants from the Federal

Government (equivalent to about three per cent of the Authority's operating costs).

The costs of constructing the metro has been in excess of US$5 billion. Its financing has been complex as it involves the Federal Government, two State Governments and eight political jurisdictions. The Federal Government contributed 80 per cent of the cost, with some US$2.2 billion transferred from the Federal Interstate Highway Fund. The balance was contributed by the local governments. The local governments raise their share through local taxes on petrol: two cents per (US) gallon in Maryland (US currency) and a one per cent tax in Virginia; but both States contribute additional money from their general revenues. Further extensions of the metro network are underway.

Transport and urban development in Washington, DC

By Federal law the Washington Transit Authority may only use land for transport purposes. Any land surplus to these requirements must be sold. Within these constraints, the Transit Authority is seeking to promote associated land use development through three types of initiatives:

- Long term leases of air rights are generating some US$4 million per year in revenue for the Authority.
- The Authority provides special access to metro stations to adjacent commercial developments in return for a long term lease payment.
- Finally the Authority encourages symbiotic development without any direct financial involvement from the developer.

Local government attempts to assist the Transit Authority by land use zoning. However, this has been difficult to sustain and developers still manage to build larger developments than permitted by zoning (Walmsley and Perrett 1992).

Table G.8: **Indicators of performance of public transport in Washington**

		Washington Metropolitan Area Transit Authority					
		All modes		*Metrorail*		*Metrobus*	
	Units[a]	*1990*	*1991*	*1990*	*1991*	*1990*	*1991*
Data on Operations							
Operating costs	$ million	665	705	313	335	353	369
Operating revenue	$ million	333	338	219	223	114	115
Operating subsidy	$ million	304	339	74	92	229	246
Total employment	no.	5 983	5 983	2 148	2 148	3 835	3 835
Vehicle km operated	million	139	148	58	65	81	83
Passenger journeys	million	285	287	145	147.1	140.3	140.4
Financial Ratios							
Cost recovery	%	50.0	47.9	70.1	66.4	32.3	31.1
Cost per passenger journey	$	2.3	2.5	2.2	2.3	2.5	2.6
Cost per vehicle km operated	$	4.78	4.77	5.35	5.14	4.36	4.47
Subsidy per passenger journey	$	1.06	1.18	0.51	0.63	1.64	1.76
Revenue per passenger journey	$	1.17	1.17	1.51	1.51	0.81	0.82
Revenue per employee	$'000	55.6	56.4	102.0	103.6	29.7	30.0
Revenue per vehicle km operated	$	2.39	2.28	3.75	3.41	1.41	1.39
Passenger journeys per employee	$'000	47.69	48.04	67.52	68.47	36.58	36.60
Passenger journeys per vehicle km operated	no.	2.05	1.94	2.48	2.25	1.73	1.70

a Local currency amounts converted to $A at average exchange rates.

Sources: Washington Metropolitan Area Transit Authority 1991 and OECD 1993, p.164

G.8 Zurich

Zurich is the capital of the Canton (or State) of Zurich and is the most important city in Switzerland in financial and economic terms. The Canton of Zurich is the largest centre for manufacturing in the country. Some 840 000 people live in the Zurich metropolitan area of 700 km^2. The Canton of Zurich has a population of around 1.1 million.

Background to transport policy in Switzerland

Schweizerischen Bundesbahnen (Swiss Federal Railways) operates the major railway services which serve the Confederation. In addition there are numerous small 'private' railways throughout the country; these are usually owned by the relevant local or regional governments. Schweizerischen Bundesbahnen (SBB) is an autonomous agency of the Swiss Federal Government. Although not incorporated, SBB has a board of directors, is responsible for its own capital stock, and publishes its own financial statements.

The Swiss Federal Assembly enacts the laws which govern SBB's operations, including those affecting staff employment and the principles in its performance contract with the Federal Government. Among other things, these require that SBB be managed according to sound business principles. Each year the Assembly approves SBB's budget, financial statements and annual report, the financial grants to cover its public service obligations, its contribution towards infrastructure costs, and the construction or closure of railway lines.

The Federal Council (the Swiss federal executive) defines more exactly what it expects from SBB in a performance contract. The current performance contract (covering the period 1987-94) divides SBB's activities into: commercial activities (long distance passenger and most freight traffic) and public service activities (an hourly regional passenger service and the 'piggyback' carriage of heavy trucks to relieve road congestion and the environment). While the Federal Government pays an operating subsidy — which is fixed in advance — to the public service activities, the commercial activities are expected to meet all their operating costs. Should the Canton or local governments demand extra services they are required to contribute towards the costs involved.

To allow a comparison to be made with the Confederation's roads budget, the Federal Government meets the costs of railways infrastructure, that is, the interest, depreciation and maintenance associated with fixed railway assets. For its part, SBB pays a user charge to the Government for its use of the rail infrastructure.

The Federal Government is considering ways to make SBB more commercially-minded, including the establishment of a separate government-owned company to build and manage railway infrastructure (European Conference of Ministers of Transport, 1993).

The right to operate scheduled bus services is vested in the Swiss Post Office. The Post Office in turn licences each of the bus operators. Deregulation and the introduction of greater competition in the provision of bus services are also being considered by the Federal Government

The Zurich transport system

Zürcher Verkehrsverbund (ZVV) is an association of the 44 public transport operators in the Canton of Zurich. It was established in 1990, with the introduction of the new Zurich S-Bahn, to coordinate the provision of services over a 2 000 kilometres public transport network for the Canton. The major partners in ZVV are the City of Zurich, SBB and the Swiss Post Office.

Although ZVV is the first verkehrsverbund in Switzerland, it is similar to that found in Munich and in many other cities in Germany (for example, Frankfurt, Hannover and Hamburg) and elsewhere in Europe (for example, Stockholm and Vienna).

ZVV performs the following functions:

- planning public transport and its services;
- setting service frequencies and fares;
- marketing its integrated fare system; and
- distributing fare revenues to the shareholders.

The Verkehrsverbund does not operate any services. This is done by each of the partners in their own right under one of two types of contract with ZVV:

- a participation agreement whereby the operator agrees to general rules of cooperation; or
- a timetable agreement under which the operator agrees to provide a given timetable for a guaranteed sum.

Participation agreements are renewed every ten years whereas timetable agreements are only for two years at a time. At present there is little competition for contracts upon renewal.

Verkehrsbetriebe Zurich (VBZ) is a semi-autonomous public utility of the Zurich City Council. VBZ operates the tram (120 route kilometres), bus (111 route kilometres), trolley bus (36 route kilometres), local railways (17 route kilometres) and funicular services within the limits of the City of Zurich.

SBB's S-Bahn network (380 route kilometres) for the Canton of Zurich was set up in 1990 from its regional rail network to which was added an 11 kilometre underground rail link in the city plus new double-deck rolling stock.

Performance of the Zurich transport system

Overall the modal split between private and public transport in the Zurich metropolitan area is about 2:1. Within the City of Zurich public transport is used for about 40 per cent of passenger kilometres. Outside the City, public transport usage accounts for around 15 per cent of passenger kilometres (Mauch, Iten and Mailbach 1992).

Data and performance indicators on public transport operations in Zurich are set out in G.9.

Financing the Zurich transport system

Fares are collected by ZVV which pays to each of the operators the sum negotiated in their agreements with the Verkehrsverbund. The amounts are usually based upon their total vehicle kilometres. In the case of SBB, ZVV makes up the difference between ZVV's tariff and SBB's standard rates for local passenger journeys.

The operating deficit of ZVV is shared equally between the Canton of Zurich and the local governments in the Canton. The latter is shared among the relevant local governments in accordance with their financial capacity and the quality of service they receive. Around 68 per cent of VBZ's operating costs are recovered commercially: 53 per cent from fares with another 15 per cent from other commercial sources.

The deficit on the S-Bahn is currently running at around 50 per cent of its operating costs but this is expected to increase with the introduction of a new fare structure based on zones. The operating deficit is funded by SBB. While the Swiss Confederation guarantees and pays for every SBB station to have an hourly train service, the Canton of Zurich has specified a more frequent service for the new S-Bahn. SBB has agreed to met the additional operating cost of the more frequent S-Bahn service for the first three years of its operation. Subsequently, the operating deficit will be borne by the Canton.

The relevant local government authorities are responsible for reimbursing ZVV for the revenue lost due to fare concessions.

Table G.9: **Indicators of performance of public transport in Zürich**

		Zürcher Verkehrsbund(ZVV)					
		All Modes			*Verkehrsbetriebe Zürich (VBZ)*		
	Units[a]	*1990-91*	*1991-92*	*1992-93*	*1990*	*1991*	*1992*
Data on Operations							
Operating costs	$ million	595	647	781	na	na	na
Operating revenue	$ million	381	392	448	na	na	na
Operating subsidy	$ million	214	255	333	na	na	na
Total employment	no.	na	na	na	2 648	2 798	2 725
Vehicle kms.operated	million	na	na	na	34	35	36
Passenger journeys	million	917	949	na	306	310	310
Performance Indicators							
Cost recovery	%	64	61	57	na	na	na
Cost per passenger journey	$	0.65	0.68	na	na	na	na
Cost per vehicle km operated	$	na	na	na	na	na	na
Subsidy per passenger journey	$	0.23	0.27	na	na	na	na
Revenue per passenger journey	$	0.42	0.41	na	na	na	na
Revenue per employee	$'000	na	na	na	na	na	na
Revenue per vehicle km operated	$	na	na	na	na	na	na
Passenger journeys per employee	$'000	na	na	na	116	111	114
Passenger journeys per vehicle km operated	no.	na	na	na	8.9	8.8	8.6

a Local currency amounts converted to $A at average exchange rates.

Source: Data obtained from VBZ
OECD 1993, p. 164

SBB contributed SFr100 million towards the capital cost of the new 11 kilometres of S-Bahn line. The taxpayers of the Canton of Zurich met the balance; the total cost of the project was SFr653 million. Voters in the Canton have agreed to an expansion of the S-Bahn costing over SFr444 million, of which SFr235 million will be funded by the Canton. This second phase is expected to be completed in 1995. The Canton also meets between 66 and 80 per cent of the capital costs of upgrading railway line capacity on regional lines.

Transport and urban development in Zurich

To facilitate modal interchanges with the new S-Bahn, SBB makes land available at stations, wherever possible, for buses, cars and cycles. However, park-and-ride has not been a success because it is expensive.

Virtually all housing is within 300 metres of a public transport stop. For environmental reasons, the City Council is looking to gradually reduce the amount of space for private cars across the City to make way for public transport. The Council is also looking to replace its diesel buses by trolleybuses. The Council is very happy with its trolleybuses and is not inclined to go to trams; indeed in the centre of the city, trams are being replaced by the S-Bahn.

G.9 Implications for Australia

In the cities examined by the Commission, the public sector is responsible for ***planning urban transport infrastructure and urban development***. In most of the cities, governments seek to have these two functions undertaken in an integrated fashion. They also seek to use the provision of public transport infrastructure as a catalyst for urban development. These approaches are perhaps most pronounced in Canada, Germany and Switzerland where there is a greater preparedness to apply sympathetic and quite strong land-use zoning and regulation to encourage the use of public transport infrastructure.

The experience of both Toronto and Washington, DC show that such applications of land-use zoning and regulation are not without their difficulties. In both of these instances land-use zoning to contain urban development to major public transport corridors has been difficult to sustain and real estate developers have managed to build larger developments than permitted by the zoning.

The public sector plays a role in the ***provision of public transport services*** in each of the cities examined but the extent of its role varies considerably. In all the cities, the largest share of public transport services is provided by operators which are owned by the public sector. With one exception, private sector operators are used in every city to supplement the services of the public sector operator. Where this occurs the private operator is usually under contract to the public sector one and is usually employed to service the outer areas of the metropolis.

The exceptions are Vancouver and Victoria in Canada. However, while BC Transit does not make use of private operators in Victoria or greater Vancouver, it does so exclusively in most of the other towns and cities in British Columbia. Moreover, private operators are also extensively used by public transport systems in the Canadian provinces of Quebec, Saskatchewan and Ontario. Private operators are even used in greater Toronto, outside the Metropolitan area (Cox and Love 1991).

Where the private sector is involved in public transport in the cities examined, it tends to operate bus services under *de facto* or *de jure* rights to the routes allocated to it. To date the public sector has been the exclusive operator of the fixed track modes (rail or tram) as well as the major bus operator. The exceptions are in the UK and Singapore where the bus services are in private hands.

Governments are looking at or moving to eliminate or reduce the regulatory barriers to entry in all modes, rail included. This is to allow the possibility of new operators or the threat of competition. In the case of the members of the European Union, the motivation is also to allow them to meet the requirements of the Single European Act to allow the rail operators in the other member states of the Union to have access to their rail infrastructure.

In a number of member countries of the European Union (including Germany, the Netherlands and Italy), governments have also moved to corporatise the government-owned rail operator (European Conference of Ministers of Transport 1993).

The UK has already moved to franchise rail passenger services, to allow open access to bus routes outside of London and to require those inside London to be put out to competitive tender. Governments in Germany and Switzerland are considering opening up their urban bus services to new operators. Moves to reduce barriers to entry in the provision of public transport services are not confined to the cities or countries examined in the previous sections of this appendix. Sweden has eliminated exclusive licensing of public transport services; the effect has been to encourage competitive tendering of services by county councils. Denmark has enacted legislation requiring all bus services in Copenhagen to be put out to competitive tender (Cox and Love 1991).

In the case of rail, moves to open the provision of services to new operators raise the issue of ***vertical separation of the railways.*** This entails separating the responsibilities for provision of rail services from the management of the rail infrastructure (signalling and track). The UK is in the process of separating these functions between British Rail and a new government-owned authority (Railtrack). Germany and Switzerland have created a separate business unit within each of their national railways to manage the infrastructure and both are considering the possibility of further separation. Separation is also underway outside the European Union. Sweden has given these functions to two separate public sector organisations and intends to further deregulate its railways by 1 January 1995 (Lundberg 1992).

One of the more striking features of the cities examined was the ***role of local government*** in the provision of urban transport services and infrastructure. Most of the local authorities in the cities examined were mostly, if not wholly, responsible for meeting the operating deficits on their public transport systems. This was true even where the country concerned had a federal system of government (for example, Canada, Germany, Switzerland and the United States). The roles played by these local governments were far in excess of those played by most local governments in the provision of transport services and infrastructure in Australia, with the possible exceptions of the Brisbane and Rockhampton City Councils.

The roles of local government in the cities examined were independent of the nature and size of the local government units. The ability for these functions to be undertaken at the local government level was not confined to those instances where one local government authority represented the entire metropolitan region. In some cases, the relevant local governments were able to cooperate to perform and finance these functions with minimal financial assistance from higher levels of government. Such voluntary action was facilitated by the provision of machinery to allow a federation of the relevant local governments to undertake these functions. This is the case, for example, in Vancouver.

Public transport in the cities examined by the Commission was characterised by the provision of ***integrated ticketing*** among the service operators. However, quite different approaches have been taken to the provision of ***coordinated services***. Munich and Zurich (and Singapore to some extent), rely upon an association of all the public transport operators (a mix of publicly- and privately-owned) to undertake these two functions on behalf of the group. The operators have done so through a company incorporated under their national legislation governing private corporations. In Singapore the coordination of services is facilitated by the Public Transport Council's regulation of the bus services but the provision of integrated ticketing has been left to the three operators to organise on their own account.

These two functions are undertaken by the major government-owned public transport operator in Toronto and Vancouver. Perhaps somewhat surprisingly, in Toronto these functions are only undertaken in respect of public transport services *within* Metropolitan Toronto and *not* for the whole of the Toronto conurbation. There appears to be no formal machinery to coordinate services or provide integrated ticketing between the Toronto Transit Commission (the Metropolitan operator), GO Transit (the provincially-owned operator of commuter passenger services over the Greater Toronto Area) and the other private and municipally-owned operators in the Greater Toronto Area. This is left to the operators.

In the cases of Leeds and Newcastle upon Tyne in the United Kingdom, the operators, financing bodies and planners have developed a new informal transport planning process. This is, if anything, more effective than previous arrangements. Goodwill is necessary, and much credit rests with the local governments which have had their authority restored following the demise of the metropolitan county councils.

For these reasons, the experience of the cities examined does *not* suggest that the functions of coordinating public transport services within a metropolitan region and providing integrated ticketing for those services can only be successfully performed within the public sector. Indeed, it perhaps even stretching the evidence to say that these functions are undertaken throughout the entire conurbation in every instance. Toronto seems to get by having these functions carried out only in *part* of the conurbation and some of the UK cities do not seem to require them to be carried out *at all*.

The ***financial performance*** of public transport in the cities analysed varies considerably. That said, even the city with the lowest rate of commercial recovery of operating costs is markedly better than the best of the Australian cities. The results in the cities examined range from a low of around 50 per cent for Washington, DC to well over 100 per cent for Singapore. The rates of cost recovery in Australian cities range from 16 per cent in Perth to 45 per cent in Sydney (see chapter A3).

In the case of Singapore and the European cities these superior rates of cost recovery would be partly due to the higher population densities and lower rates of car ownership and use. However, these factors are unlikely to explain the bulk of the differences with the North American cities where the population densities are often lower and the rates of car ownership and use higher than Australian cities.

In Toronto the rates of cost recovery for both the Toronto Transit Commission and for GO Transit are virtually identical at around 65 to 70 per cent. These rates of recovery are relatively high by the standards of the group of cities examined, even though the population densities of the catchment areas served by each are vastly different. One of the reasons for the superior financial performance of the two Toronto government-owned operators may lie in the fact that the Ontario Government agrees formal cost recovery targets with each operator. Accordingly, any cost over-runs in any one area of operation have to be financed by the operators out of savings in other cost items. This requirement appears to impose some discipline upon the negotiations on wages and conditions with the relevant labour unions.

The ***productivity performance*** of the public transport operators in the cities examined was assessed on the following range of partial indicators:

- commercial revenue, operating cost and operating deficit per passenger trip;
- passenger trips, commercial revenue and operating cost per vehicle kilometre operated; and
- passenger trips and commercial revenue per employee.

The Commission would have preferred to have used a more comprehensive range of performance indicators than these, including some indicators on service quality. Unfortunately, as is the case in Australia the data available on the performance of public transport in these countries is often poor, especially in the area of service quality. In virtually all cases the data required to calculate any indicators additional to the above, were either not collected or unable to be obtained by the Commission.

Some caution must attend any conclusions drawn from comparisons between data on the performance of public transport systems in different cities, states and countries. The geography and topography of cities are quite different and these differences affect the performance of the entire urban transport system, including public transport. One of the consequences will be that the modal composition of public transport patronage can vary substantially. Similarly described operational data (passenger trips, operating expenditures revenue) may in fact be defined and accounted for differently.

The performance of the operators in question for the years 1990 and 1991 varies considerably on these productivity indicators. On the face of it, by far the most impressive operator is the Singapore metro as it ranks ahead of all of the other operations on every indicator, except revenue per employee. The best result on that score is obtained by the Washington, DC metro.

Despite the variation, the performance of each of these operators is consistently superior to that reported for government-owned urban public transport operators in Australia in the same period for similar indicators (Steering Committee on National Performance Monitoring of Government Trading Enterprises 1993).

Most Australian government-owned public transport operators are able to carry about 20 000 to 23 000 passengers for every employee, with the State Transit Authority of NSW carrying around 30 000 passengers per employee in Sydney. These results may be compared to 48 000 passengers per employee for the Washington Transit Authority, 60 000 for BC Transit in Vancouver, 91 000 for the Singapore metro, 111 000 for VBZ in Zurich and 138 000 for Trans-Island Bus Services in Singapore.

Traffic and passenger densities certainly explain some of the differences in the results between Australia, on the one hand, and Singapore and the European cities on the other. But they are not as significant in the comparisons with the North American cities. Moreover, the transport technology is more or less the same for all the comparisons and there is little evidence of economies of scale in bus operations which carry a substantial share of the passengers in many of the above comparisons.

While public transport's share of urban travel is still declining, the experience in the cities analysed suggests that ***operating cost savings*** are able to be made without adversely affecting services or fares.

A good number of the conurbations in the United Kingdom outside London have made a successful transition from ***public to private ownership of transport operators***. The success stories have been those conurbations where the local governments and the operating companies recognised the reality and inevitability of the new arrangements, planned and responded quickly, and were determined to make the new system work.

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APPENDIX H

Developments in road pricing

APPENDIX H DEVELOPMENTS IN ROAD PRICING

H.1 Introduction

The direct pricing of particular road use at specific times is one way to reduce congestion and pollution, as well as to extend private involvement in the provision of roads.

While Australia has only limited experience with road pricing, the experience overseas with various schemes has been more extensive. Recent developments in electronic toll collection systems open up new possibilities and applications for road pricing.

H.2 Road pricing in other countries

Road pricing — charging based on the place and time of use — has been introduced in a number of cities including Singapore, Oslo and Bergen, is to be introduced in Stockholm in 1996 (table H.1), and is under consideration in Cambridge, in the United Kingdom. In the Randstad region, encompassing the main urban areas of the Netherlands, a comprehensive transport plan involving significant road pricing has been produced. The congestion pricing part of the plan has not yet been implemented.

The Hong Kong experiment

An experiment in Hong Kong with electronic road pricing, between 1983 and 1985, demonstrated that a system based on the time of day and location of travel was both technically feasible and effective in reducing congestion. Compared with other attempts at levying and collecting tolls, via toll gates, the costs of implementation were fairly low. According to Austroads (1991), the initial cost of the scheme would have been about $US30m, and the annual cost about $US6m, with revenue estimates ranging from $US20 to $US70m a year. The scheme was also technically effective.

The aim of the scheme was (eventually) to establish user charges for road use at 200 congested locations, by detecting and charging vehicles as they crossed these sites. The charges would vary according to the site and time of day and be billed each month to the user.

Table H.1 **Urban road pricing in other countries**

Cities	*Type of pricing scheme*
Singapore	Area licensing operating in the city centre. Currently planning to move to a fully automated electronic road pricing system.
Norway	
Bergen	City cordon tolls using manual and automatic collections.
Oslo and Trondheim	Toll Rings using a combination of electronic and manual collection.
Italy	
Milan	Supplementary licensing scheme for the CBD.
Sweden (planned for 1996)	
Stockholm and Goteborg	Toll rings using a combination of electronic and manual collection.

Source: Derived from information contained in Hau (1992) and Lewis (1993)

In 1983 the Hong Kong Government proceeded with the operation of a pilot scheme involving 18 sites in a congested multi-lane environment and the equipping of 2 600 vehicles, of which 1 200 were government cars, 700 were buses and the remainder voluntary participants.

Using electronic number plates (ENPs) as transponders, each priced at $US59 in 1985, the cost of the 210 000 ENPs comprised about half of the total system capital cost of around $US30m (Hau 1992). Since then, the price of transponders has fallen by about two-thirds and is continuing to fall.

In 1985 the Government decided not to proceed with the scheme, due mainly to public concerns about invasions of privacy, in relation to the territory's absorption by China in 1997. The technology apparently functioned successfully, although some observers suggested that the full scale scheme would have revealed some flaws in enforcement provisions. Technological developments have since solved the privacy problems.

Area licensing in Singapore

In 1975 the Singapore Government introduced an area licensing system (ALS) in the central area of the city. In the morning peak period a fee was charged to enter this zone with exemptions for high occupancy vehicles (this exemption was later abolished), motorcycles and commercial vehicles. Later, the scheme was extended to the afternoon peak period. Parking fees inside the zone were also doubled.

Since 1990 the daily fees have been approximately $S6 for company vehicles, and $S3 for private cars and taxis (Lewis 1993). The scheme is a manual system, enforced by police manning of all the entry points to the CBD and checking (by visual inspection) that all vehicles display the appropriate stickers. Despite increases in car ownership and city employment, traffic flows are less today than they were eighteen years ago when the scheme was introduced.

Box H.1: **Singapore's proposed electronic road pricing scheme**

The electronic road pricing (ERP) scheme which Singapore is planning to introduce in 1995 will replace the manual road pricing system now in place. The technology for the ERP scheme works in the following ways:

- Underground detectors which sense the passing of a vehicle are connected to a controller (boxed unit beside the road) which then communicates with the in-vehicle unit (IVU) via antennae on a gantry above the road;
- Signals from the antennae instruct the IVU to deduct the toll from the stored-value smart card. The toll would differ for vehicle types and for time of day, with a liquid display on the card showing the driver the balance of value stored on the card; and
- When vehicles are detected without IVUs or stored-value cards or with insufficient credit, cameras are activated to capture images of the rear of vehicles (for number plate identification). The images are stored in the controller and sent to a control centre which then sends out infringement notices.

The technology has the advantage that the toll can be varied for type of vehicle, location and time of day. Sign-posts should inform drivers of the various charges. Drivers can visually observe the amount being deducted from their store-valued card. ERP enables tolls to be collected without inhibiting the flow of traffic, or preventing vehicles from changing lanes at the electronic checkpoints. By using smart-card technology with pre-paid stored values, the privacy problems (apparent with the Hong Kong ERP trials) are overcome since all the information is in the card and not with the authorities managing the system, and only the identification number of violators are recorded.

The cost of the IVUs being considered for the Singapore ERP scheme ranges from $S75 to $S175 per unit.

Apart from contributing to a more efficient use of road space, the ERP has other advantages which stem from the use of the latest smart-card technology. The stored-value cards have the potential to be used as electronic purses. Given the necessary infrastructure, they could be used for a variety of other purposes such as riding on public transport, purchasing petrol and paying parking charges.

Source: Singapore Registry of Vehicles

In addition to the restrictions under the ALS, there are other fees and restrictions on car ownership and use administered by the Registry of Vehicles: a vehicle quota system which sets a ceiling on total vehicle ownership; additional registration fees (set at 150 per cent of the market value of the vehicle); and a weekend car scheme to allow restricted ownership and use of a private motor vehicle. Revenues from these taxes and levies on vehicle ownership totalled around $S1.8 billion in 1991 (Registry of Vehicles 1991).

Since introduction of the Area Licensing Scheme in 1975, road congestion has declined, average speeds have increased and air quality has improved in Singapore. However, the scheme is inflexible in terms of its time and area of application, it can only be applied in a relatively large zone, and its enforcement is very labour intensive. For these reasons, the Singapore Government is looking to replace the scheme with an electronic road pricing (ERP) system.

In 1989, eight joint venture contractors were prequalified to tender for the ERP project. Subsequently, five proposals were submitted but no contract was awarded as none of the tenders fully satisfied the tender requirements. Accordingly a second prequalification was held in 1991 and tenders called in 1992. Three of the systems tendered have been short listed for further evaluation. Currently field trials of the rival systems are in the process of being conducted to demonstrate their effectiveness. Full implementation of ERP is expected by 1997 (see box H.1).

Supplementary licensing in Milan

In Milan a supplementary licence scheme operates to restrain access to the CBD during peak hours. The scheme has been effective in reducing the use of private cars for access by 50 per cent, with 40 per cent of the deterred trips now made by public transport, 35 per cent parking outside the central area and 15 per cent having changed their travel times to avoid the peak period.

Stockholm and Göteborg

In Stockholm all drivers are required to purchase a public transport season ticket, which doubles as a permit to use the roads. Drivers caught without a permit face heavy fines. The authorities have recently agreed to convert to a full electronic road pricing system by 1996.

Plans for Stockholm and Göteborg are based on marginal social cost pricing, including the cost of pollution from vehicle emissions, and an agreement to hypothecate the revenue from road pricing to public transport and road construction.

In September 1992 an agreement between the main political parties in Sweden was reached on the introduction of a combined manual and electronic toll collection system, like the Oslo Toll Ring, with a further option of introducing differential pricing. The National Road Administration (SNRA) has the authority to ensure the standardisation, compatibility and coordination of road toll systems in the country.

Cordon tolls in Norway

Currently there are about 30 ongoing toll road projects throughout Norway. These projects are designed primarily to finance specific road infrastructure projects like tunnels and fjord-crossing projects (bridges and below-sea tunnels). Around Norway's three largest cities (Oslo, Bergen and Trondheim) there are established toll rings to finance a pre-specified package of road infrastructure investments.

The Oslo Toll Ring began using electronic toll collection in December 1990, after opening in February 1990. The toll ring operates 24 hours a day throughout the year using a flat toll. Oslo is currently considering the merits of switching to a time-differentiated charging scheme.

Norway's third largest city, Trondheim, began using electronic tolls in October 1991, charging motorists entering the city during daylight hours. Both the Oslo and Trondheim toll rings use automatic vehicle identification (AVI) technology, allowing post-payment via conventional monthly billing statements and prepayment via electronic funds transfer. In the Trondheim toll ring a slight time-differentiation has been introduced.

In 1986 tolling was introduced in Bergen requiring payment by all vehicles except buses which entered a cordoned area between the hours of 6am and 10pm on weekdays. The entry tolls are collected manually from booths, are about $A1 and are estimated to have reduced traffic by about seven per cent (Austroads 1991). Electronic tolling is currently under consideration.

This scheme was designed to raise revenue (the toll revenue being hypothecated) for road construction rather than as a demand management technique.

It has been estimated that the cost of installation *per lane* for full electronic toll collection in Norway is a third to a half of the cost of a manual toll collection system (Hensher 1991).

According to the Norwegian Ministry of Transport, a further focus on charging systems, introducing a greater element of time-differentiated charges — within the already existing toll ring systems — is most likely to be the next concrete step of Norwegian road pricing policy.

Norway is an active participant in researching innovations in electronic road pricing, where a combined smart card which can be used on cordon tolls, public transport, parking, and even other general electronic purse services, is expected to be on the market in just a few years.

Road pricing in the Netherlands

The Dutch Government has proposed the introduction of a large-scale multiple cordon-based road pricing system. Charges would be both time and location dependent. The collection of charges would be by electronic means, using anonymous pre-payment to ensure privacy. The scheme envisages the use of in-vehicle units (IVUs) and stored-value smart-cards.

The second transport structure plan allows for ‘mobility within the boundaries of a sustainable society’ (Ministry of Transport, Netherlands). To cope with congestion and pollution, road pricing was found to be an essential policy measure.

Due to public opposition, introduction of the scheme has been reduced in scope. In April 1992, the Government announced a system of supplementary licensing for motorists using the main road network during peak periods (Hau 1992).

The Government currently plans to introduce a system of peak-hour charges (congestion pricing) in 1997 to battle congestion. Car drivers using the trunkroads in the Amsterdam/Rotterdam region between 6am to 10am will be charged *f*5 per day. It is expected that such road pricing will lead to drivers travelling at other periods, carpooling, and some change in destinations. Congestion is expected to fall by between 30 and 50 per cent. After the year 2000 the scheme is likely to be transferred to a full electronic road pricing scheme using smart-cards, and this technology will enable the charging to be aimed at tackling environmental concerns as well as congestion.

The requirements the Dutch authorities have set for the introduction of a full ERP scheme include:

- the need for safe-guarding the privacy of individual drivers, requiring anonymous payment;
- the need to charge vehicles in an existing road configuration at normal speeds and without the need to build huge toll plazas;
- the need to provide a secure, low cost and user-friendly charging method;
- the need to achieve a highly reliable charging transaction, without additional activities required while driving;
- the need for a flexible charging system, requiring location and time dependent charges; and

- the need for international standardisation, in particular concerning the road to vehicle communication link and the functionality of the in-vehicle equipment.

Government policy is that revenue collected from congestion charging or environmental charging, should be returned to car-drivers or the general public, ensuring revenue neutrality. The charges should be designed to alter behaviour, not to raise revenue. In correspondence received from the Netherlands Ministry of Transport, the Chairman of Peak Charging Project stated categorically:

> ...one should be very careful with the money. There is only one solution: give the money back!!!!

Toll roads in France

There are currently 6 000 km of toll roads in France, with a a further 3 000 km planned over the next ten years. To date urban areas have not been affected by tolls, which start 30 km from Paris and outside other urban centres.

Urban toll roads are now being planned and built, such as the Prado-Carenage tunnel in Marseille. Other projects are also being examined in Grenoble and Paris, where the City authorities intend to double the southern part of the ring road with a tunnel. A toll highway is also to be constructed from Porte Maillot to Orgeval in the Paris region.

All seven French highway companies have tested electronic toll collection equipment and some now have electronic gates requiring drivers to slow to 50 to 60 kilometres per hour. The Government’s objective is to use the same equipment on all French highways and to coordinate and standardise equipment with neighbouring countries, particularly Spain, Italy and possibly Germany which is interested in using electronic tolling in urban areas. In France there will be an intermediate phase where both manual and electronic toll gates are used.

The electronic systems being considered are those which require no identification of the motorist or the vehicle, so no privacy concerns are involved.

To regulate traffic, the present tariffs are modulated, with lower rates in off-peak periods and increased rates during the peak hours. This has proved effective, particularly during summer holiday periods in the Rhone valley and on weekends in the Paris region.

The toll revenue is retained by the highway companies to fund loan reimbursement, road maintenance and taxes.

Tolled motorways in Italy

The Italian toll motorway network consists of over 5 000 kms, of which almost 3 000 kms are operated by the highway company Societa Autostrade. The tolls do not presently operate in urban areas.

The motorways currently use a combination of manual and automatic collection systems (reserved for viacard holders). There are various types of cards consisting of:

- pre-paid stored value viacards worth 50 100 or 150 000 lira;
- current account viacards: the toll due is directly charged to the motorists' bank account;
- Viacards Plus: these current account cards can also be used to pay for the major motorway services (to buy petrol, refreshments, etc.); and
- Telepass cards: a small device aboard the vehicle, functioning like a transceiver, enables motorists to enter and leave the motorway without stopping at the gate. The equipment classifies the vehicle, records the distance travelled and debits the toll to the motorist's viacard current account.

Pre-paid viacards respect privacy like any telephone card. Current account viacards, instead, involve payment from a bank and therefore require identification of the current account holder. In both cases, however, when a motorist commits an abuse in passing through a self-service or a telepass gate, a number-plate identification system is activated in order to trace the violator.

The toll rates on motorways are established by the Government and represent a tax intended to cover the construction, maintenance and operation of the motorways.

The system is based on a 'concession' system, whereby motorway companies which are granted a concession by the State, receive the net toll revenue in order to finance themselves and then hand over the infrastructure to the State, in perfect condition and free of charge, at the end of the concession period.

Congestion metering in Cambridge

A system of charging vehicles directly for their congestion is currently in the design stage in Cambridge, United Kingdom. Using smart-card technology, the plan is for a cordon of electronic beacons at all entry points to the city which activates the IVU as it passes the beacon. Once activated, the charging is based on vehicle speed (as an indication of congestion), and ceases when the engine is turned off or when the vehicle exits the city.

The system is currently being trialled, and a decision on whether to proceed with the plan is expected by 1996.

Developments in the United States

There are presently a number of electronic toll systems currently in operation in the USA utilising 'read only' technology developed by the Amtech Corporation. Installations include the Oklahoma Turnpike system, the Dallas North Tollway, two bridges in New Orleans and the New York State Freeway. These systems are designed to raise revenue and to fund road projects, rather than as congestion pricing mechanisms.

The development of congestion pricing as such, is in its infancy, but is most advanced in California, where the Department of Transportation (Caltrans) has plans for three congestion pricing schemes.

Route 91 express lanes (SR91)

Current and projected traffic figures show that the SR91 is one of the most congested freeways in the country. The express lanes project is designed to relieve this congestion by providing additional lane capacity using 10 miles of the median strip of the existing SR91 along the Santa Ana Canyon to create four additional lanes. High occupancy vehicles (HOVs), initially defined as vehicles with three or more occupants (HOV3), will have access to the express lanes at no charge; vehicles with one or two occupants will be able to use the lanes by paying a variable toll, depending on the time of day and the congestion levels. Current projections are that drivers will be willing to pay a $US2.50 toll for peak hour travel, although the system will accommodate much higher prices which can be introduced if the HOV lanes become congested. A further option would be to charge the HOV3 vehicles, but at a discounted rate.

An AVI system will be used facilitating electronic tolling on the express lanes. The AVI system, to be centred on a transponder or 'tag' mounted near the rear view mirror, is projected to cost around $US30. Users will establish a pre-paid account of around $US80 a month to be issued with the tag. Overhead readers will send a high frequency radio signal to the transponder, and the unique identification code reflected back by the transponder can be used for both toll collection and traffic management.

San Francisco-Oakland Bay Bridge

The Metropolitan Transportation Commission (MTC)'s proposal to improve transit on the San Francisco-Oakland Bay Bridge through variable tolls has been selected by the Federal Highway Administration (FHWA) as the first congestion pricing pilot program under the *Intermodal Surface Transportation Efficiency Act 1992* (ISTEA).

Federal funding has recently been made available for the first phase of a program to replace the existing fixed toll with a variable toll for different times and different vehicle occupancy patterns. State legislation is required for full implementation of the project and it remains doubtful whether it will get beyond the initial design stage. Opposition from sections of the local business community HOV schemes is making the political decision to proceed more difficult.

Historically, there has been significant opposition to the creation of HOV lanes on previously open access lanes. The tolling of new lanes is generally more acceptable.

San Diego - Interstate 15

In contrast to the Bay Bridge project, the San Diego I-15 congestion pricing proposal has been approved by the State legislature but has yet to be accepted by FHWA under the ISTEA scheme. In contrast to the SR-91 project, rather than constructing new lanes, the San Diego County project seeks to use under-utilised capacity of the existing HOV lanes.

The basic idea is that continued free access to the express lanes will be guaranteed for HOVs, while single occupancy vehicles (SOVs) will also be able to use the reversible HOV lanes by paying ‘the market rate’. Revenue from the HOV toll would be used to develop further HOV and transit facilities.

The authority hopes to develop a highly dynamic system of variable tolls and is developing an AVI system sensitive enough to allow drivers with electronic tags to elect to travel on a non-premium lane and not be charged.

H.3 Conclusion

The experience overseas (and more recently in Australia — see chapter A9) with a number of variants of road pricing demonstrates that such policy options are viable and capable of playing a useful role in rationing road use.

Latest developments in the technology make electronic road pricing a practical measure in many situations. The ability to price different vehicles for their use of particular roads or sections of roads at particular times, opens up the possibility for a more efficient allocation of road space.

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