Bureau of Transport Economics

WORKING PAPER 40

COMPETITIVE NEUTRALITY BETWEEN ROAD AND RAIL

The Bureau of Transport Economics undertakes applied economic research relevant to the portfolios of Transport and Regional Services. This research contributes to an improved understanding of the factors influencing the efficiency and growth of these sectors and the development of effective policies.

A list of recent publications appears on the inside back cover of this publication.

ISSN 1440-9707
ISBN 0 642 28305 2

This publication is available free of charge from the Bureau of Transport Economics, GPO Box 501, Canberra, ACT 2601, or by phone 02 6274 6846, fax 02 6274 6816 or email *bte@dotrs.gov.au*

http://www.dotrs.gov.au/programs/bte/btehome.htm

Printed by the Department of Transport and Regional Services

PREFACE

The term ‘competitive neutrality’ is used in competition policy to describe the conditions under which governments provide goods and services in competition with the private sector. The transport industry has appropriated the term to describe competition between the road and rail sectors. At the risk of possible confusion, but in keeping with industry usage, the BTE has used the ‘transport’ version in this Working Paper.

Much of the debate on competitive neutrality between the road and rail sectors has focussed on particular cases of perceived lack of neutrality, such as excise on diesel, sales tax on vehicles and investment in infrastructure.

In contrast, the BTE has deliberately kept the scope of its analysis broad by including all current taxes and charges, access to infrastructure, subsidies, and externalities. Road and rail transport covers a large range of activities. In order to keep the analysis tractable and ensure timely completion, the study was limited to competition between road and rail freight on the intercapital corridors. It was not possible, for example, to include the differential competitive effects of disparate regulations facing road and rail.

Members of the team that produced this paper were Dr David Gargett (team leader), David Mitchell and Lyn Martin. The team acknowledges the contributions of Dr Mark Harvey and Dr Leo Dobes.

Dr Mark Harvey
Deputy Executive Director (A/g)

Bureau of Transport Economics

Canberra

September 1999

CONTENTS

FIGURES

TABLES

ABBREVIATIONS

AADT	average annual daily traffic
ANTS	A New Tax System (recently legislated)
BTE	Bureau of Transport Economics
CPI	consumer price index
CV	commercial vehicle
esal	equivalent standard axle load
esal-km	equivalent standard axle load kilometres
FCL	full container load
GDP	gross domestic product
gvm	gross vehicle mass
gvm-km	gross vehicle mass kilometres
IRI	International (road) Roughness Index
LCC	life cycle cost
LCL	less than full container load
NRM	National Association of Australian State Road Authorities (road) roughness meter counts
ntkm	net tonne kilometre
OLS	ordinary least squares
PCI	pavement condition index
pcu	passenger car equivalent units
pcu-km	passenger car equivalent kilometres
pkm	passenger kilometre
PSI	pavement serviceability index
vkt	vehicle kilometres travelled

ABSTRACT

If the Commonwealth Government's new tax system (ANTS), and associated legislation such as the *Diesel and Alternative Fuels Grants Scheme Bill 1999*, had been in place in 1998-99, average input costs for interstate non-bulk rail and interstate non-bulk road would have been 8 per cent and 15 per cent lower, respectively, than actual average input costs in 1998-99. If such changes in costs were reflected in freight rates, then growth in road's share of interstate non-bulk freight would increase marginally at the expense of rail's share.

If both road and rail paid more *competitively neutral* charges, including charges for externalities, in a system designed to fully recover costs from users, road freight rates would rise by 12 per cent and rail rates would increase by about 4 per cent relative to the post–ANTS situation. The net effect of introduction of ANTS and associated legislation, in conjunction with a hypothetical shift to more competitively neutral charges, would see both road and rail input costs fall by 5 per cent relative to actual costs in 1998-99. With no change in relative input costs, and in the absence of a solution to some of rail's logistic difficulties relative to road, the long-term decline in rail's share of the freight market is unlikely to change.

Fundamentals could change, such as the mooted new (RailRoad) technology, which permits truck trailers to be carried on flat rail wagons, combines the advantages of rail line-haul with door-to-door road delivery of less than full container loads. Through this new system (and others like it), it seems plausible that rail could capture a significant share of the Sydney–Melbourne freight market. This would be a significant reversal of current trends.

AT A GLANCE

- Under the current road user charging system, trucks overall are undercharged for their use of the road system. Moreover, larger, more heavily laden vehicles and those travelling longer distances are charged the least (per tonne kilometre) while smaller, less heavily laden vehicles and those travelling shorter distances cross-subsidise them.
- A more competitively neutral charging structure would involve some form of road user charge based on mass-distance and an annual registration fee to recover part of the capital cost of roads.
- If both road and rail paid more competitively neutral charges, including charges for externalities, in a system designed to fully recover costs from users, both road and rail freight rates would fall by 5 per cent relative to current freight rates. With no shift in relative freight rates, and in the absence of other changes, the historical decline in rail's share of intercity freight transport is likely to continue.

CHAPTER 1 A DARWINIAN ANALYSIS OF COMPETITION BETWEEN ROAD AND RAIL

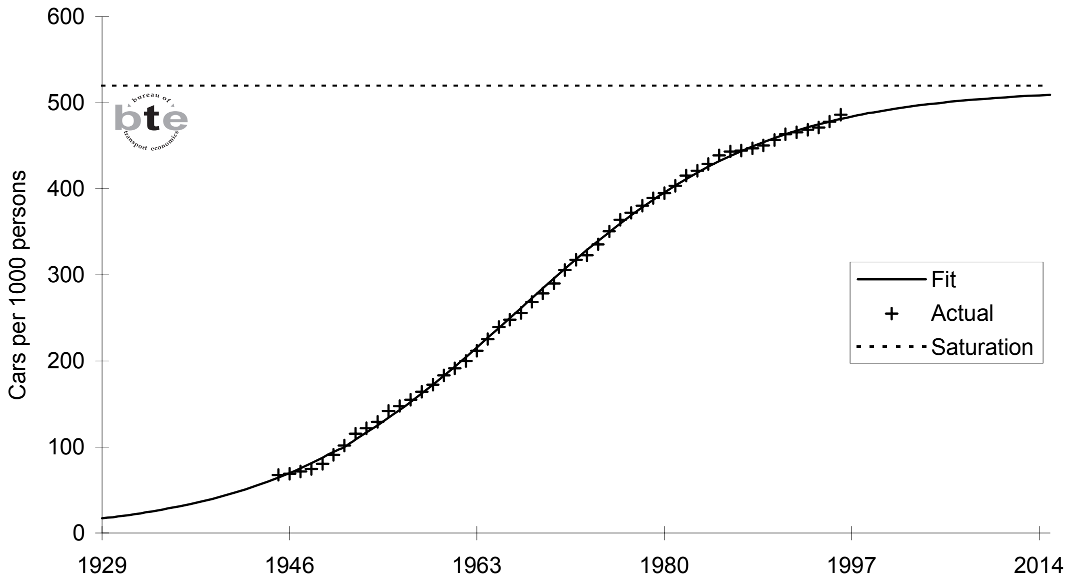
In order to understand competition between the road and rail sectors (hereafter referred to as 'road' and 'rail' respectively), it is necessary to analyse them in the context of their long-term evolution in Australia. Such an understanding is essential to reaching a policy position on the continuing debate about competitive neutrality between road and rail.

PATTERNS OF GROWTH AND DIFFUSION

The long-term evolution of transport modes is a reflection of their patterns of growth and diffusion, which are in turn determined by market forces and government policies.

S-shaped (sigmoidal) curves, such as figure 1.1, are often used to portray patterns of growth or development for various phenomena.

Figure 1.1 Per capita Australian motor vehicle ownership



Source BTCE 1996b, p. 6.

Sigmoidal curves can be intuitively appealing. They portray a relatively slow initial period of growth in which a product or an idea gradually establishes itself, followed by a period of rapid growth as a ‘bandwagon’ effect takes hold. At some stage a turning (inflection) point is reached: while absolute growth continues, there is a falling-off in the rate of growth thereafter. In this phase of maturity, a ‘steady state’ equilibrium or ‘saturation’ level is eventually reached, and may be followed by decline or decay.

One example of such a pattern of growth is that of a tree, and foresters use a range of sigmoidal functions to estimate timber yields (BTCE 1996b, appendix 1). Figure 1.1 demonstrates that the diffusion of cars as transport vehicles in Australia has followed a sigmoidal pattern, with the current ownership of cars per person levelling off at about one car for every two persons.

Sigmoidal functions[1] can be derived mathematically from ‘predator-prey’ models (Montroll and Badger 1974, and Richards 1969, provide reasonably non-technical expositions). Following the initial establishment of an organism or a product in a niche environment or market, it may achieve rapid growth because of special characteristics that permit it to dominate its immediate environment. But sooner or later its growth starts to become limited by its environment, including competitors or predators, or its own inherent or genetic limitations.

Marchetti (1987), concerned primarily with socioeconomic phenomena, distinguishes three cases of limited growth. An obvious case is the Malthusian population: a single species growing in a niche of limited resources, such as a colony of bacteria growing in a culture bottle. In this case, the extent of resources available determines the size of the niche (the ‘saturation’ level in figure 1.1) that can be occupied, and the species essentially competes against itself. One-to-one competition, where a new species is introduced into a niche previously occupied by another species, provides a second case: the substitution of cars for horses as a means of personal transport is an example. A third case, which is a better portrayal of the real world, is that of multiple competition: several species competing (for example, wood, coal, natural gas and nuclear power competing within the primary energy market). Other cases can be distinguished (for example, the ‘non-Malthusian’ case of an expanding niche due to technological advances that increase available resources), but the theme is the same.

1 Although there is a large family of sigmoidal functions, the most commonly used (including in this Working Paper) is the logistic function which is symmetrical about its point of inflection. It is usually expressed in the form:

$$f(t) = \frac{k}{1 + \exp(-a - bt)}$$

In his now-famous econometric study, Griliches (1957) showed that the diffusion of a new technology, hybrid corn, followed a sigmoidal pattern of acceptance and usage in various American states, although it was introduced in each area at different times and under different conditions. The International Institute for Applied Systems Analysis in Laxenburg, Austria has, over about two decades, applied similar analysis to thousands of different phenomena (Marchetti 1991, Gruebler and Nakicenovic 1991). Examples include deaths from the 1665 plague in London, the number of papers written on the greenhouse effect and climate change, the spread of Gothic cathedrals through Europe, use of rare earth cobalt magnets, ownership of cars in various countries, numbers of new computer manufacturers, inventions and innovations over the last 200 years, miles of telegraph wire laid in the United States of America, emergence of new transport modes, patents taken out for various inventions, substitution of diesel engines for steam locomotives in the United Kingdom, the discovery of various chemical elements, and the use of plastic materials in pipes in the USA.

It is important to note that there is no single or universal explanation for the observed sigmoidal pattern of growth or diffusion. While the reasons for each particular case will clearly differ, there appears to be a remarkable similarity in growth patterns over a wide range of phenomena, products and organisms.

Analysis based on sigmoidal patterns (called 'logistic' in this Working Paper because the logistic function has been used) is therefore essentially phenomenological. In other words, logistic analysis can be used mechanistically to predict the results of competitive phenomena such as future market shares of road and rail, without explaining why. Logistic analysis, to be of use for policy questions, needs to be informed by knowledge of the characteristics of the species and the environment in each specific case.

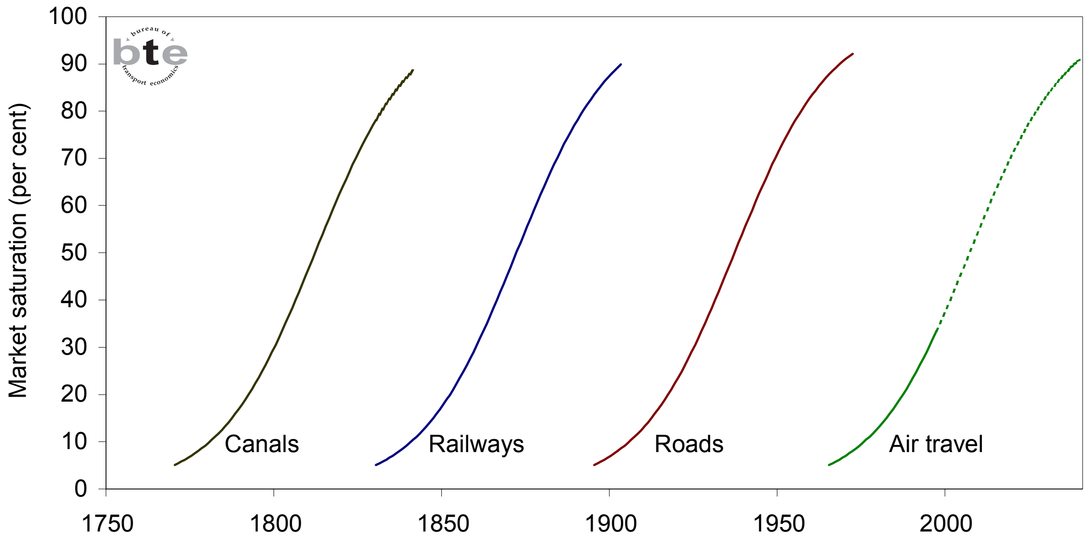
LOGISTIC ANALYSIS OF TRANSPORT MODES

It is possible to conceptualise different modes of transport as representing competing species, either in a passenger, or a freight, 'niche' or market. Figure 1.2 illustrates a long-term historical perspective based on this concept. Canals are seen to have been supplanted by the new technology-species of railways from the mid-nineteenth century. In turn, railways were replaced by roads, and air travel is seen as being a new technology with the potential to replace roads as the dominant mode of travel.

Because figure 1.2 is a stylised representation of the growth of new modes, it does not portray the decay or obsolescence of supplanted technologies.

In practice, the use of canals as a transport mode would have begun to decline with the advent of the railway. As the dominance of railways grew, the corresponding share of the market niche left to canals would have fallen. Similarly, the share of the market held by railways would have started to decline as the use of roads increased.

Figure 1.2 Stylised sequential growth of us transport modes



Source Marchetti 1986, p. 381.

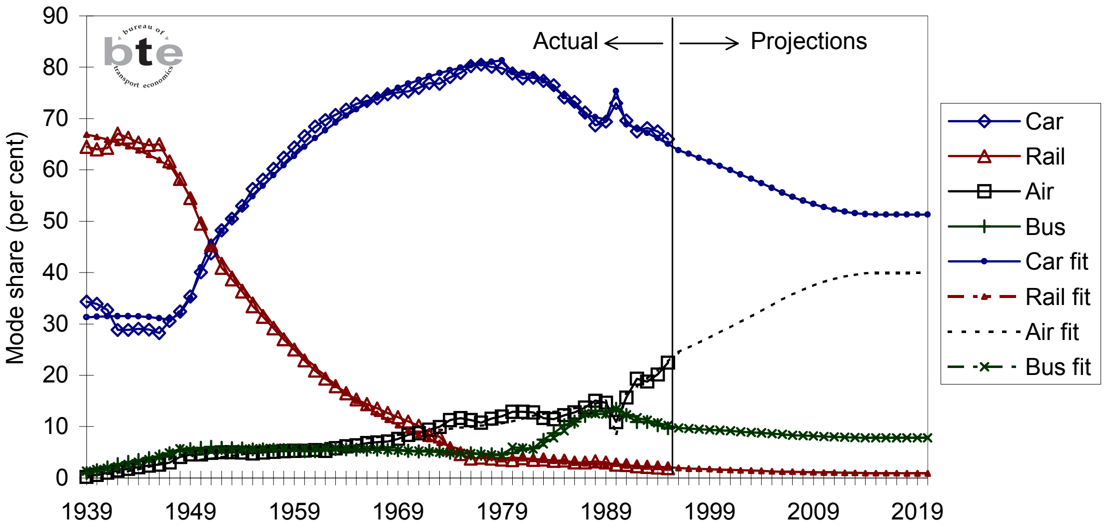
Transport modes do not suddenly become extinct, and use of them may in fact persist for some time after they are replaced by a new technology, so that it is more realistic to expect competition between more than two modes at any one time.

An example of this more realistic picture is given in figure 1.3, which shows the contemporaneous market shares of four modes of passenger transport in Australia. The use of railways has been declining since the end of World War II, with the car winning most of the market. However, bus and air travel have limited the dominance of car travel: air travel is winning out on long-distance corridors (BTE 1998). Given our lack of knowledge of future technologies, any projections need to be cautious, but a mechanistic application of logistic analysis suggests that air travel will continue to win market share for some time, albeit to differing degrees in different corridors.

It is worth noting the fairly symmetrical rise and fall of successive transport technologies, illustrated in figure 1.3. Gruebler and Nakicenovic (1991) obtain similar patterns in analysing competition between more than two transport modes at the one time. Kwasnicki and Kwasnicka (1996) also obtain similar patterns in an analysis of the use of primary energy and of smelting processes, and state (p. 32) that single technologies follow a 'bell-shaped curve' when competing against more than one other technology. Such patterns are often termed 'logistic substitution'.

In reporting his empirical studies of a wide range of phenomena, Marchetti (1991) claims to discern waves of innovation 55 years apart, and links this periodicity to the Kondratiev cycle and to innovations in the use of primary energy. He gives the midpoints (inflection points of the logistic functions) of the successive waves for canals-railways-roads as 1836, 1891 and 1946 (Marchetti 1991, figure 18), suggesting the emergence of a new technology at the beginning of the 21st century. Marchetti (1987, p. 4) speculated that magnetic levitation (maglev) trains could be expected to be introduced 'before the year 2000', and he thought it possible that Japan 'may open the race'.

Figure 1.3 Modal shares of Australian non-urban passenger travel (PKM using fare variables and imposed saturation of air share)



Source BTE 1998.

Gruebler and Nakicenovic (1991) analyse the transport sector in greater detail, showing Darwinian logistic patterns between passenger modes such as the horse, car, air, rail, boat and bus in various countries. In terms of freight, they conclude that a 60-year cycle in Japan means that road transport will continue to grow at the expense of railways until about 2017, when a new 'phantom' mode will appear, possibly in the guise of air transport or maglev trains. The greater degree of uncertainty regarding freight transport they attribute to its different nature, because it involves a non-homogeneous product mix ranging from bulk, low-value density, to non-bulk goods transport (p. 31).

The BTE has no better information than anyone else regarding a potential new freight technology that might successfully compete in the Australian freight market. However, recent proposals by RailRoad Technologies are considered in chapter 5 as a plausible competitor to the currently dominant mode of road transport.

THE AUSTRALIAN INTERSTATE FREIGHT SECTOR

Developments in the Australian freight market can best be understood by first identifying the causes of growth in the total traffic (by all modes), and then analysing the trends in shares held by each mode in the total 'market'.

Interstate freight makes up 40 per cent of the total non-urban road and government rail freight task (i.e. excluding urban road freight, private bulk rail freight and coastal shipping – traffics that have limited relevance to road–rail competition). The freight task is measured in net tonne kilometres (ntkm). A ntkm is equal to one tonne moved one kilometre. At the national level, most measures of task are in billions of ntkm.

The interstate non-bulk freight task has been growing rapidly, at about four per cent per year in both the earlier and latter halves of the 25-year period to 1995 (tables 1.1 and 1.2). The year 1984 was chosen as the break because it was not a recession year. At a four per cent annual growth rate, interstate non-bulk freight doubles in about 18 years. Moreover, interstate non-bulk *road* freight is growing even more rapidly. Its predicted five per cent per year growth rate will result in a doubling in under 15 years (Perry and Gargett 1998, p. 20).

A regression of total freight on real gross domestic product (GDP) gives an income elasticity of 1.28. In other words, total freight has in the past grown 28 per cent faster than GDP. Appendix table I.2 shows the details of the estimated equation. The fit to the data is quite good (figure 1.4).

The regression equation for total interstate non-bulk freight implies a forecast growth rate of four per cent per year, assuming real income growth of 3.25 per cent per year (BTCE 1996a – this ignores the business cycle, as is usual in long-term forecasting). Using this assumption, total interstate non-bulk freight is projected to rise from about 47 billion ntkm in 1995 to about 126 billion ntkm in 2020 (figure 1.4). Thus the total task is assumed to rise to more than two-and-a-half times the 1995 level by 2020.

It should be noted that the growth in total freight traffic has shown no signs of tapering off, along the lines of the usual logistic pattern. It has been assumed that exponential growth will continue over the projection period.

A model of interstate mode share trends

Figure 1.5 shows the trends over the past 25 years in each mode's share of interstate non-bulk freight, as well as forecasts derived using logistic substitution models of mode share (Marchetti and Nakicenovic 1979, Kwasnicki and Kwasnicka 1996).

Coastal shipping was already shrinking rapidly in the years 1971 to 1984. By the late 1980s, non-bulk coastal shipping had basically fallen back to the more or less irreducible coastal trades — that is, to and from Tasmania, Western Australia and the Northern Territory. Coastal shipping is also more prone than other modes to discontinuities. The sharp drop in 1982–83 coastal shipping seems to have been due to the discontinuation of services that were not resumed after the end of the recession.

TABLE 1.1 THE INTERSTATE NON-BULK FREIGHT TASK

(billion ntkm)

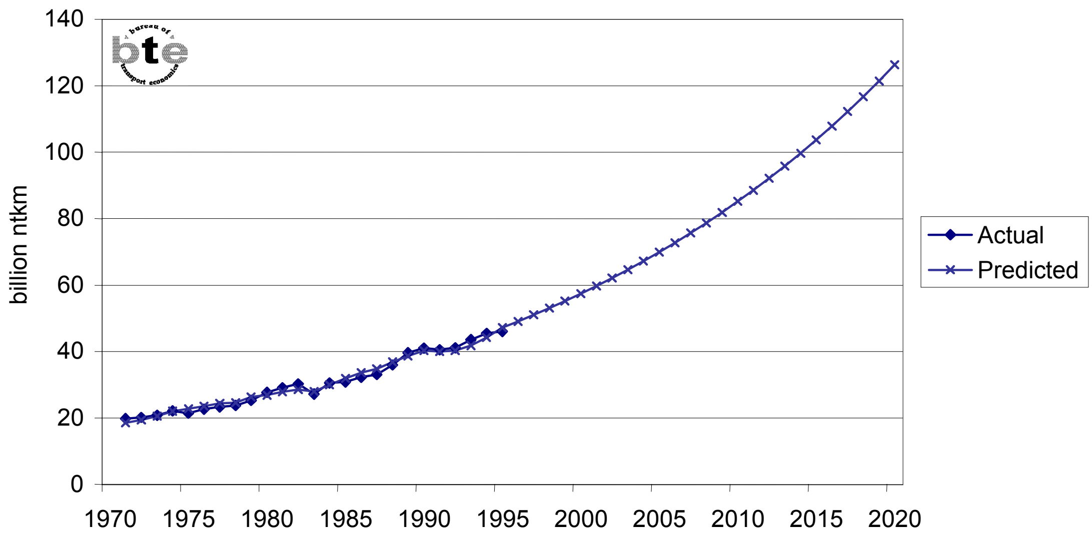
Year ending June	*Total*	*Road*	*Rail*	*Coastal shipping*
1971	19.81	4.26	8.96	6.58
1972	20.19	4.54	9.08	6.56
1973	20.77	5.38	9.12	6.27
1974	22.13	5.95	9.62	6.56
1975	21.49	6.25	9.02	6.22
1976	22.63	7.44	9.35	5.84
1977	23.39	8.11	9.66	5.62
1978	23.73	8.49	9.42	5.82
1979	25.31	9.51	10.21	5.59
1980	27.66	10.81	11.01	5.84
1981	29.05	11.73	11.48	5.84
1982	30.24	12.62	11.89	5.73
1983	27.19	11.88	11.34	3.96
1984	30.53	14.10	12.04	4.39
1985	30.82	14.64	11.94	4.24
1986	32.24	16.19	11.96	4.09
1987	33.13	16.66	12.43	4.05
1988	35.93	18.41	13.58	3.94
1989	39.63	19.77	15.28	4.59
1990	41.05	21.13	15.44	4.48
1991	40.54	21.77	14.35	4.43
1992	41.15	22.15	14.45	4.55
1993	43.56	23.57	15.22	4.78
1994	45.44	24.77	15.59	5.08
1995	46.02	26.02	14.65	5.36

Note Figures may not add to total due to rounding.

Source Appendix table I.1.

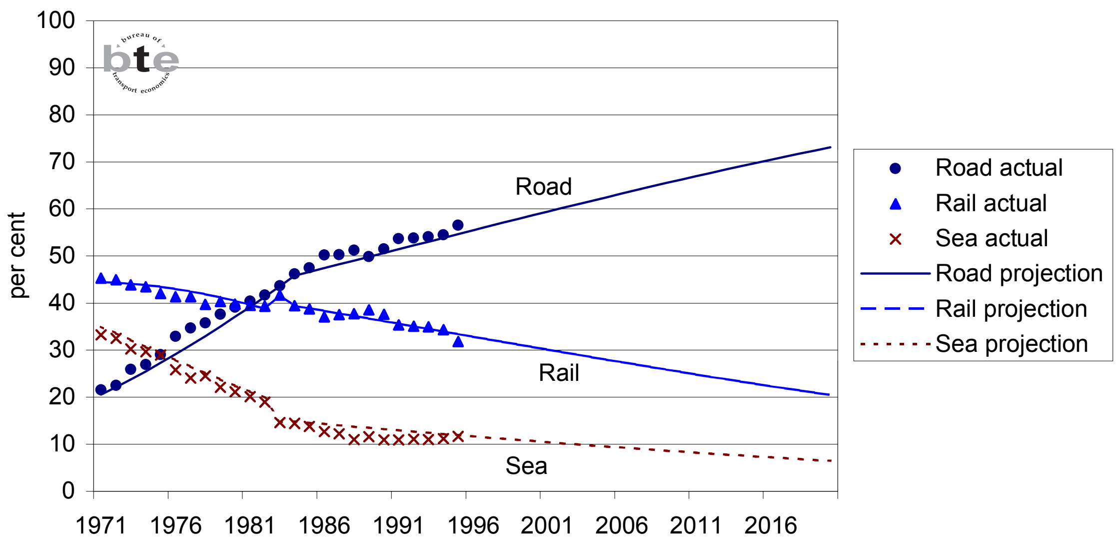
Rail's share has been declining slowly but surely (aside from the discontinuity introduced by the 1983 coastal shipping drop). If the trend continues, rail's share of the interstate non-bulk freight market should drop to just over 20 per cent by 2020. In absolute terms, however, the rail task in 2020 would be about 26 billion ntkm, up by around 73 per cent from 15 billion ntkm in 1995 (table 1.2). In other words, although rail is losing mode share, it should still be growing in absolute terms.

Figure 1.4 Trends in Total Interstate Non-bulk Freight



Sources BTE estimates, ABS 1996 and earlier issues.

Figure 1.5 Trends in Interstate Non-bulk Freight Mode Share



Source BTE estimates.

Table 1.2 Interstate Non-Bulk Freight: Growth Comparisons

	Non-bulk freight				*Growth*		
	Actual			*Forecast*	*Actual*		*Forecast*
	1970–71	*1983–84*	*1994–95*	*2019–20*	*1971–84*	*1984–95*	*1995–2020*
	(billion ntkm)				*(per cent/year)*		
Road	4.3	14.1	26.0	90	9.6	5.7	5.1
Rail	9.0	12.0	14.6	26	2.2	1.8	2.3
Coastal	6.6	4.4	5.4	10	–3.1	1.9	2.5
Total	**19.8**	**30.5**	**46.0**	**126**	**3.4**	**3.8**	**4.1**
Real GDP					3.2	3.4	3.25

Source BTE estimates.

The years 1971 to 1984 were years when the share of road in interstate non-bulk freight was growing especially rapidly. Two factors contributed to this growth. First, road was gaining almost all the traffic that coastal shipping was losing. The second factor was the halving of real road freight rates from 1975 to 1985, as large articulated trucks took over the line–haul between metropolitan centres.

In contrast to the falls in the market shares of rail and coastal shipping, road’s share in 2020 is likely to increase to over 70 per cent. This would imply interstate road freight of about 90 billion ntkm in 2020, compared with 26 billion ntkm in 1995.

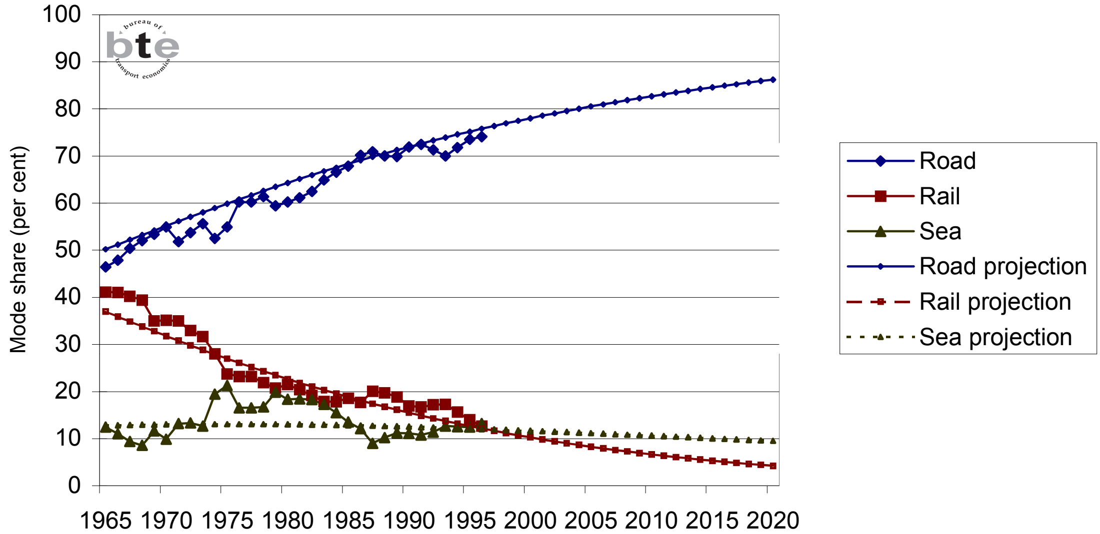
There are several possible factors that might upset these projections. The actual growth rate in GDP might be higher or lower than 3.25 per cent per year. Freight transport might start decoupling from economic growth and begin to saturate, as car ownership has in Australia. There might be large increases or decreases in relative freight rates. A new mode, such as a ‘new rail’ mode (chapter 5), may establish itself with radically improved service characteristics, and with the ability to win market share from both ‘old rail’ and from road.

TRENDS IN CORRIDOR MODE SHARE

The BTE has derived data on freight flows for seven interstate corridors: Sydney–Melbourne, Eastern States–Perth, Sydney–Brisbane, Melbourne–Brisbane, Sydney–Adelaide, Sydney–Canberra, and Melbourne–Adelaide. Examination of the different corridors can shed light on differing trends within the interstate totals.

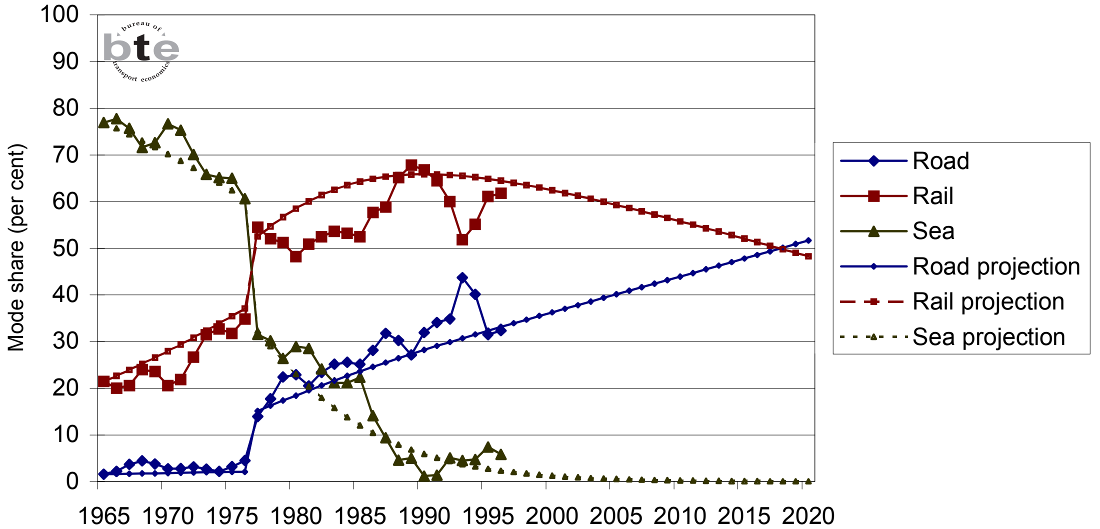
Figures 1.6 to 1.8 show the long-term changes in mode share on three corridors of differing length. On intermediate length corridors, such as Sydney–Melbourne (figure 1.6), rail has been in long-term decline, and road has steadily been gaining market share. On a long corridor, such as the Eastern States–Perth (figure 1.7), rail is holding its share. On a short corridor, such as Canberra–Sydney (figure 1.8), road took over as the dominant mode long ago.

Figure 1.6 Freight mode split projections — Sydney–Melbourne



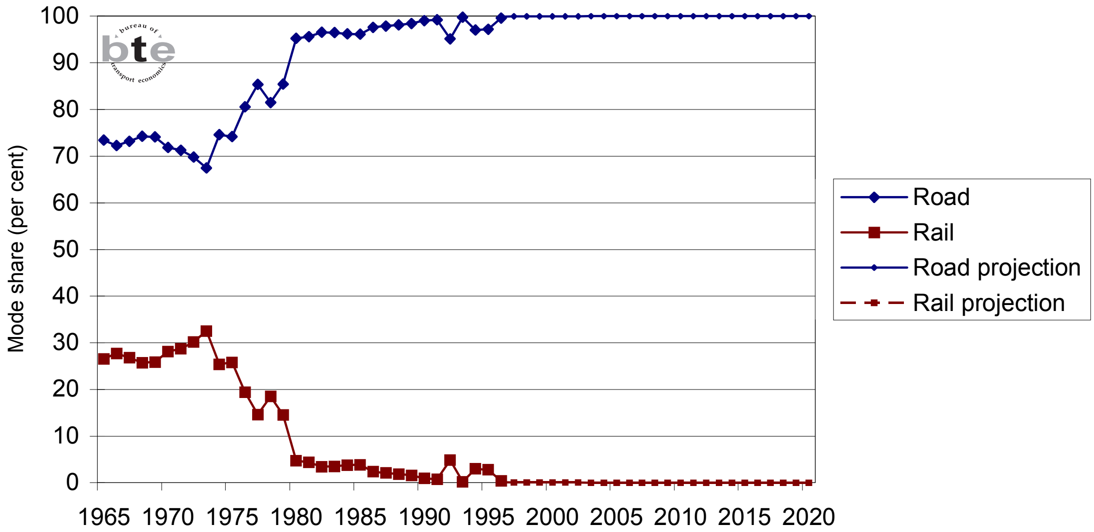
Sources BTE estimates; BTE Coastal shipping database; BTCE 1990b; ABS 1996 and earlier issues; ABS 1997 and earlier issues.

Figure 1.7 Freight mode split projections — Eastern States–Perth



Sources BTE estimates; BTE Coastal shipping database; BTCE 1990b; ABS 1996 and earlier issues; ABS 1997 and earlier issues.

Figure 1.8 Freight mode split projections — Sydney–Canberra



Sources BTE estimates; BTCE 1990b; ABS 1996 and earlier issues; ABS 1997 and earlier issues.

The short-run impact of policy changes on freight transport mode shares depends upon relative price changes and short-run elasticities of substitution between transport modes. The BTE estimated elasticities of substitution from aggregate interstate non-bulk freight transport data. Long-term mode share paths were then recalculated using the competitiveness coefficients from the logistic substitution models. The results of this analysis are given in chapter 4.

CAN THE MARCH OF HISTORY BE ALTERED?

Like all projections, modal splits are necessarily based on technology that exists today. Projections cannot normally take into account the infinite number of potential future technological developments and relative prices. However, it is possible to introduce likely scenarios to assess how they might affect long-term modal shares. Ideally, such scenarios should be informed by knowledge obtained from policy makers or transport operators who are aware of impending changes.

One possibility is a change in relative prices between modes. Deregulation of bus transport in the early 1980s resulted for some years in an increase in market share for inter-urban coach travel, but this increase was competed away following the subsequent deregulation of the aviation sector. In general, changes in relative price competitiveness result in a shift up or down in the logistic curve, but do not tend to alter its basic long-term trend. Where a response is possible from competing modes, even a shift in the curve may be only temporary.

The relative position of an existing mode is likely to be affected significantly only if a new technology is developed that extends its competitive 'life', or if a new technology emerges and achieves dominance. There are many examples of existing technologies being supplanted by new ones. Roads may be an example of a technology whose life was ‘extended’: Nakicenovic (1987) perceives two ‘pulses’ of road use. Roads were initially used by motor vehicles, which rapidly displaced horse-drawn vehicles, and then transport in general (particularly buses and trucks) also made use of the road network to expand.

COMPETITIVE NEUTRALITY BETWEEN ROAD AND RAIL

Freight activity is extremely diverse. In order to keep the analysis tractable, the main area of competition between road and rail was taken to be the interstate non-bulk freight sector. Bulk traffic, on the other hand, is generally better suited to specific modes such as sea and rail. Intrastate traffic is more likely to involve shorter distances — an area where rail has greater difficulty competing.

The analysis presented in subsequent chapters essentially examines two broad scenarios: a change in relative prices (and hence competitiveness) between road and rail, and the entry of a significantly different new mode.

Price changes

A basecase, the current situation prior to the implementation of the Commonwealth Government’s new tax system legislation (current pre-ANTS) is compared with the situation that would have applied in 1998-99 had the Government’s new tax legislation already been in place (current post-ANTS) in chapter 2. In chapter 3, the two current situations are compared with a scenario where both road and rail operators are charged on a more economically efficient (competitively neutral) basis.

New technology

Although the BTE has no special insights into any possible future technologies, a recent proposal may provide significant scope for competition with both today’s road and rail technologies. RailRoad Technologies Pty Ltd has plans to open a new Melbourne-to-Sydney rail freight service in 1999. The planned service will incorporate Roll-on-Roll-off intermodal road-to-rail freight transport permitting rapid loading, use of existing rail infrastructure and potential cost savings of up to 25 per cent (RailRoad Technologies 1998). The logistics of the service mean that it should offer service quality similar to road, but at reduced freight rates. This is something that ‘old’ rail has never been able to achieve. The scenario is examined in chapter 4.

TABLE 2.1 THE *CURRENT PRE–ANTS* AND *POST–ANTS* SITUATIONS: ROAD AND RAIL COSTS

(cents per ntkm)

	Category	***Current pre-ANTS***		***Current post–ANTS***	
		RAIL	***ROAD***	***RAIL***	***ROAD***
	B	C	D	E	F
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**
8	Federal excise	0.30	0.93	0.00	0.53
9	State franchise fees	0.00	0.21	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**
12	Mass-distance charge	0.87	0.00	0.87	0.00
13	Imputed fuel charge	0.00	0.48	0.00	0.53
14	Vehicle registration fees	0.00	0.11	0.00	0.11
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**	
27	**Rail terminal costs**	**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**
30	Change FCL rate (per cent)			-8	-16
31	**Road terminal costs**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**
34	Change LCL rate (per cent)				-9

Note a. Percentage change from previous case, i.e. *pre–ANTS* to *post–ANTS*.

Source Appendix III.

CHAPTER 2 THE *CURRENT* SITUATION

Whether road or rail operates at a relative advantage to the other has been a major issue in the Australian transport community in recent times. The question is difficult to answer analytically, but almost impossible without some framework for making comparisons.

A logical place to begin is with the *current* situation. Examining the current situation provides a starting point for answering the basic question of whether there is a difference in the way the two modes are treated. The analysis undertaken can then provide guidance as to what differences need addressing to ensure competitive neutrality. It is this basecase, the *current* situation, that is addressed in this chapter.

Since this study commenced, legislation has been enacted to implement the Commonwealth Government's new tax system (ANTS). Implementation of ANTS, and accompanying legislation such as the *Diesel and Alternative Fuels Grants Scheme Act 1999*, will reduce taxes on fuel and capital inputs to road and rail operators, altering the current situation. In order to address this change, two versions of the current situation are presented. The c*urrent pre–ANTS* situation presents estimates of road and rail input costs and freight rates applying in the 1998-99 financial year, prior to the introduction the new tax system. The c*urrent post–ANTS* situation presents estimates of road and rail input costs and rates that would have applied in the 1998-99 financial year, had the new tax system applied then.

Once the *current pre-ANTS* and *post-ANTS* situations have been specified, interest then shifts to possible changes in cost/rate structures, should 'competitive neutrality' be introduced.

One potential interpretation of the concept of 'competitive neutrality' is that the two modes be treated 'consistently', irrespective of whether the regime that applies to both of them is logical, or whether it is defensible from an economic, or some other, perspective. If, however, the allocation of resources within the economy is not to be distorted, both road and rail should be treated not only on a consistent basis, but also from an economically defensible pricing perspective. Chapter 3 therefore analyses a *competitively neutral* scenario, where both modes are charged in a more efficient way – one that more fully reflects the costs of resources used.

AN ‘AVERAGE’ COMPARISON

As discussed in BTCE (1997c, pp. 3–7), a basis for comparison is difficult to find. Ultimately, individual taxes and charges are most relevant at the operational level: that of the providers and users of transport services. BTCE (1997c) therefore classified taxes and charges on the basis of variability in cost and usage from the operator’s perspective. It should be noted that comparisons of past investment by governments in road or rail infrastructure are not relevant to competitive neutrality from an operational perspective.

Ideally, taxes and charges would be compared at the operational level for all possible routes where the two modes compete. This is clearly impracticable, and it was necessary to construct an idealised, representative route for each mode for the analysis in this Working Paper: an ‘average’ road freight haul of 1125 kilometres, and an ‘average’ rail freight route of 1200 kilometres (weighted average distances on 7 major intercity corridors). Routes of these lengths provide a sensible basis for comparison because they are most likely to see competition between road and rail. Significantly shorter routes would see road dominate rail (figure 1.8, Sydney–Canberra), while routes that are very much longer could be expected to be dominated by rail transport (figure 1.7, Eastern States–Perth). In so far as a ‘representative’ route must be chosen to make the analysis tractable, an average (medium) route is probably the most logical.

Although a choice has been made of necessity, the reader should bear in mind that the results obtained in this Working Paper are strictly valid only for the ‘average’ route chosen. Extrapolation to other routes requires careful interpretation and qualification.

ESTIMATED OPERATING COSTS UNDER THE CURRENT PRE–ANTS SITUATION

The impact of government policies on the competitive environment facing each mode is felt mainly in the areas of fuel taxes, infrastructure use charges, sales taxes, excise and customs duties, and externalities.

Table 2.1 presents estimates of the cost components for an average road and average rail corridor (assumed to be 1125 km and 1200 km respectively) likely to be affected by a change in taxes and charges. Cost components unlikely to be affected by changes to taxes and charges specific to freight transport, such as labour, capital and maintenance costs, were grouped together under the category ‘other line-haul costs’. Costs are expressed in terms of cents per ntkm. The bases of the calculations are detailed in appendix III.

Road and rail costs sum to rates for door-to-door delivery for full container or truck loads (FCL). For less than full container or truck loads (LCL), rail is not usually used, while road has an additional cost of transhipment and delivery by smaller trucks to and from the road freight terminals. It can be seen that road and rail currently compete mainly in the full container load and full truck load market, and that rail needs to offer significantly lower rates to balance the lower service quality it delivers (table 2.1, cells: C29, D29).

In table 2.1 the non-excise fuel cost of rail and road (cells: C6, D6) equals the cost of fuel less federal and state fuel taxes for each mode, approximately 25 cents per litre for rail and 29 cents per litre for road. Total fuel tax paid by each mode (cells: C7, D7) is the sum of federal fuel excise and State fuel franchise fees. Both rail and road pay federal excise tax (cells: C8, D8), but only road pays the State fuel franchise fees (cells: C9, D9).

When it comes to infrastructure use fees (cells: C11, D11) the two modes face completely different charging regimes. Rail pays mass-distance access fees to the rail access corporations (0.87 cents per ntkm, cell: C12). Road is 'credited' with a nominal 18 cents per litre of federal excise (amounting to 0.48 cents per ntkm – cell: D13). The excise credit item (cell: D10) for road ensures that fuel excise is not counted twice – once as federal excise tax and again as the imputed fuel charge. Splitting fuel excise into three categories – Federal excise, excise credit and imputed fuel charge – was done to aid comparison between the *current pre-ANTS* situation, the *current post-ANTS* situation and the *competitive neutrality* scenario. In addition, trucks (6-axle articulated trucks are used as the standard heavy vehicle) pay $4000 per year registration. This amounts to 0.11 cents per ntkm (cell: D14).

Railways are currently exempt from sales taxes (cell: C15), tariffs on locomotives (cell: C16 includes tariffs only on wagons), and stamp duty on transfer of vehicles (cell: C17). Road, on the other hand, pays these amounts (cells: D15 to D17).

Accident costs for rail and road (cells: C18, D18) include only the insured component of estimated cost.

Railways internalise the costs associated with several functions: for example, enforcement costs and the costs of regulation. Road currently bears costs of complying with regulations (cell: D21), but not enforcement costs (cell: D19).

Neither mode pays for externalities such as noxious emissions, congestion and noise (rows: 20, 22 and 23).

Other line-haul costs (cells: C24, D24) include costs not elsewhere specified in table 2.1, such as labour, capital and maintenance costs. Rail line-haul profit (cell: C25) shows that line-haul rail freight currently under-recovers total costs. A nominal line-haul profit (cell: D25) was assumed for road freight.

Rail line-haul costs are relatively low (cell: C26), but terminal and pickup / delivery costs bring door-to-door rates to 5.06 cents per ntkm (cell: C29), about 13 per cent less than full truck load contract rates (road line-haul rates) of about 5.8 cents per ntkm (cell: D29). Less than full truck load (LCL) freight generally goes through a road terminal, adding significant extra costs for consolidation / deconsolidation and for pickup / delivery of smaller loads (cells: D31, D32).

B-double door-to-door FCL rates are about 4.6 cents per ntkm, significantly below comparable 6-axle articulated truck rates. However, the much larger size of a 'full truck load' for B-doubles means some disadvantages due to indivisibility of load, and this somewhat limits the competitive effect. That said, the advent of B-doubles in large numbers on interstate routes has contributed to nominal road freight rates remaining constant over the 1990s (i.e. falling real road freight rates).

ESTIMATED OPERATING COSTS UNDER CURRENT POST–ANTS SITUATION

The main differences between the *current pre–ANTS* and *post–ANTS* competitive situations are changes in taxes on fuel and replacement of wholesale sales taxes with a GST.

It was not the intention of this study to estimate the full impact on the prices of rail and road inputs of replacing wholesale sales tax with the GST. A general equilibrium analysis would be required to answer such a question. In the absence of such analysis it was assumed that the pre-tax price for transport inputs would not change as a result of ANTS, and therefore that the change in the price of all inputs would reflect the tax rates.

The non-excise cost of fuel for rail and road (cells: E6, F6) is assumed to be unchanged by ANTS. However State fuel franchise fees are abolished and rail no longer pays fuel excise. Road also pays a significantly lower federal fuel excise tax of 20 cents per litre, amounting to 0.53 cents per ntkm (cell F8).

Sales tax on most goods will be replaced by a 10 per cent GST in July 2000. Commercial operators are to receive full credit for this tax, making the effective tax rate zero. Hence sales tax is zero under ANTS (cell: F15).

Other road line-haul costs not elsewhere accounted for in table 2.1, which include maintenance and repairs, tyres, administration and labour, are assumed to fall 3 per cent relative to the pre-ANTS situation (cell: F24). It was assumed that rail pickup / delivery is undertaken in urban areas by vehicles eligible for the diesel fuel rebate, implying a fall in rail pickup / delivery costs of 7 per cent (cell: E28). Road pickup / delivery, largely carried by vehicles ineligible for the diesel fuel rebate, assumed to fall by 4 per cent (cell: F32). The calculations underlying these assumptions are outlined in appendix III.

The net impact of these assumed changes would see interstate non-bulk road input costs fall by 15 per cent and interstate non-bulk rail input costs fall by 8 per cent with the introduction of ANTS, relative to the *current pre–ANTS* situation. Road rates fall the most because trucks use far more fuel and thus benefit much more than rail from the reduction in excise. Trucks also obtain deductibility of sales taxes under the ANTS scheme, whereas rail was already exempt.

B-double door-to-door FCL rates maintain their relativities under ANTS, remaining significantly below comparable 6-axle articulated truck rates.

RATE-SETTING SCENARIOS

How do these cost / rate changes following the implementation of *ANTS* affect freight volumes? This depends on how freight rates are assumed to be set and on the effect of ANTS on road and rail costs relative to input costs in the rest to the economy.

There are two possible extreme rail rate-setting scenarios, with corresponding volume change scenarios.

1. Road sets the rates in interstate traffic. Rail rates would fall to match the reduction in road rates. Rail losses would rise.
2. Alternatively, rail budget constraints would limit rail rate reductions to the limits set by rail cost changes under the ANTS.

Table 2.2 summarises the likely rate changes upon implementation of ANTS for the alternative rate setting scenarios. Rates for sea freight were assumed to remain unaffected by any changes in competitive scenarios for road and rail.

TABLE 2.2 FREIGHT RATE CHANGES FROM THE *CURRENT PRE–ANTS* TO *POST–ANTS* SITUATIONS

(per cent change)

	Scenario 1: Rail rates adjust to road rates	*Scenario 2: Rail rates adjust to rail costs*
FCL rail rate	–15	–8
FCL road rate	–15	–15
LCL road rate	–9	–9
Average freight rate[a]	–13	–10

Note a. The trend mode shares for interstate non-bulk land freight in 1994–95 were: FCL rail 33 per cent; FCL road 27 per cent; and LCL road 40 per cent.

Source BTE estimates.

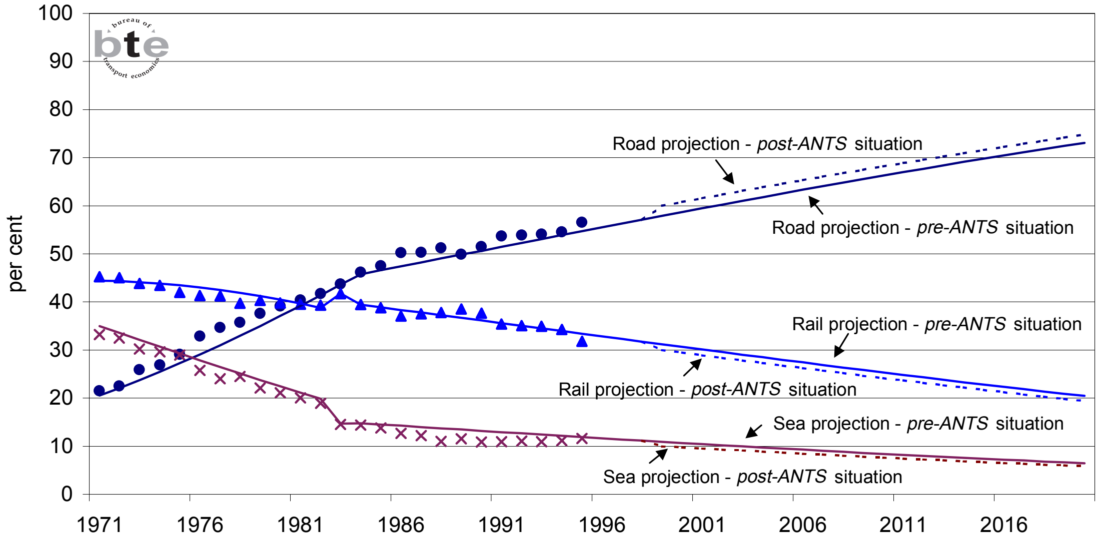
FREIGHT VOLUME AND SHARE CHANGES

Since both road and rail rates decline by the same proportion (FCL rail and road rate changes in table 2.2) in the first rate-setting scenario, freight will not shift between modes. However, since the introduction of ANTS would result in a general reduction in freight rates, relative to other input costs, this would induce a temporary increase in total freight growth. Under the GST, basic input prices are estimated to fall by 3 per cent (Costello, 1998), implying average freight rates will fall relative to other input costs. Additionally, the fiscal stimulus associated with the tax package would increase demand for final goods and therefore demand for transport services. These two factors would see growth in freight volumes rise by an additional half to one per cent above their customary four per cent. Since relative freight rates between road and rail are maintained, trends in mode share would not change (i.e. road continuing to increase share, rail and sea losing).

Under the second rate-setting scenario, in which rail rates declined less than road rates, there would be substitution from rail to road, as well as an increase, albeit smaller, in the growth in total freight (due to the general fall in freight rates). In this case, the average freight rate falls by 10 per cent — less than the increase under the first scenario where rail rates follow road rates down. As in the first scenario, the fall in freight rates relative to other production inputs would increase the demand for freight transport. Thus the overall volume changes will be similar to, but somewhat smaller than, the half to one per cent temporary increase in the growth rate discussed previously.

There will also be an impact on mode shares. The historical decline in rail's mode share is likely to be exacerbated by the introduction of ANTS. Notwithstanding continued growth in both modes, rail's share would drop from the current (1998) figure of 32 per cent to 30 per cent of total interstate non-bulk freight (including sea), and continue its long-term downward trend from there (figure 2.1).

figure 2.1 Interstate non-bulk mode share trends under the *current pre–ANTS* and *post–ANTS* situations



Source BTE estimates.

TABLE 3.1 A *COMPETITIVELY NEUTRAL* SCENARIO:
ROAD AND RAIL COSTS

(cents per ntkm)

	Category	Current post–ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD
	B	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]	-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]		-9		6

Note a. Percentage change from previous case, i.e. *pre–ANTS* to *post–ANTS* and *post–ANTS* to *competitive neutrality*.

Source Appendix III.

CHAPTER 3 A *COMPETITIVELY NEUTRAL* SCENARIO

Under the *competitively neutral* pricing scenario, each mode bears the full costs of its operation, including any social (private plus public) cost it imposes on the system.

It may not be efficient in terms of usage to require that each mode recover fully all of the private and public costs for its use of infrastructure. For example, if a road, once built, is relatively uncongested and has no close substitutes, then an efficient level of use is achieved if each vehicle is charged only for the damage it causes to the road, to other users, and to the environment. In other words, pricing above avoidable, or marginal, cost (say to achieve full cost recovery) would lead to less than efficient road utilisation.

However, utilisation is only one aspect — provision being the other. Full cost recovery may be desired to cover the costs of road provision. For example, where institutional constraints require full cost recovery in any one mode, say rail, then efficient pricing and investment may imply full cost recovery in all competing modes, such as road, to ensure efficient allocation of resources among the modes.

The assumption was made in this paper that full cost recovery for each mode would be required under a *competitively neutral* pricing system. Mechanisms exist to achieve this outcome with minimal distortions. Prices based on inverse elasticities (often referred to as Ramsey pricing) and/or multi-part tariffs provide scope for recovering costs while minimising the impact on efficient usage. For this study a two-part road user tariff, consisting of a fixed component (registration fee) and a variable component (essentially a road-wear charge), was adopted.

RESULTS

The main differences between the *current post–ANTS* situation and the *competitively neutral* scenario relate to infrastructure use charges (table 3.1, rows: 11 to 14), sales tax (row: 15) and charges for externalities (rows: 18, 20, 22 and 23).

In the *competitively neutral* scenario a two-part road user tariff was estimated (see appendix II). Using this model the road-wear component for a 6-axle articulated truck over the arterial network is of the order of 0.63 cents per ntkm (cell: H12). The fuel excise is removed and a mass-distance charge, reflecting the cost of road-wear, is implemented.

Another 0.34 cents per ntkm would be necessary (charged as a fixed annual amount — cell: H14) to fully recover current network expenditure. This represents an annual registration fee for a 6-axle articulated truck of about $12 900 per year — versus the currently NRTC-*costed* $8000 per year and the currently NRTC-*charged* $4000 per year (lower, in part, due to the cross-subsidy from smaller trucks). All up, a 6-axle articulated truck travelling interstate 189 000 km / year would pay $36 700 per year in infrastructure use charges ($12 900 rego and $23800 mass-distance charge) an increase of 67 per cent over current charges.

Rail would no longer be exempt from tariffs on locomotives (cell: G16) or stamp duty (cell: G17).

Another major change resulting from the imposition of a *competitively neutral* charging system is the application of explicit charges for externalities.

Road and rail would each pay for the non-insured costs of accidents (much higher for road — cells: G18, H18). New charges for congestion, pollution and noise would nevertheless be low, because most of the interstate journey is outside urban areas (cells: H20, G22, H22, G23 and H23). Greenhouse gas costs were not calculated because of the large degree of uncertainty associated with estimating both potential climate change and the costs associated with ameliorating or adapting to this change. Road, however, emits more than three times the greenhouse gases emitted by rail per unit of freight task — 71g of CO_2 / ntkm for road versus 23g of CO_2 / ntkm for rail (BTCE 1995b, p. 181).

The net effect of the changes (principally full infrastructure charging for road and charging for externalities) would be to raise rail FCL rates by 4 per cent, road FCL rates by 12 per cent and LCL rates by 6 per cent relative to the *current post–ANTS* situation. Rate changes for B-doubles would be similar to those calculated for 6-axle semis.

Compared with the *pre-ANTS* situation, the *competitively neutral* scenario, in conjunction with ANTS, would reduce both road and rail's input costs by 5 per cent. Assuming changes in costs are reflected in rates, there would be no change in relative freight rates, and hence no impact on mode shares. However, if competitive pressures are different in each mode, there may be differences in how costs are passed on.

RATE-SETTING SCENARIOS

What might be the effect on freight volumes of cost/rate changes under a *competitively neutral* pricing scenario relative to the *current post-ANTS* situation? Again, like the change induced by introduction of ANTS, the effect on freight volumes and mode share will depend mainly on what mechanism one assumes for the setting of rail freight rates.

There are again two possible extreme rail rate-setting scenarios.

Scenario 1: Road sets the rates in interstate traffic. Rail rates rise to match the increase in road rates. Rail profit would rise.

Scenario 2: Alternatively, competition from new entrants in the rail business limits growth in rail rates equal to rail cost changes under the *competitively neutral* scenario.

Table 3.2 summarises rate changes for the *competitively neutral* scenario. Rates for sea freight were assumed to remain unaffected by any changes in competitive scenarios for road and rail.

TABLE 3.2 FREIGHT RATE CHANGES FROM THE *CURRENT POST–ANTS* SITUATION TO THE *COMPETITIVELY NEUTRAL* SCENARIO

(per cent change)

	Scenario 1: Rail rates adjust to road rates	*Scenario 2: Rail rates adjust to rail costs*
FCL rail rate	+12	+ 4
FCL road rate	+12	+12
LCL road rate	+6	+6
Average freight rate[a]	+10	+7

Note a. The trend mode shares for interstate non-bulk land freight in 1994–95 were: FCL rail 33 per cent; FCL road 27 per cent; and LCL road 40 per cent.

Source BTE estimates.

FREIGHT VOLUME AND SHARE CHANGES

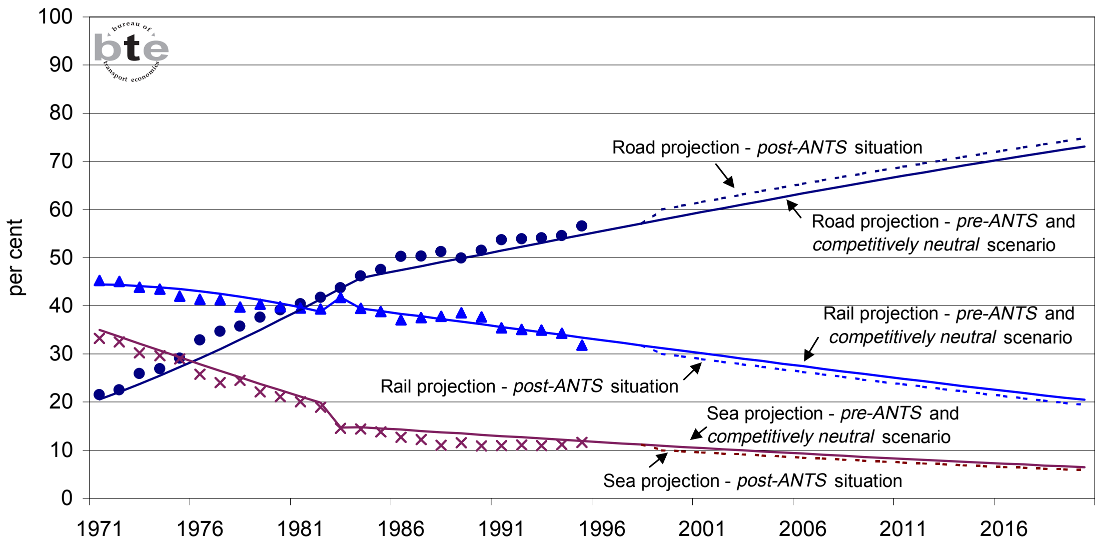
Since both road and rail rates decline in the first rate-setting scenario freight will not shift between modes. (FCL rail and road rate changes in table 3.2). However, the 10 per cent increase in the average freight rate under this rate-setting scenario should see a temporary reduction in total freight growth. In other words, freight volumes would rise by one percentage point less than their customary four per cent in the year of introduction (i.e. one year of a reduced three per cent growth rate — hardly enough to notice, given the high growth in freight traffic). Trends in mode share would remain unchanged (i.e. road continuing to increase share; rail and sea losing share).

Under the second rate-setting scenario, in which rail rates increase less than road rates, there would be substitution from road to rail, as well as a temporary reduction in growth in total freight (due to the general rise in rates).

In this case, the average freight rate goes up 7 per cent — less than the increase under the first scenario where rail rates follow road rates. Thus the overall volume changes will be similar to, but somewhat smaller than, the 1 per cent temporary decrease in the growth rate discussed previously.

There will also be one-off mode shift effects. Rail mode share is likely to increase briefly from the current (1998-99) *post-ANTS* figure of 30 per cent, to around 32 per cent of total interstate non-bulk freight (including sea), before resuming its long-term downward trend. Assumed past trends continue, rail's share is likely to be back to 30 per cent within three years after the change in rate relativities (figure 3.1).

figure 3.1 Interstate non-bulk mode share trends under the *current post–ANTS* and the *competitively neutral* scenario



Source BTE estimates.

In combination with ANTS, *competitive neutrality* may lead to relatively lower rail freight rates, but it may have little impact on the long-run trend in which rail loses mode share. This is partly due to the small change in relative prices estimated, but also due to the impact of non-price factors (such as reliability and flexibility) on the competition between road and rail.

By way of comparison, relative to the *current pre-ANTS* situation, *competitive neutrality*, combined with ANTS, would see both road and rail FCL charges fall by approximately 5 per cent. There would be no change in *relative* interstate non-bulk road and rail freight rates for the representative routes analysed here. The impact on total freight demand would depend on the change in freight rates relative to other input prices.

While only small changes in mode share can be expected, long-run efficiency gains are anticipated from improved heavy vehicle road pricing and charging for externalities.

CHAPTER 4 A *NEW TECHNOLOGY* SCENARIO

Road and rail currently compete mainly in the full container load / full truck load (FCL) market, and rail charges a significantly lower rate reflecting its lower quality of service.

Table 2.1 shows that the current pre-ANTS FCL rail rate is about 5.0 cents per ntkm while the full truck load rate is 5.8 cents per ntkm. Rail does not generally compete in the less-than-full truckload (LCL) market, where rates are considerably higher — about 11 cents per ntkm.

While the previous analysis has assumed there will be no significant departure from past trends, it is very difficult to anticipate the market. One development on the horizon that could change the competitive position of rail, is a ‘new rail’ venture by RailRoad Technologies (1998).

RailRoad Technologies plans to load all sizes of truck trailers (essentially less-than-full truck load traffic) onto flatbed rail cars at city outskirts (where city rail congestion is avoided). If successful, costs could fall significantly below LCL rates.

Door-to-door LCL costs with this new rail service are likely to be above the prevailing FCL rail rates (table 3.1). However, it is anticipated that they will be about 25 per cent below competing road LCL rates, where freight has to be consolidated from small trucks to large trucks in road terminals, shipped, and then deconsolidated at the other end.

This cost advantage, however, will be crucial only because the quality of this new rail service could equal that of road on a route such as Sydney–Melbourne. For example, a truck in Melbourne could load goods at a store in St Albans, and have its trailer driven onto a train for the journey to Sydney, where a prime mover could drive the trailer off the train direct to a store in Cabramatta. The service essentially combines the line-haul advantage of rail with the door-to-door road delivery of less-than-full container freight consignments. This innovative blending of the modes can have the same effect as new technology, resulting in a service which is neither road nor rail.

FREIGHT VOLUME CHANGE UNDER A *NEW TECHNOLOGY* SCENARIO

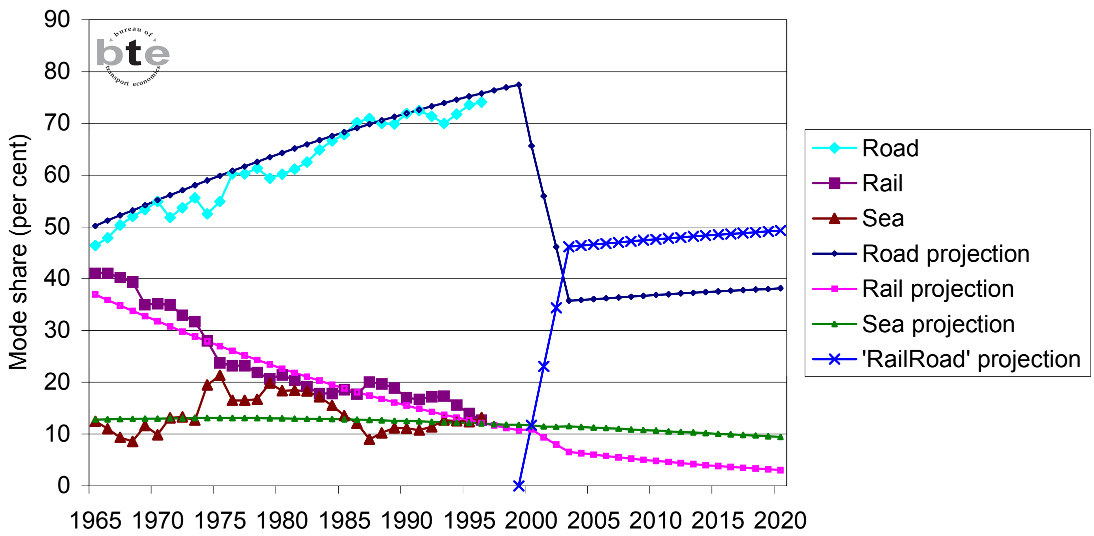
The change from the *current pre-ANTS* situation to the *competitive neutrality* scenario is estimated not to change road and rail's relative operating costs for interstate non-bulk freight. Hence, there is unlikely to be any departure from current trends in terms of freight mode shares.

It is possible that the new technology approach of RailRoad Technologies might alter that balance by positioning 'new rail' to offer a similar quality of service to road in the LCL market but with substantial decreases in rates.

If the new rail mode meets its targets, it might take a substantial share away from road permanently. Figure 4.1 shows RailRoad Technologies' expectations (RailRoad Technologies 1998, pp. 1524–1525) for the new operation to open in 1999 on the Sydney–Melbourne route. In five years time, full realisation of RailRoad Technologies' plans would see it achieve a 50 per cent share of all Melbourne–Sydney freight traffic. This compares with what would be an almost unchanged share of about 10 per cent for 'old' rail on the Sydney–Melbourne corridor (figure 1.6), even if the changes to charging outlined under the *competitively neutral* scenario in chapter 3 were implemented.

The projections in figure 4.1 derive from the business plan of Railroad Technologies. While the BTE neither endorses or refutes these projections, the contrast of the changes in mode share envisioned here, with those calculated in association with competitive neutrality price changes, is instructive.

figure 4.1 Freight mode split projection, Sydney–Melbourne — RailRoad Technologies plans



Sources BTE estimates; RailRoad Technologies 1998.

TABLE 5.1 ROAD AND RAIL CHARGES UNDER THE *CURRENT PRE-ANTS* AND *POST-ANTS* SITUATIONS AND UNDER THE *COMPETITIVELY NEUTRAL* (POST-ANTS) SCENARIO

(cents per ntkm)

	Category	Current pre–ANTS		Current post–ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD	RAIL	ROAD
	B	C	D	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.30	0.93	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.21	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.48	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]			-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]				-9		6

Note a. Percentage change from previous case, i.e. *pre–ANTS* to *post–ANTS* and *post–ANTS* to *competitive neutrality*.

Source Appendix III.

CHAPTER 5 CONCLUSIONS

The BTE was asked to review the issue of competitive neutrality between the road and rail sectors. In order to keep the task tractable, the BTE restricted its analysis to interstate non-bulk road and rail freight transport, the main area of competition between road and rail.

The BTE has estimated road and rail charges and input costs for three different scenarios. The *current pre-ANTS* situation presents estimates of road and rail charges and input costs applying in 1998-99. Since this study commenced, legislation was passed for the Commonwealth Government’s new tax system (ANTS). The *current post-ANTS* situation presents estimates of road and rail charges and input costs that would have applied in 1998-99 had ANTS applied then. The *current pre-ANTS* and *post-ANTS* situations were compared with a *competitively neutral* (post-ANTS) scenario, where both rail and road operators are charged the additional costs their operations impose on the system — a competitively neutral scenario promoting economically efficient allocation of resources between road and rail. The main reforms needed to achieve the *competitively neutral* scenario are to impose charges on heavy vehicles that more fully reflect the cost of heavy vehicle road use, and ensuring that both road and rail operators face the full cost of all externalities.

Table 5.1 presents estimates of road and rail charges and input costs for the three scenarios.

The main changes between the *current pre-ANTS* and *post-ANTS* situations are the replacement of wholesale sales taxes with the GST, previously paid by road operators on capital and other inputs, and the introduction of the diesel fuel rebate for rail and road freight operators. It has been estimated that the full implementation of ANTS would reduce both road and rail input costs (and consequently charges) — rail by 8 per cent and road (FCL traffic) by 15 per cent. While the freight task of both will continue to grow, these price changes are anticipated to hasten the decline in rail’s share.

Introduction of the *competitively neutral* scenario, given ANTS, would see both road and rail input costs and charges rise relative to the *current post-ANTS* scenario — road by 12 per cent and rail by 4 per cent. However, it is worth keeping in mind that the increase in infrastructure charges for road freight depends on estimates of efficient pricing for roads. A major difficulty in setting prices for road use, using current technology, is that a network-wide price must be set, but road-wear costs, for a given vehicle type, vary dramatically across the network. The figure adopted in this exercise is the best estimate for the road costs associated with a six-axle articulated truck on an arterial road, reflecting the fact that most heavy vehicle travel takes place on arterial roads. The cost of road-wear for the same vehicle on a lower standard road would be considerably higher.

Table 5.2 summarises the estimated cumulative impact on road and rail charges of moving from the *current pre-ANTS* to the *post-ANTS* situation, and the subsequent introduction of a *competitively neutral* scenario on interstate road and rail charges. The reference point is the *pre-ANTS* situation, where road and rail charges are set equal to 100. The table shows that implementation of ANTS followed by the introduction of the *competitively neutral* scenario would see both road and rail charges fall by approximately 5 per cent, relative to the *current pre-ANTS* situation. This would imply virtually no change in the relative price of road and rail freight for the representative routes analysed. While there is no change in the relative price of road and rail freight from the current situation, introduction of a *competitively neutral* pricing regime would yield benefits through the more efficient pricing of transport inputs.

TABLE 5.2 IMPACT OF *ANTS* AND *COMPETITIVE NEUTRALITY* ON ROAD AND RAIL COSTS

	Rail	*Road*
Current pre-ANTS	100	100
Post-ANTS	92	85
Competitive neutrality	95	95

Source Table 5.1.

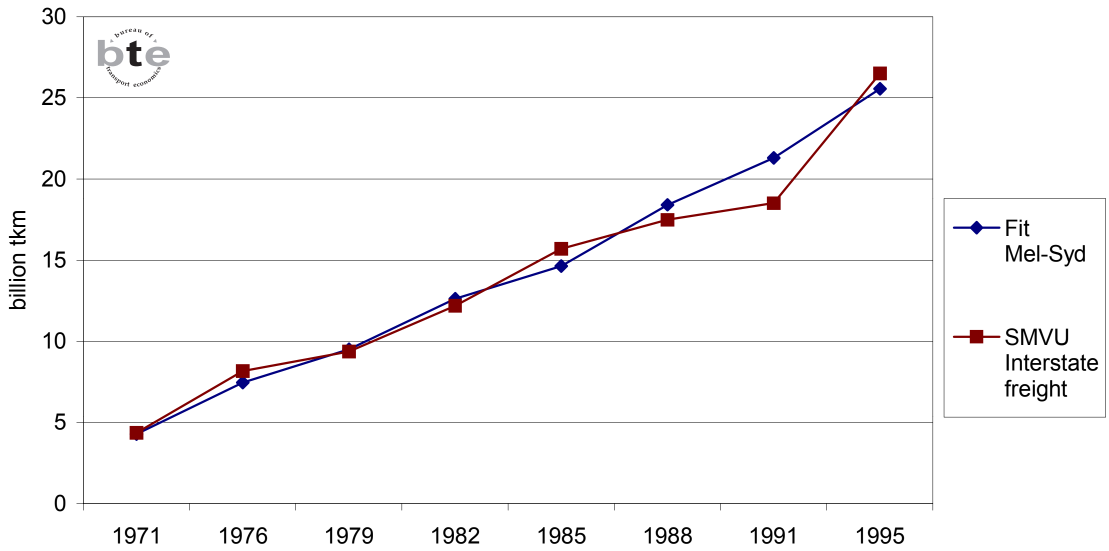
Fundamentals could change in the transport industry, along the lines of the innovative blending of modes planned by RailRoad Technologies (see Chapter 4). This 'new rail' seeks to capitalise on the strengths of both modes and to solve some of the pressing logistics problems of 'old rail' (terminal configuration / location and congestion on city lines) while competing for LCL traffic at lower rates than road. However, in the absence of such fundamental shifts, the relative competitive positions of road and rail for non-bulk freight is unlikely to change.

APPENDIX I INTERSTATE NON-BULK FREIGHT MODELS

Data sources and construction of estimates

The data on interstate road freight are taken from the Survey of Motor Vehicle Use (SMVU, ABS 1996 and earlier issues), interpolated using estimates of road freight derived from truck counts at Marulan on the Hume Highway (BTCE 1990b, p. 75). A regression of SMVU ntkm on Melbourne–Sydney tonnes, plus a time trend from 1975–76 to 1994–95, gave the fit shown in figure I.1. Only the Melbourne–Sydney data in SMVU years were used in the regression, but once calculated, the equation allowed interstate road freight for intervening years to be estimated. These are the estimates presented in table I.1.

Figure I.1 SMVU Non-bulk Interstate Freight and Fit



Sources BTCE estimates; ABS 1996 and earlier issues.

Data on total interstate rail freight tonnes were sourced from the National Rail Corporation and individual systems. A break in the series in 1993-94 was allowed for by adjusting upwards by 12.5 per cent all data before that year. The resulting series of total interstate rail freight also contained some bulk freight. A series of interstate *non-bulk* rail freight tonnes was derived by multiplying by a 'non-bulk fraction'. Information on the size of this fraction over time came from numerous sources, and resulted in an assumed upwards trend from 75 per cent in 1970–71 to almost 90 per cent in 1994-95. Multiplying the 'total interstate rail freight' series, by the 'non-bulk fraction' series, and by an assumed average haul of 1650 kilometres (BTCE 1996a), gave the estimates of interstate non-bulk rail ntkm shown in table I.1.

TABLE I.1 THE INTERSTATE NON-BULK FREIGHT TASK

(billion ntkm)

Year ending June	*Total*	*Road*	*Rail*	*Coastal shipping*
1971	19.81	4.26	8.96	6.58
1972	20.19	4.54	9.08	6.56
1973	20.77	5.38	9.12	6.27
1974	22.13	5.95	9.62	6.56
1975	21.49	6.25	9.02	6.22
1976	22.63	7.44	9.35	5.84
1977	23.39	8.11	9.66	5.62
1978	23.73	8.49	9.42	5.82
1979	25.31	9.51	10.21	5.59
1980	27.66	10.81	11.01	5.84
1981	29.05	11.73	11.48	5.84
1982	30.24	12.62	11.89	5.73
1983	27.19	11.88	11.34	3.96
1984	30.53	14.10	12.04	4.39
1985	30.82	14.64	11.94	4.24
1986	32.24	16.19	11.96	4.09
1987	33.13	16.66	12.43	4.05
1988	35.93	18.41	13.58	3.94
1989	39.63	19.77	15.28	4.59
1990	41.05	21.13	15.44	4.48
1991	40.54	21.77	14.35	4.43
1992	41.15	22.15	14.45	4.55
1993	43.56	23.57	15.22	4.78
1994	45.44	24.77	15.59	5.08
1995	46.02	26.02	14.65	5.36

Note Figures may not add to total due to rounding.

Sources BTE estimates; BTE Coastal shipping database; ABS 1996 and earlier issues, ABS 1997 and earlier issues, DoT 1995 and earlier issues.

Data on coastal shipping came from the Commonwealth Department of Transport and Regional Development. 'Cargo tonnes' as used prior to 1980–81 were translated into tonnes by multiplying by 0.66. Multiplying by an assumed average haul of 1400 kilometres (BTCE 1996) gave the estimate of interstate non-bulk shipping ntkm given in table I.1.

Estimated equations for the interstate freight model

Total interstate freight was estimated with a single equation in the levels (using the natural logarithm transformed raw data). Freight is related to economic activity, its ultimate generator, and a simple ordinary least squares (OLS) regression results in a consistent estimator of the coefficient on GDP. The simple OLS coefficient on the natural logarithm of real GDP was 1.23. Given autocorrelation, the equation was re-estimated using the Cochrane–Orcutt technique, resulting in a coefficient of 1.28 for real GDP (that is, the income elasticity).

TABLE I.2 ESTIMATED EQUATION FOR TOTAL INTERSTATE FREIGHT

Variable	*Estimated Coefficient*	*t-statistic*
Constant	–12.668	–17.22
ln real GDP	1.277	21.91

Notes Dependent variable: natural logarithm of total interstate freight (billion ntkm)
Estimation method: Cochrane-Orcutt, Rho = 0.48
Adjusted R^2 = 0.99
Estimation period: 1970–71 to 1994–95

Source BTE estimates.

Mode share equations were estimated using logistic substitution models. The logistic substitution model is an evolutionary model of technology use (see chapter 1). In this case technology refers to the freight transport mode. The model is based on the following simple assumptions:

1. each technology at time *t* can be characterised by a single index describing its performance (its index of competitiveness); and
2. the amount of technology *i* in use at time *t+1* is proportional to the amount of technology in use in the previous period and its competitiveness.

These assumptions give an ‘evolution’ equation:

$$f_i(t+1) = \ln\left(\frac{c_i}{c_{av}}\right) f_i(t), \text{ for each } i. \quad \text{(I.1)}$$

where

$f_i(t)$ = the share of total freight transport of mode *i* at time *t*;

c_i = the competitiveness of technology *i*; and

$c_{av}(t)$ = the average competitiveness of all modes at time *t*.

Rearranging equation I.1 and back-substituting gives equation I.2:

$$\ln\frac{f_i(t)}{f_k(t)} = \ln\frac{f_i(t_0)}{f_k(t_0)} + \ln\left(\frac{c_i}{c_k}\right)(t - t_0) \quad \text{(I.2)}$$

where subscript *k* denotes the base, or reference, mode (in this case taken as road).

Equation I.2 is then estimated using the estimating equation I.3:

$$y_i(t) = a_i + b_i(t - t_0) \quad \text{(I.3)}$$

where $y_i(t) = \ln \frac{f_i(t)}{f_k(t)}$, $a_i = \ln \frac{f_i(t_0)}{f_k(t_0)}$ and $b_i = \ln\left(\frac{c_i}{c_k}\right) = \ln c_i$ (as $c_k = 1.0$).

Once b_2 for rail (for example) has been estimated, the competitiveness index of rail can be calculated as $c_2 = \exp(b_2)$.

In 1982–83, there was a large decline in the share of interstate freight transport carried by coastal shipping. To account for the shift in competitiveness before and after this event, separate competitiveness indexes were calculated for the pre- and post-1983 periods. The estimates are given in tables I.3 and I.4.

TABLE I.3 FREIGHT TRANSPORT LOGISTIC SUBSTITUTION MODEL — PARAMETER ESTIMATES, 1971 TO 1982

Mode	*i*	*a*	*b*	*c*
Road	1	–	–	1.00
Rail	2	0.7709	–0.0759	0.927
Sea	3	0.5318	–0.1148	0.892

Note Road was used as the base mode.

Source BTE estimates.

TABLE I.4 FREIGHT TRANSPORT LOGISTIC SUBSTITUTION MODEL —PARAMETER ESTIMATES, 1983 TO 1995

Mode	*i*	*a*	*b*	*c*
Road	1	–	–	1.00
Rail	2	0.3311	–0.0344	0.966
Sea	3	–0.6722	–0.0407	0.960

Note Road was used as the base mode.

Source BTE estimates.

APPENDIX II NON–URBAN ROAD PRICING — A REVIEW

In general, efficient charges for non-urban road use would require at least charging each vehicle for the wear and tear (deterioration) it causes to the pavement. Road-wear is a function of the strength of the road, environmental factors and cumulative axle loadings. This appendix sets out the theory of pricing for non-urban road use and compares the BTE's estimates of efficient heavy vehicle charges with the NRTC's current charges.

In comparison with an efficient charging regime, the BTE results indicate that heavily laden heavy vehicles are presently undercharged, lightly laden heavy vehicles overcharged, and that the current imputed fuel excise credit does not recover the road-wear costs caused by heavy vehicles. Some form of mass-distance charge would be more efficient.

Table II.1 presents the main findings. The BTE estimates the avoidable cost of road-wear attributable to a 6-axle articulated truck, carrying a 20–tonne load, at 0.63 cents per ntkm for arterial roads. Average fixed costs allocated to heavy vehicles mean an additional 0.34 cents per ntkm for the same vehicle configuration. Average total cost attributable to heavy vehicles is thus approximately 1.0 cent per ntkm, appreciably higher than the NRTC's current total charge of approximately 0.64 cents per ntkm (assuming 20 cents per litre imputed fuel use charge).

Table II.1 provides estimates of heavy vehicle costs using two other cost allocation methods. Luck & Martin's 'cost-occasioned' methodology (BTE 1988), when applied to current expenditure and road use, results in heavy vehicle costs of approximately 1.1 cents per ntkm. Life cycle cost estimates, derived from the BTE's pavement life cycle cost (LCC) model for the National Highway System, give a figure of about 0.8 cents per ntkm.

Road wear costs vary significantly across different roads. National Highway System roads are generally built to a higher level of durability to cater for higher traffic levels. Hence the marginal cost of road-wear of a heavy vehicle on the National Highway System will be less than the marginal cost of the same vehicle on the arterial road network. Consequently, higher trafficked roads are generally the lowest marginal cost roads (e.g. Sydney–Brisbane in table II.1).

TABLE II.1 ARTERIAL ROAD NETWORK COSTS — 6-AXLE ARTICULATED TRUCK, 20-TONNE LOAD

(cents per ntkm at 1997–98 prices)

Source	*Road-wear cost*	*Average fixed cost*	*Average total cost*
BTE (Arterial roads)	0.63	0.34	0.97
NRTC (Arterial roads)	0.39	0.21	0.60
Luck & Martin (Arterial roads)	0.75	0.33	1.08
BTE LCC model (All major corridors)	0.44	0.46[a]	0.90
BTE LCC model (Sydney–Brisbane)	0.29	0.27[a]	0.56
BTE LCC model (Adelaide–Perth)	0.59	0.70[a]	1.29

Notes BTE LCC denotes the BTE's road pavement life cycle cost model (BTE 1990).

a. The average fixed costs for these links, and for all National Highways were calculated as the annualised replacement cost attributable to heavy vehicles (tables II.4 and II.8) divided by heavy vehicle usage.

Sources BTE estimates; BTCE 1992, 1990; BTE 1988; NRTC 1998; NAASRA 1976.

THEORY OF ROAD PRICING

The first and crucial requirement for the efficient pricing of roads is that trip-makers pay directly all the social (private and public) costs of the trip. For non-urban truck use this essentially means recovery of road-wear costs for each trip. Because road-wear rises exponentially with load, this is most efficiently done with some form of mass-distance charge.

However, road provision is generally a declining cost industry. As traffic levels increase, thicker and more durable pavements are warranted, resulting in lower average road-wear costs. Efficient road use pricing based on these lower road-wear costs will result in a larger (capital cost) deficit for the road provider. Thus, additional fixed charges imposed on road users (e.g. through vehicle registration charges) are required if policy makers wish to recover some or all of the residual cost of road provision. In addition, setting charges to recover capital as well as maintenance costs provides a link between investment and pricing. In other words, '… efficiency in resource use has sometimes to be sacrificed for efficiency in investment' (Roth 1996, pp. 99-100).

A range of pricing schemes can satisfy a budget constraint while minimising efficiency losses. The more common schemes are:

- average cost pricing;
- Ramsey (inverse elasticity) pricing; and
- multi-part pricing.

Average cost pricing

Average cost pricing, as the name implies, means that prices are set equal to average cost. Average cost pricing ensures that the budget constraint is satisfied, but at the cost of reducing the efficient level of usage. There are many industries where, despite a relatively low marginal cost, prices are set closer to average cost than marginal cost. For example, the marginal cost of including an additional user is close to zero (up to the point of congestion) for urban public transport, computer software, and airlines.

Ramsey (inverse elasticity) pricing

Ramsey pricing involves raising price above marginal cost in inverse proportion to the price elasticity of demand — in simple terms, 'what the market will bear'. The principle underlying Ramsey pricing is that the total loss in efficiency from meeting a budget constraint is minimised where the marginal efficiency loss is equal across different markets. Ramsey pricing, although it involves some efficiency loss in comparison to marginal cost pricing, is generally superior to average cost pricing because there is scope to differentiate between users and thereby reduce the total efficiency loss. Ramsey pricing, however, may involve additional administrative costs associated with determining and maintaining estimates of the various price elasticities and mark-up for each market segment.

Multi-part pricing

Multi-part pricing combines marginal cost pricing with additional, often fixed, charges designed to recover total cost. The most common form of multi-part pricing is two-part pricing, comprising a price for each unit, set equal to marginal cost, and an access fee designed to recover fixed costs. Most utilities, such as water, electricity and telecommunications, use two-part pricing.

While two-part pricing may result in no efficiency loss from marginal use, efficiency losses may still occur to the extent that some users, whose net benefits are less than the access fee, do not use the service. Two-part pricing will generally be superior to average cost pricing because there is scope to differentiate access fees between users, charging users with a higher valuation a higher access fee, and users with a lower valuation a lower access fee.

The NRTC's current road user charges are an example of two-part pricing. The NRTC treats 20 cents per litre of diesel fuel excise as a road use fee and levies an annual vehicle registration charge differentiated by vehicle type as the access fee. The road use fee does not reflect marginal cost as it does not correlate with road-wear.

The heavy vehicle charging schedule derived by the BTE for chapter 4 is also a multi-part pricing scheme. Two-part or multi-part pricing is often preferred in practice because it is generally more efficient and simpler to implement than Ramsey pricing.

Second-best pricing rules

In reality, there are distortions in many markets. It may be that, where institutional or other constraints prevent those distortions from being removed, setting price equal to marginal cost may not be the most efficient approach. Where there are two or more related markets, and marginal cost pricing is not achievable in any one market, it may be more efficient to set prices so that demand in each market is closer to the level that would occur if prices were equal to marginal cost everywhere.

For example, consider long-distance road and rail freight. Suppose road users did not pay the full (marginal) cost of road-wear, and that it was not possible to alter this. It may be more efficient, then, to allow rail to price below marginal cost, such that the marginal efficiency loss in the rail market is just equal to the marginal efficiency gain achieved through the diversion of traffic from road to rail.

Marginal cost (or ‘first-best’) pricing is often preferred because it is simpler to calculate, and the additional benefits of second-best pricing over first-best pricing, are relatively small (Friedlaender and Mathur, 1982, p. 214). Further, implementing second-best pricing imposes additional costs in information collection and analysis. Second-best pricing rules were not estimated for this Working Paper. Rather, marginal cost pricing rules were derived, and access fees were set, to ensure full recovery of costs.

COST RECOVERY IN PRACTICE

In practice, road cost recovery may be achieved in two main ways:

- PAYGO — current expenditure-based approach; or
- LCC — life cycle cost-based approach.

PAYGO approach

The NRTC’s PAYGO approach assumes that the costs of road use are equal to a 3-year rolling average of actual and budgeted road expenditure. Road expenditure is categorised by type of expenditure, such as maintenance, construction, and miscellaneous expenditure. Expenditure is allocated among different road users (vehicle type) based on road use giving rise to that expenditure. Road use variables used to allocate costs include vehicle kilometres (vkt), passenger car equivalent kilometres (pcu-km), gross vehicle mass kilometres (gvm-km) and equivalent standard axle load kilometres (esal-km).

Under the PAYGO approach, expenditure allocated to different vehicle types depends critically on the assumptions about the allocation of costs between vehicle types and the scope of the road network under consideration.

Road expenditure is separated by type (NRTC 1998, table 2.3, p. 17) and each type of expenditure is allocated among vehicle classes using the NRTC's expenditure allocation template (NRTC 1998, table 2.13, p. 27). The NRTC uses expenditure allocated to vehicle types to calculate heavy vehicle charges.

NRTC cost allocation

Table II.2 summarises the costs allocated to heavy vehicles using the NRTC's cost allocation method.

The NRTC estimated total arterial road expenditure to be $4210 million in 1997-98. Of this, $580 million was not allocated to vehicles, leaving $3630 million to be allocated by vehicle for the use of arterial roads. Column 1 lists the expenditure allocation between the NRTC's expenditure categories. Column 2 lists the proportion of costs that are non-separable (unable to be specifically attributed to vehicle types). Column 3 lists the total non-separable arterial road expenditure. Under the NRTC's current allocation procedure, non-separable expenditure is attributed to vehicle types using a very general vkt criterion. Column 5 lists the share of heavy vehicle vkt as a proportion of total vkt on arterial roads, and column 4 lists total road expenditure attributable to heavy vehicles (equals the product of column 3 and column 5). Column 7 gives total separable expenditure (that specifically attributable to vehicle types), column 10 the attribution parameter, and column 9 the proportion of separable costs attributable to heavy vehicles on the basis of the attribution parameter. Column 8 is then the amount of separable road expenditure attributable to heavy vehicles.

The NRTC estimated total avoidable pavement rehabilitation expenditure, the sum of routine maintenance, periodic surface maintenance and road rehabilitation expenditure, to be $517 million ($37 million plus $480 million). Six-axle articulated trucks account for about 45 per cent of all heavy vehicle esal-km on arterial roads and are thus assigned about $231 million of avoidable heavy vehicle costs. Dividing by 6-axle articulated trucks' total ntkm of 59 700 million and multiplying by 100 for cents implies that the NRTC attributes to heavy vehicles an avoidable road-wear cost of approximately 0.39 cents per ntkm. The total cost attributed by the NRTC to heavy vehicles is approximately 0.60 cents per ntkm.

Note, however, that the NRTC does not actually charge 0.60 cents per ntkm. Although the total charges for an interstate semitrailer are similar, the components differ. The actual NRTC charging regime is based on recovering a large proportion of the road-wear costs through a use-based imputed fuel excise of 20 cents per litre. This is not an efficient proxy for a true mass-distance charge: figure II.1 compares the fuel-based levy with mass-distance charging systems for road-wear in the present BTE study, with a previous one (BTE

1988), and with a life cycle cost model (BTCE 1990a). The NRTC's fuel-based system currently overcharges lightly loaded trucks and undercharges heavily laden trucks.

TABLE II.2 SUMMARY — NRTC ARTERIAL ROAD EXPENDITURE ALLOCATION 1997-98

	$ million
Total arterial road expenditures	**4210**
Non-allocated	**-580**
Vehicle registration	190
Driver licensing	160
Loan interest	160
Heavy vehicle regulation enforcement	70
Allocated costs	**3630**
of which:	

Type			Non-separable expenditure				Separable expenditure			
	Total	Proportion non-separable	Total	Heavy vehicles		Allocation variable	Total	Heavy vehicles		Allocation variable
Column no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Source	a	b	=(1)*(2)	=(3)*(5)	c		=(1)-(3)	=(7)*(9)	b,c	
	($ million)	*(per cent)*	*($ million)*	*($ million)*	*(per cent)*		*($ million)*	*($ million)*	*(per cent)*	
Servicing	300	100	300	21	7	vkt	0	0	0	
Routine maintenance	260	50	130	**9**	7	vkt	130	**130**	100	gvm-km
Reseals	240	50	120	**8**	7	vkt	120	**120**	100	gvm-km
Bridge repair	100	67	67	5	7	vkt	33	33	100	gvm-km
Road rehabilitation	510	55	281	**20**	7	vkt	230	**230**	100	esal-km
Low-cost improvements	200	0	0	0	7	vkt	200	18	9	vkt, pcu-km
Construction – pavements	740	55	407	28	7	vkt	333	333	100	esal-km
Construction – bridges	190	85	162	11	7	vkt	29	5	17	pcu-km
Construction – land	180	90	162	11	7	vkt	18	3	17	pcu-km
Construction – earthwork	270	90	243	17	7	vkt	27	5	17	pcu-km
Construction – other	410	90	369	26	7	vkt	41	7	17	pcu-km
Miscellaneous works	50	100	50	4	7	vkt	0	0	0	
Corporate services	170	100	170	12	7	vkt	0	0	0	
TOTAL	3620		2460	172			1160	883		
Avoidable cost				**37**				**480**		

Thus for heavy vehicles:

Arterial road expenditure

	Avoidable	Non-avoidable	Total
All vehicles	n.c.	n.c.	3630
Heavy vehicles	**517**	**539**	**1055**
Share avoidable (per cent)	14		

6–axle articulated trucks:

Proportion total esal-km (per cent)	**44.6**
Total ntkm (million)	**59700**
Number of vehicles	**30218**
Avoidable unit cost, all arterial roads (cents per ntkm)	**0.39**
Registration fees per truck ($ per annum)	**7946**
Total unit cost (cents per ntkm)	**0.60**

Notes Figures may not reconcile due to rounding. n.c. denotes not calculated.

a. NTRC 1998, p. 17.

b. NRTC 1998, p. 27.

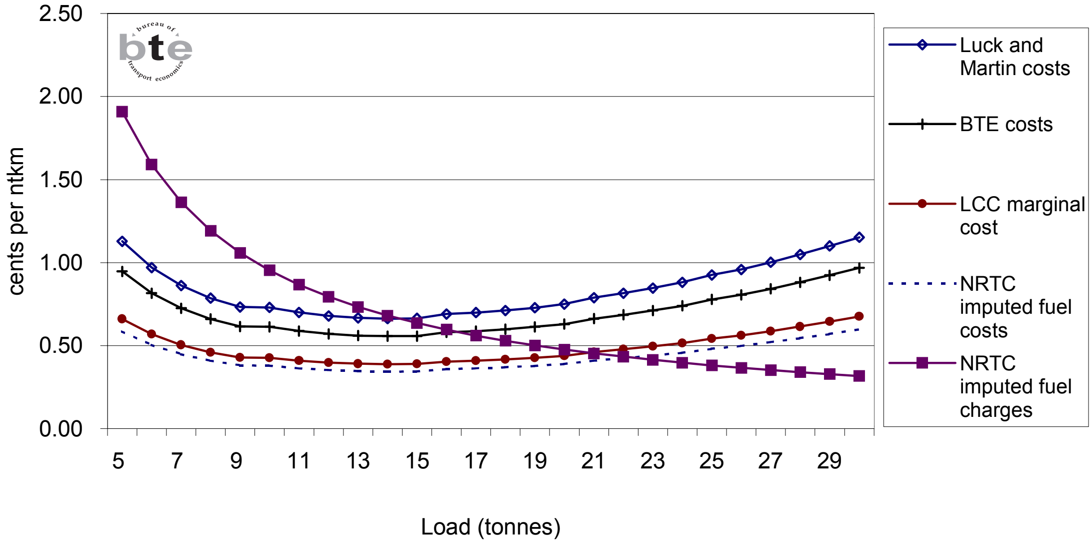
c. Share of heavy vehicle road use of all roads by criteria variable(s), NRTC 1998, p. 77.

Sources BTE estimates; NRTC 1998.

The sum of the rest of the non-avoidable truck costs, in columns 4 and 8, is $539 million. Six-axle articulated trucks are responsible for about 45 per cent of all heavy vehicle esal-km on arterial roads and are thus assigned about $243 million of non-avoidable heavy vehicle costs. Dividing by the number of 6-axle articulated trucks in the fleet gives a warranted registration charge of about $8000 per truck per year. This amounts to about 0.21 cents per ntkm for an average 6-axle articulated truck load and distance. Again, this is not what the NRTC actually charges (registration charges are currently $4000 per year for a

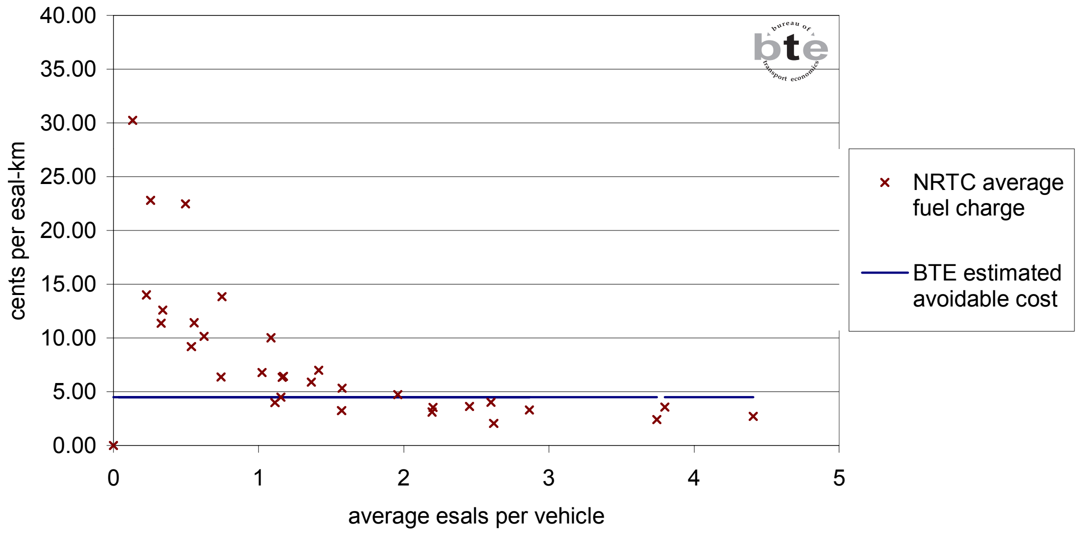
6-axle articulated truck, approximately 0.11 cents per ntkm) due to extensive cross-subsidisation from small trucks to large ones.

figure II.1 avoidable Road-wear costs and charges — 6-axle articulated truck



Sources BTE estimates; BTCE 1992, 1990; NRTC 1998; BTE 1988.

figure II.2 NRTC average hypothecated fuel charge and Avoidable Road-wear costs — all heavy vehicles



Sources BTE estimates; BTCE 1992, 1990; NRTC 1998.

TABLE II.3 SUMMARY — LUCK & MARTIN (BTE 1988) ARTERIAL ROAD EXPENDITURE ALLOCATION 1997–98

	$ million
Total arterial road expenditures	**4210**
Non-allocated	**-580**
Vehicle registration	190
Driver licensing	160
Loan interest	160
Heavy vehicle regulation enforcement	70
Allocated costs	**3630**
of which:	

Type			Non-separable expenditure				Separable expenditure			
	Total	Proportion non-separable	Total	Heavy vehicles		Allocation variable	Total	Heavy vehicles		Allocation variable
Column no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Source	a	b	=(1)*(2)	=(3)*(5)	c		=(1)-(3)	=(7)*(9)	b,c	
	($ million)	*(per cent)*	*($ million)*	*($ million)*	*(per cent)*		*($ million)*	*($ million)*	*(per cent)*	
Servicing	300	0	0	0	0		300	300	100	esal-km
Routine maintenance	260	0	0	0	0		260	**260**	100	esal-km
Reseals	240	0	0	0	0		240	**240**	100	esal-km
Bridge repair	100	0	0	0	0		100	28	28	vkt, pcu-km, gvm-km
Road rehabilitation	510	0	0	0	0		510	**510**	100	esal-km
Low-cost improvements	200	0	0	0	0		200	28	14	vkt, pcu-km
Construction – pavements	740	0	0	0	0		740	104	14	vkt, pcu-km
Construction – bridges	190	0	0	0	0		190	72	38	vkt, pcu-km, gvm-km
Construction – land	180	0	0	0	0		180	25	14	vkt, pcu-km
Construction – earthwork	270	0	0	0	0		270	38	14	vkt, pcu-km
Construction – other	410	0	0	0	0		410	57	14	vkt, pcu-km
Miscellaneous works	50	0	0	0	0		50	7	14	vkt, pcu-km
Corporate services	170	0	0	0	0		170	170	100	esal-km
TOTAL	3620	0	0	0			3620	1839		
Avoidable cost				0				**1010**		

Thus for heavy vehicles:

Arterial road expenditure

	Avoidable	Non-avoidable	Total
All vehicles	n.c.	n.c.	3630
Heavy vehicles	**1010**	**829**	**1839**
Share avoidable (per cent)	28		

6–axle articulated trucks:

Proportion total esal-km (per cent)	**44.6**
Total ntkm (million)	**59700**
Number of vehicles	**30218**
Avoidable unit cost, all arterial roads (cents per ntkm)	**0.75**
Registration fees per truck ($ per annum)	**12235**
Total unit cost (cents per ntkm)	**1.08**

Notes Figures may not reconcile due to rounding. n.c. denotes not calculated.

a. NTRC 1998, p. 17.

b. NRTC 1998, p. 27.

c. NRTC 1998, p. 77.

Sources BTE estimates; NRTC 1998; BTE 1988.

Furthermore, the current NRTC charging system is not efficient at allocating road-wear costs between vehicle classes. Figure II.2 illustrates the profile of the NRTC's current charging structure and costs for arterial road use. The figure plots the average imputed fuel revenue (cents per esal-km), for each of the NRTC's vehicle type classifications, and the average avoidable cost. On average, the NRTC's current charging regime over-recovers costs attributable to smaller vehicles and under-recovers costs attributable to heavier vehicles.

TABLE II.4 SUMMARY — BTE ARTERIAL ROAD EXPENDITURE ALLOCATION 1997–98

	$ million
Total arterial road expenditures	**4210**
Non-allocated	**-580**
Vehicle registration	190
Driver licensing	160
Loan interest	160
Heavy vehicle regulation enforcement	70
Allocated costs	**3630**
of which:	

Type			Non-separable expenditure				Separable expenditure			
	Total	Proportion non-separable	Total	Heavy vehicles		Allocation variable	Total	Heavy vehicles		Allocation variable
Column no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Source	a	b	=(1)*(2)	=(3)*(5)	c		=(1)-(3)	=(7)*(9)	b,c	
	($ million)	*(per cent)*	*($ million)*	*($ million)*	*(per cent)*		*($ million)*	*($ million)*	*(per cent)*	
Servicing	300	100	300	50	17	pcu-km	0	0	0	
Routine maintenance	260	20	52	**9**	17	pcu-km	208	**208**	100	esal-km
Reseals	240	20	48	**8**	17	pcu-km	192	**192**	100	esal-km
Bridge repair	100	33	33	6	17	pcu-km	67	19	28	vkt, pcu-km, gvm-km
Road rehabilitation	510	20	102	**17**	17	pcu-km	408	**408**	100	esal-km
Low-cost improvements	200	0	0	0	0		200	18	9	vkt, pcu-km
Construction – pavements	740	55	407	68	17	pcu-km	333	333	100	esal-km
Construction – bridges	190	55	105	40	38	vkt, pcu-km, gvm-km	86	86	100	gvm-km
Construction – land	180	90	162	27	17	pcu	18	3	17	pcu-km
Construction – earthwork	270	90	243	92	38	vkt, pcu-km, gvm-km	27	27	100	esal-km
Construction – other	410	90	369	62	17	pcu-km	41	7	17	pcu-km
Miscellaneous works	50	100	50	8	17	pcu-km	0	0	0	
Corporate services	170	100	170	28	17	pcu-km	0	0	0	
TOTAL	3620	773	2041	415			1580	1300		
Avoidable cost				**34**				**808**		

Thus for heavy vehicles:

Arterial road expenditure

	Avoidable	Non-avoidable	Total
All vehicles	n.c.	n.c.	3630
Heavy vehicles	**842**	**873**	**1715**
Share avoidable (per cent)	23		

6–axle articulated trucks:

Proportion total esal-km (per cent)	**44.6**
Total ntkm (million)	**59700**
Number of vehicles	**30218**
Avoidable unit cost, all arterial roads (cents per ntkm)	**0.63**
Registration fees per truck ($ per annum)	**12883**
Total unit cost (cents per ntkm)	**0.97**

Notes Figures may not reconcile due to rounding. n.c. denotes not calculated

a. NTRC 1998, p. 17.

b. NRTC 1998, p. 27.

c. NRTC 1998, p. 77.

Sources BTE estimates; NRTC 1998.

Table II.3 estimates the costs allocated to heavy vehicles using Luck and Martin's 'cost-occasioned' arterial road expenditure allocation approach (BTE 1988). Their allocation procedure, when applied to 1997–98 road expenditure and road use data, results in articulated trucks being allocated 1.08 cents per ntkm (for a 6-axle articulated truck carrying a 20-tonne load). The main differences between their approach and the NRTC approach are that: (i) all arterial road expenditure is considered to be separable; and (ii) avoidable road-wear expenditure is allocated using esal-km as opposed to the NRTC method where a combination of gvm-km and esal-km is used. Use of esal-kms will attribute a greater share of maintenance costs to heavy vehicles than gvm-km.

Additionally, Luck and Martin allocated a greater share of other (non-maintenance) road expenditures to heavy vehicles than the NRTC.

Table II.4 shows the cost allocation results using the BTE's allocation assumptions for this study. The avoidable cost is estimated to be 0.63 cents per ntkm, for a 6-axle articulated truck carrying a 20-tonne load. The total cost is estimated to be 0.97 cents per ntkm.

The main differences between the BTE's cost allocation and the NRTC's cost allocation is that the BTE attributes 80 per cent of avoidable road-wear expenditure to heavy vehicles on the basis of esal-kms. Also, non-separable road expenditure is attributed to vehicles predominantly on the basis of pcu-kms, resulting in a greater proportion of non-separable cost being allocated to heavy vehicles than under the NRTC's approach.

Life cycle approach to estimating road-wear costs

The BTE also estimated road-wear costs by using a life cycle cost model of the Australian road system.

The life cycle approach to road costs involves analysing the total cost of a road over the whole of its life, from time of design and construction, through operation, until retirement. Life cycle costing can be used to assess the cost of road use by different vehicle types. It provides more reliable estimates of road use costs than the PAYGO expenditure-based costing, but requires substantially more information.

The marginal cost of road use depends on the share of pavement deterioration (road-wear) attributable to traffic. In short, road-wear is mostly caused by the interaction of weathering and heavy vehicle traffic. Newbery (1988) demonstrated that where (1) traffic is the sole source of road-wear, (2) traffic flow is constant over time, and (3) the pavement is restored to its initial condition when roughness reaches a critical level, then the marginal cost of road-wear is equal to the average discounted present value of all future pavement rehabilitation expenditure, averaged over cumulative traffic loadings. Newbery shows quantitatively that, provided pavement maintenance is undertaken in a consistent manner, the magnitude of the marginal cost of road-wear is sensitive to the proportion of road-wear attributable to independent weathering, but relatively insensitive to the rate of traffic growth.

The following section provides analytical measures and estimates of the marginal cost of road use on the National Highway System.

Marginal cost of road-wear — no independent environmental effect

If it is assumed that pavement roughness increases only with cumulative traffic loadings (i.e. there is no independent environmental deterioration of road pavements, but the interaction of environmental conditions and traffic loads exacerbate the road-wear attributable to traffic loads), and that there are constant traffic loadings, then the pavement roughness progression relationship (Small et al. 1989) is:

$$\pi_t = \pi_0 - (\pi_0 - \pi_f)\left(\frac{\lambda Qt}{N}\right)e^{mt} \qquad \text{(II.1)}$$

where

π_t = pavement roughness at time t;

π_0 = initial pavement roughness;

π_f = terminal pavement roughness triggering overlay;

e = base of natural logarithms;

λ = proportion of traffic loadings in outer lane;

N = measure of pavement structural performance measured as the number of cumulative esals until overlay;

Q = annual traffic loadings (esals); and

m = weathering (aging) effect on pavement.

The marginal cost of road-wear, MC_m, is then a function of the annualised overlay cost divided by annual traffic loadings.

$$MC_m = \phi\beta\frac{rM}{Q} \qquad \text{(II.2)}$$

where

r = discount rate;

M = net present value of all future overlay expenditures; and

$\phi = \frac{rTe^{rT}}{(e^{rT} - 1)} \geq 1, \; all\ T \geq 0$;

$\beta = \frac{e^{mT}}{(1 + mT)} \geq 1, \; all\ T \geq 0$; and

T = time to next pavement overlay.

Marginal cost of road-wear in the presence of pure environmental pavement deterioration

Now consider the case where pavement deterioration is attributable to both independent environmental factors and traffic loads (e.g. Paterson 1987). The pavement deterioration function is:

$$\pi_t = \left\{\pi_0 - (\pi_0 - \pi_f)\left(\frac{\lambda Qt}{N}\right)\right\}e^{mt} \qquad \text{(II.3)}$$

The marginal cost of road-wear is now:

$$MC'_m = \phi\,\beta'\frac{rM}{Q} \qquad \text{(II.4)}$$

where $\beta' = \frac{\left(e^{m(T'-T)} - 1\right)}{\left[e^{m(T'-T)}(1+mT) - 1\right]} \le 1, \textit{all } T \ge 0$; and

T' = time to next overlay in the absence of traffic loadings.

Where there is no independent environmental deterioration $\beta > 1$; that is, environmental effects enhance the deterioration caused by traffic loadings on pavements. Where independent environmental deterioration does occur $\beta' < 1$; that is, part of the cost of pavement deterioration is no longer attributable to traffic loadings. β' is the same as Newbery's parameter μ (Newbery 1988, equation 22, p. 309). Newbery (p. 310) states that β' is relatively large and stable for climates and maintenance strategies likely to be encountered in Brazil and Tunisia, but likely to be smaller and more sensitive to maintenance criteria in countries with freezing climate. The average value of m for Australian conditions is approximately 0.02 (BTE 1999, forthcoming). Supposing an overlay interval of 10 years (T = 10) and a pavement life in the absence of traffic of 60 years[2] (T' = 60), then β' = 0.76. The BTE in its calculations of traffic-related pavement deterioration has attributed 80 per cent of the road maintenance costs to traffic loads (esals).

Newbery (1988, p. 312) also demonstrated that the marginal cost imposed on all other users will be slightly positive where weathering is present, but the size of this is small.

2 Recent evidence (Al-Suleiman et al. 1992) suggests that road pavements may last for more than 50 years in the absence of traffic.

Marginal cost of road-wear over a network

Suppose a road network consisting of two different sections of road, identified by superscripts 1 and 2, with different structural and traffic characteristics. The marginal cost of road-wear on each road section is MC_m^1 and MC_m^2. The marginal cost over the network is:

$$MC_m^N = \sigma_1 MC_m^1 + \sigma_2 MC_m^2 \quad \text{(II.5)}$$

where $\sigma_i = dQ_i \big/ \sum_j dQ_j$, the share of additional network traffic loadings on road section *i*. Equation II.5 states that the marginal maintenance cost over the network is the weighted average of the marginal maintenance cost on each section of the network, where the weights are the contribution of traffic on each section to total annual traffic loadings across the network.

Growth in traffic loadings

Suppose traffic loadings are allowed to grow over time. Following Small et al. (1989) traffic loadings at time *t* are:

$$X_t = \lambda \int_0^t \left(Q_0 e^{gz} + q\right) dz = \lambda\left[Q_0 \frac{\left(e^{gt} - 1\right)}{g} + qt\right] \qquad \text{(II.6)}$$

where

Q_0 = baseline traffic level;

g = annual rate of traffic growth;

q = small constant annual traffic increment; and

z = coefficient of integration.

The cost of the overlay is altered because the overlay must be thicker to bring the pavement to a strength that, at the new starting traffic level $Q_0 e^{gT}$, will give the pavement the same lifetime as before. The new overlay cost is *C'* and the net present value of all future overlay expenditures is *M'*.

The marginal cost of maintenance in the case of growing traffic loadings, MC_m^g, is:

$$MC_m^g = \phi\theta \frac{rM'}{Q_0} \qquad \text{(II.7)}$$

where $\theta = \dfrac{g}{m\left(e^{gT} - 1\right) + ge^{gT}} < 1$ for all $T > 0$.

BTE's Pavement Life Cycle Cost model (BTCE 1990)

The BTE's pavement life cycle cost model (hereafter LCC model) was designed to estimate the life cycle cost of road pavements. The model includes all costs associated with road provision and operation: research and development costs; production and construction costs; maintenance, operating and logistics support costs; and retirement and disposal costs. In practice, research and development costs, and production and construction costs are lumped together as the initial capital cost of road construction.

Two key aspects of the model for estimating the life cycle maintenance costs are the pavement deterioration algorithm and the unit pavement maintenance costs. The LCC model uses a variant of Paterson's (1987) pavement deterioration algorithm, modified to suit Australian conditions (equation II.8). The algorithm used in the model includes terms to capture the effect of cracking, rutting, patching and potholing under Australian conditions.

$$\begin{aligned} dR_t &= 134e^{mt}SNCK^{-5.0}dNE4 + mR_t dt + 0.012dRDL + 0.0066dCRX \\ &\quad + \left(0.003Hp\ dPAT + 0.16dVPOT\right) \end{aligned} \qquad \text{(II.8)}$$

where

dR_t = the increase in IRI roughness over period dt;

$SNCK$ = modified structural number adjusted for the effect of cracking;

$dNE4$ = incremental number of equivalent standard axles over period dt (million esals per lane);

$dRDL$ = increase in occurrence of 20-millimetre rutting, expressed as a percentage of the total wheel path length;

$dCRX$ = the increase in percentage of pavement area of the occurrence of intermittent cracks wider than 2 millimetres;

m = environmental coefficient;

R_t = roughness at time t (metres per kilometre IRI);

Hp = patch protrusion (millimetres);

$dPAT$ = increase in area of surface patching (per cent); and

$dVPOT$ = increase in volume of potholes (millimetres per lane kilometre).

The algorithm posits that road-wear is a function of cumulative esals, road condition and time. The contribution of independent environmental effects to pavement deterioration depends on the level of traffic loadings and the structural condition of the pavement. For lightly loaded pavements, the independent environmental effects contribute a greater share of the increase in roughness.

Table II.5 lists the unit pavement maintenance costs used in the LCC model (BTCE 1992) updated to 1997–98 prices, using the BTCE road construction and maintenance price index (BTCE 1997b and BTE estimates).

TABLE II.5 PAVEMENT MAINTENANCE UNIT COSTS

($ per square metre of pavement area)

Maintenance	*BTCE (1992) unit cost — 1997-98 prices*
Routine maintenance	$0.65
Reseal	$2.70
Asphalt overlay 50mm	$13.50
Pavement reconstruction	$60.00

Sources BTCE 1992, p. 30; BTCE 1997b, p. 2.

The avoidable (marginal) cost of road-wear was derived from the BTCE's estimates of the costs of maintaining the National Highway system (BTCE 1992), derived using the LCC model.

BTCE (1992, pp. 4–5) defined total road maintenance expenditure as the sum of the following road expenditures:

- *routine maintenance* includes pothole repair, minor pavement resealing or resurfacing of limited thickness and length, edge repair, shoulder regrading, minor pavement repairs, roadside maintenance, drainage clearance, grass cutting, sign cleaning, minor bridge and culvert maintenance;
- *specific maintenance* includes pavement resealing and resurfacing, with thin asphalt overlays;
- *restoration maintenance,* typically performed after flooding or traffic accidents; and
- *pavement reconstruction* (also called *pavement rehabilitation*), another form of pavement maintenance, undertaken to restore the pavement to its original condition after the pavement has reached the end of its functional life.

The term *intervention maintenance* is also used to describe specific maintenance, restoration maintenance and pavement reconstruction.

An additional class of maintenance, *maintenance to conserve the operational performance of the pavement,* was not included as maintenance expenditure in BTCE (1992) as this type of work is normally considered to represent upgrading, enhancement or improvement rather than maintenance. Activities falling into this category include work undertaken to restore or upgrade the level of service due to changes in traffic volumes, projects designed to increase the width to volume ratio, to compensate for increased axle loads and/or provide for unforeseen traffic growth, widening, realigning and bypass work.

Estimating the marginal cost of road use

Having established analytical measures of the avoidable cost of road-wear, the results from BTCE (1992) were used to estimate the avoidable costs of road-wear for the National Highway System. The National Highway links analysed in BTCE (1992) covered the National Highway System as defined at that time, but the definition has since changed. The Newell Highway (Brisbane–Melbourne) and the Sturt Highway (Adelaide–Sydney) are now part of the National Highway System (DoTC 1993), but were not analysed in BTCE (1992).

BTCE (1992) estimated *average* annual maintenance expenditure for the National Highway System, over the next 40 years, as $243 million (at 1990–91 prices). To compute the marginal cost on each link it was assumed that *annualised* maintenance expenditure was equal to *average* maintenance expenditure.

Estimates of the avoidable cost of road-wear, for each link identified in BTCE (1992), are listed in table II.6. An overlay interval was assumed for each link, listed in the table, and growth in esal-km on each link assumed to be five per cent per year. The cost estimates were adjusted to 1997–98 prices using the BTE road construction and maintenance price index (BTCE 1997b).

The results suggest that the marginal cost of road-wear over the National Highway System was 3.12 cents per esal-km at 1997–98 prices, (equivalent to 0.44 cents per ntkm for a 6-axle articulated truck carrying a 20-tonne load).

Table II.7 provides estimates of marginal cost of road-wear for the major intercapital corridors. Using the same assumptions about overlay interval and growth in traffic loadings, the avoidable cost of road-wear across the major intercapital corridors was estimated to be 1.75 cents per esal-km at 1997–98 prices (equivalent to 0.24 cents per ntkm for a 6-axle articulated truck carrying a 20-tonne load).

Estimating the cost of capital for road use

It may be demonstrated that the PAYGO system is equivalent to charging road users for road-wear and the cost of capital, provided the road system has a uniform age distribution.

Under the LCC model the marginal cost of road-wear relates only to future maintenance costs of the road network. If a return on capital is required it must be calculated explicitly. The capital costs of replacing specific links of the National Highway System were calculated using the average costs of construction assumed in BTCE (1997a, table 3.2, p. 12) times the length of highway, and are listed in table II.8.

The annualised capital cost is equal to the product of the real discount rate (assumed equal to seven per cent) and the estimated capital cost of the road. For example the estimated replacement cost of the Sydney–Brisbane link was $842 million, and the Adelaide–Perth link $1070 million.

The BTE estimated the capital costs attributable to heavy vehicles, for the Sydney–Brisbane and Adelaide–Perth links (table II.1), using a linear combination of the BTE's allocation template (table II.4) for construction expenditure on pavements, land and earthworks.

TABLE II.6 AVOIDABLE ROAD-WEAR COSTS — NATIONAL HIGHWAY LINKS

Link	Annual maintenance expenditure: Routine	Intervention	Total	Length	Mean total AADT	Mean CV AADT	Share CV	Average esals per CV	Annual esal–km	Overlay interval	'Simple' marginal cost (MC^o_m)	Marginal cost (MC^g_m)
	($ million at 1990–91 prices)			(km)	(AADT)	(AADT)	(per cent)	(esals per vehicle)	(million esal–km)	(years)	(1997-98 cents per esal–km)	
Liverpool–Marulan	2.676	5.477	8.153	159	19562	5086	26.0	1.8	531.299	10	1.66	1.12
Marulan–Snowy Mts Hwy	1.993	5.712	7.705	200	9536	2479	26.0	1.8	325.741	10	2.56	1.73
Snowy Mts Hwy–Vic. border	1.973	3.852	5.825	181	6430	1672	26.0	1.8	198.829	12	3.17	2.06
Hornsby–Minmi	1.508	2.981	4.489	85	28836	3573	12.4	1.8	199.534	10	2.44	1.64
Wallarah Ck–Swansea	0.384	1.024	1.408	42	16327	2122	13.0	1.8	58.554	10	2.60	1.76
Newcastle–Aberdeen	0.990	2.326	3.316	108	15317	2533	16.5	1.8	179.732	10	2.00	1.35
Aberdeen–Armidale	1.945	4.760	6.705	257	4903	818	16.7	1.8	138.118	12	5.26	3.41
Armidale–Qld border	1.084	2.443	3.527	209	3754	488	13.0	1.8	67.009	14	5.70	3.55
Federal Hwy	0.703	1.778	2.481	67	8592	773	9.0	1.8	34.027	12	7.90	5.12
Barton Hwy	0.257	0.778	1.035	37	5528	718	13.0	1.8	17.454	12	6.42	4.17
Melbourne–Seymour	0.885	1.704	2.589	91	20810	3730	17.9	1.9	235.395	10	1.19	0.80
Seymour–NSW border	1.634	3.026	4.660	203	9163	3018	32.9	1.9	424.876	10	1.19	0.80
Melbourne–Ballarat	0.872	1.774	2.646	94	15257	2392	15.7	1.9	155.932	10	1.84	1.24
Ballarat–SA Border	1.543	3.537	5.080	321	4060	1185	29.2	1.9	263.797	11	2.09	1.38
Brisbane–Gympie	1.212	2.476	3.688	163	18080	2055	11.4	1.5	183.393	10	2.18	1.47
Gympie–Rockhampton	2.084	4.641	6.725	468	3133	483	15.4	1.5	123.759	14	5.88	3.67
Rockhampton–Townsville	3.148	7.480	10.628	715	3075	425	13.8	1.5	166.372	14	6.92	4.31
Townsville–Cairns	1.502	6.184	7.686	346	3703	411	11.1	1.5	77.858	14	10.69	6.66

TABLE II.6 AVOIDABLE ROAD-WEAR COSTS — NATIONAL HIGHWAY LINKS (CONTINUED)

Link	Annual maintenance expenditure: Routine	Annual maintenance expenditure: Intervention	Annual maintenance expenditure: Total	Length	Mean total AADT	Mean CV AADT	Share CV	Average esals per CV	Annual esal–km	Overlay interval	'Simple' marginal cost (MC^{o}_{m})	Marginal cost (MC^{g}_{m})
	($ million at 1990–91 prices)			(km)	(AADT)	(AADT)	(per cent)	(esals per vehicle)	(million esal–km)	(years)	(1997–98 cents per esal–km)	
Ipswich–NSW border	1.112	3.344	4.456	226	3767	935	24.8	1.5	115.692	12	4.17	2.71
Ipswich–Toowoomba	0.686	1.329	2.015	95	10476	1826	17.4	1.5	94.975	10	2.30	1.55
Toowoomba–Roma	1.390	7.532	8.922	337	2740	343	12.5	1.5	63.286	14	15.27	9.52
Roma–Morven	0.649	3.552	4.201	177	333	244	73.3	1.5	23.645	14	19.24	11.99
Morven–Barcaldine	1.657	5.036	6.693	416	432	97	22.5	1.5	22.093	18	32.81	18.77
Barcaldine–Cloncurry	2.511	9.110	11.621	634	383	68	17.8	1.5	23.604	18	53.32	30.50
Cloncurry–NT border	1.103	5.752	6.855	320	520	91	17.5	1.5	15.943	18	46.57	26.64
Adelaide–Tailem Bend	0.880	1.658	2.538	95	10417	1356	13.0	2.0	94.039	11	2.92	1.93
Tailem Bend–Vic. border	0.996	1.733	2.729	192	2758	828	30.0	2.0	116.052	12	2.55	1.65
Adelaide–Port Augusta	1.687	2.722	4.409	298	4354	716	16.4	2.0	155.759	12	3.07	1.99
Port Augusta–Ceduna	1.804	2.376	4.180	468	684	251	36.7	2.0	85.752	14	5.28	3.29
Ceduna–WA border	1.938	1.999	3.937	483	420	84	20.0	2.0	29.618	18	14.40	8.24
Port Augusta–NT border	4.335	5.119	9.454	927	363	115	31.7	2.0	77.822	14	13.16	8.20
Perth–Northam	0.340	0.748	1.088	70	6457	799	12.4	1.5	30.622	12	3.85	2.50
Northam–Southern Cross	1.140	2.346	3.486	271	1530	283	18.5	1.5	41.989	14	8.99	5.60
Southern Cross–Norseman	1.546	3.130	4.676	355	742	229	30.9	1.5	44.509	14	11.38	7.09
Norseman–SA border	3.090	4.576	7.666	721	430	198	46.0	1.5	78.160	14	10.62	6.62
Perth–Wubin	0.982	2.229	3.211	250	1666	286	17.2	1.5	39.146	14	8.88	5.54
Wubin–Meekatharra	1.771	2.284	4.055	493	314	66	21.0	1.5	17.815	18	24.65	14.10
Meekatharra–Port Hedland	3.647	4.073	7.720	862	146	25	17.1	1.5	11.799	18	70.86	40.54

TABLE II.6 AVOIDABLE ROAD-WEAR COSTS — NATIONAL HIGHWAY LINKS (CONTINUED)

Link	Annual maintenance expenditure: Routine	Intervention	Total	Length	Mean total AADT	Mean CV AADT	Share CV	Average esals per CV	Annual esal–km	Overlay interval	'Simple' marginal cost (MC^{o}_{m})	Marginal cost (MC^{g}_{m})
	($ million at 1990–91 prices)			(km)	(AADT)	(AADT)	(per cent)	(esals per vehicle)	(million esal–km)	(years)	(1997–98 cents per esal–km)	
Port Hedland–Broome turnoff	2.646	4.076	6.722	567	674	147	21.8	1.5	45.634	14	15.95	9.94
Broome turnoff–Fitzroy Creek	1.281	2.092	3.373	366	481	80	16.6	1.5	16.031	14	22.79	14.20
Fitzroy Creek–Halls Creek	1.541	2.429	3.970	283	727	125	17.2	1.5	19.368	14	22.20	13.84
Halls Creek–NT border	1.318	2.103	3.421	402	310	41	13.2	1.5	9.024	14	41.06	25.59
Hobart–Launceston	1.023	2.112	3.135	176	4634	1256	27.1	1.1	88.754	12	3.83	2.48
Launceston–Devonport	0.512	1.033	1.545	94	6912	748	10.8	1.1	28.230	12	5.93	3.85
Devonport–Burnie	0.392	0.741	1.133	49	11395	1132	9.9	1.1	22.270	10	5.51	3.72
Darwin–Katherine	1.377	2.249	3.626	289	1162	457	39.3	1.9	91.593	14	4.29	2.67
Katherine–Alice Springs	5.367	5.326	10.693	1177	314	150	47.8	1.9	122.437	14	9.46	5.89
Alice Springs–SA border	1.205	1.632	2.837	295	273	84	30.8	1.9	17.185	16	17.88	10.68
Katherine–WA border	1.687	2.445	4.132	468	126	55	43.7	1.9	17.851	18	25.07	14.34
Tennant Creek–Qld border	2.017	2.569	4.586	444	283	137	48.4	1.9	42.184	16	11.77	7.04
Total – Australia	80.023	161.408	241.431	16046	2573.6	502.6	19.5	1.7	5085	14	5.14	3.18

Sources BTE estimates, BTCE 1992, tables 4.2, 5.6 and I.1.

TABLE II.7 AVOIDABLE ROAD-WEAR COSTS — SELECTED INTERCAPITAL CORRIDORS

Specific corridors	Annual maintenance expenditure: Routine	Intervention	Total	Length	Mean total AADT	Mean CV AADT	Share CVs	Average esals per CV	Annual esal-km	Overlay interval	'Simple' marginal cost (MC^{o}_{m})	Marginal cost (MC^{g}_{m})
	($ million at 1990–91 prices)			(km)	(AADT)	(AADT)	(per cent)	(esals per vehicle)	(million esal-km)	(years)	(1997-98 cents per esal–km)	
Sydney–Melbourne	9.161	19.771	28.932	834	11913	3069	25.8	nc	1716	10	1.83	1.22
Sydney–Brisbane	7.023	16.878	23.901	927	8292	1284	15.5	nc	759	15	3.41	2.10
Sydney–Adelaide	na	na	na	na	na	na	na	nc	na	na	na	na
Sydney–Canberra	5.372	12.967	18.339	426	13130	3184	24.2	nc	891	10	2.23	1.49
Melbourne–Brisbane	na	na	na	na	na	na	na	nc	na	na	na	na
Melbourne–Adelaide	4.291	8.702	12.993	702	6063	1272	21.0	nc	630	11	2.23	1.47
Adelaide–Perth	11.545	17.897	29.442	2666	1223	273	22.3	nc	466	14	6.84	4.22
All major corridors	37.392	76.215	113.607	5555	5532	1211	21.9	nc	4462	13	2.76	1.75

Notes na not available
nc not calculated.

Sources BTE estimates; BTCE 1992, tables 4.2, 5.6 and I.1.

TABLE II.8 CAPITAL COST OF NATIONAL HIGHWAY SYSTEM CORRIDORS

Corridor	*Length*	*Cost*	*Estimated total VKT - 1996*	*Estimated CV VKT - 1996*	*Annualised replacement cost*	*Total ntkm*	*Average capital cost*
	(km)	*($ million in 1997-98 prices)*	*(million vkt)*	*(million vkt)*	*($ million in 1997-98 prices)*	*(million ntkm)*	*(cents / ntkm)*
Sydney–Melbourne	830	2609	4066	774	183	12378	0.68
Sydney–Brisbane	946	842	3608	627	59	10027	0.27
Sydney–Adelaide	1111	410	1435	292	29	4678	0.28
Canberra connections	122	297	450	36	21	575	1.68
Melbourne–Brisbane	1534	463	1999	598	32	9562	0.16
Melbourne–Adelaide	702	1109	1885	346	78	5539	0.65
Adelaide–Perth	2688	1070	1660	309	75	4940	0.70
All major corridors	7936	6801	15103	2981	476	47699	0.46

Note Corridor lengths differ only slightly from those listed in table II.7 because they are sourced from different databases.

Sources BTE estimates, BTE 1988; BTCE 1997a, table 3.2, p. 12; SMEC 1998.

Capital costs may be recovered by levying a fixed annual charge on each heavy vehicle, which when combined with a variable charge for road-wear is equivalent to a two-part pricing scheme for heavy vehicle road use. For the purpose of calculating the average capital cost (table II.8) an average load of 16 tonnes was assumed for commercial vehicles. The BTE recognises, however, that allocating capital costs across road users in inverse proportion to their elasticity of demand for road use would theoretically be less distorting than the method employed here.

CONCLUSIONS

Current road use charges for heavy vehicles are inefficient in that they do not accurately reflect the costs of road-wear. By comparison with a more economically efficient charging system, the NRTC’s cost allocation process overcharges lighter vehicles and undercharges heavier vehicles. It also overcharges lightly laden vehicles and undercharges heavily laden vehicles.

Overall, heavy vehicles are undercharged for the road-wear they cause. The BTE’s estimate of the average avoidable cost of road-wear over the arterial road network is higher than the NRTC’s current charges. Current NRTC total charges for 6-axle articulated trucks (imputed fuel levy and registration charge) are about 66 per cent of the BTE estimate of almost 1.0 cent per ntkm for the total cost (road-wear cost plus the other costs of road provision) over the whole arterial road network.

The marginal cost of road use varies across the road network. Current NRTC total charges are approximately equal to the calculated costs of major intercapital links. However, these high-traffic roads are a special set of some of the lowest-cost roads in the country.

Mass-distance-based road use charges offer greater scope to reflect the avoidable cost of heavy vehicle road use.

APPENDIX III DATA SOURCES AND CALCULATIONS

This appendix describes in detail the sources, assumptions and calculations used to derive the road and rail freight charges for the *current pre-ANTS* and *post-ANTS* situations, and under a *competitively neutral* scenario, listed in table III.1. To aid the reader, corresponding notes to the calculations are printed on the right-hand pages, and the table re-appears on each facing page.

TABLE III.1 ROAD AND RAIL CHARGES UNDER THE *CURRENT PRE-ANTS* AND *POST-ANTS* SITUATIONS AND UNDER A *COMPETITIVELY NEUTRAL* SCENARIO

(cents per ntkm)

	Category	Current – pre-NTS		Current – post-ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD	RAIL	ROAD
	B	C	D	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.30	0.93	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.21	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.48	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]			-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]				-9		6

Note a. Percentage change from previous case, i.e. *pre-ANTS* to *post-ANTS* and *post-ANTS* to *competitive neutrality*.

Sources See opposite page and following notes.

NOTES TO TABLE III.1

Cell	*Notes*
C6	4.1 litres per thousand gross tonne kilometres (ARA 1998, p. 3), divided by 0.57 (train weight adjustment, BTE estimate), divided by 0.85 (box weight adjustment) divided by 1000 equals 0.0085 litres per ntkm, then times 25 cents per litre (estimate of rail fuel cost of 60 cents per litre minus pre-ANTS excise of 35 cents per litre).
D6	0.53 litres per kilometre (Austway 1998) divided by 20 tonnes (average load) times 29 cents per litre.
E6, F6	As for pre-ANTS (C6, E6)
C7–H7	Sum of rows 8 and 9.
C8	Fuel usage of 0.0085 litres per ntkm (C6) times 35 cents per litre (excise)
D8	Fuel usage 0.0265 litres per ntkm (D6) times 35 cents per litre (excise).
E8	Recognition of the rail industry as an off-road user of diesel and extension to rail operators of the full rebate of excise on diesel.
F8	Fuel usage 0.0265 litres per ntkm (D6) times 20 cents per litre (excise).
H8	Excise removed for road as well as rail.
C9	Rail does not pay the equivalent of the State franchise fee.
D9	Fuel usage 0.0265 litres per ntkm (D6) times 7.8 cents per litre (average State fuel franchise fee).
E9, F9	State franchise fees no longer exist under the new taxation arrangements.
D10	Negative of cell D13 in order to avoid double counting of what is entered as an imputed fuel charge for infrastructure.
C11–H11	Sum of next rows 12 to 14.
C12	\$117 million access fees (ARA 1997a) divided by 16 000 million ntkm (including boxes – NR 1997, p. 10) divided by 0.85 (box adjustment) times CPI adjustment (1.0141) times 100 (to convert to cents).
G12	Assumed that rail freight operators currently pay the full cost of their infrastructure use.
H12	BTE estimated the damage (short run avoidable cost) caused by trucks on arterial roads as 23 per cent of total arterial spending (appendix II, table II.4) i.e. 0.232 times \$3630 million, equals \$842 million. Six-axle articulated trucks account for 44.6 per cent of esal-km (NRTC 1998, p. 77). Multiplying by 0.446 and dividing by articulated trucks total ntkm of 59 700 million (NRTC 1998, pp. 76–77) times 100 (for cents) gives 0.63 cents per ntkm. The mass-distance charge is the 0.63 c/ntkm road-wear assessment.
D13	Fuel usage of 0.0265 times the imputed cost of the 18 cents per litre ‘credited’ by the NRTC when calculating heavy vehicle road use charges. In order to avoid double counting it is subtracted at D10, as it is already included in taxes paid on fuel (D7).
F13	Fuel usage of 0.0265 times the imputed cost of the proposed 20 cents per litre ‘credited’ by the NRTC when calculating heavy vehicle road use charges
C14, E14, G14	Not applicable — internalised.
D14	\$4000 annual vehicle registration fee divided by 189 000 km per year for interstate 6-axle articulated trucks (assuming 1.75 return trips per week at 2250 km, 48 weeks per year) divided by 20 tonnes (average load) times 100 (for cents).

TABLE III.1 ROAD AND RAIL CHARGES UNDER THE *CURRENT PRE-ANTS* AND *POST-ANTS* SITUATIONS AND UNDER A *COMPETITIVELY NEUTRAL* SCENARIO

(cents per ntkm)

	Category	Current – pre-NTS		Current – post-ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD	RAIL	ROAD
	B	C	D	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.30	0.93	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.21	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.48	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]			-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]				-9		6

Note a. Percentage change from previous case, i.e. *pre-ANTS* to *post-ANTS* and *post-ANTS* to *competitive neutrality*.

Sources See opposite page and following notes.

NOTES TO TABLE III.1

Cell	*Notes*
H14	Non-avoidable arterial road expenditure attributed to heavy vehicles is $873 million (appendix II, table II.4). Six-axle articulated trucks are allocated 44.6 per cent of this expenditure on the basis of esal-km (NRTC 1998, p. 77). Thus $389,400,000 is allocated to the 30 218 6-axle articulated trucks, resulting in a $12 883 registration fee for each truck. This is then divided by 189 000 (annual kilometres) and by 20 tonnes (average load), times 100 (for cents).
D15	Average sales tax estimated at 3.43 cents per km (Skene 1996, p. 7), times 22/20 (to reflect current average tax rate of 22% rather than Skene's 20%) and CPI adjustment (1.078) divided by 20 tonnes (average load).
F15, H15	Sales tax replaced by a 10 per cent GST in July 2000. Commercial operators receive full credit for this tax, making the effective tax rate zero.
C16	Tariff of 5 per cent on rolling stock only, and not on locomotives. Assuming 25 wagons per train times $0.15 million per wagon divided by 40 years (life of wagons) divided by 300 million (ntkm per train per year) times 0.05 (tariff) times 100 (for cents).
D16	5.39 cents per km for customs duty and sales tax and 3.43 cents per km for sales tax (Skene 1996, p. 8), implying 1.96 cents per km for customs duty. Adjusted for CPI (1.078) and divided by 20 tonnes (average load).
G16	Tariff of 5 per cent assumed to apply also to locomotives (2 times $1.77 million, depreciated over 20 years) as well as to wagons (C16).
D17	Equivalent to 0.62 cents per km for 6-axle articulated trucks (Skene 1996). Adjusted for CPI (1.078) and divided by 20 tonnes (average load).
G17	Assuming each item of rollingstock is sold once in its life, then half the initial cost of the train (2 time $1.77m for locomotives and 25 times $0.15m for wagons) annualised over the life of the rollingstock (divided by 25 years for locomotives and 40 years for wagons) times stamp duty of 3.5 per cent (NSW = 3 per cent and Victoria 4 = per cent, BTCE 1997c, p. 33), divided by 300 million ntkm (freight task) times 100 (for cents).
C18	$69 million rail accident costs in 1993 for all rail systems (BTCE 1995a). Assume 33 per cent can be attributed to freight movements. Total freight revenue all systems in 1993 was $2700 million giving an accident rate per dollar of revenue of 0.852 per cent. In 1997 National Rail freight revenue was $445 million, giving implied accident costs of $3.8 million divided by 16 000 million ntkm divided by 0.85 (box weight adjustment) , adjusted for CPI (1.0141), times 100 (for cents) equals 0.03 cents per ntkm. Assume half of this covered by insurance and hence met by the operators.
D18	Road crash costs $6100 million in 1993 (BTCE 1994), adjusted for CPI (1.125) equals $6865 million. To derive 6-axle articulated truck share, FORS 1997 figures were used (pers. comm.). Articulated trucks involved in 2.8 per cent of hospitalised accidents and associated with 9.6 per cent of deaths. Even though costs of 'deaths' are higher there are a lot more accidents involving hospitalisation. Therefore assuming articulated trucks account for 5 per cent of accident costs, giving these trucks accident costs of $6865 times 0.05 = $343 million. Assume these trucks through their insurance meet half of this cost, and 6-axle articulated trucks share of this (based on pcu–km) is 55 per cent or $94 million. Divide by 59 700 million (total ntkm for 6-axle articulated trucks – appendix II) times 100 (for cents).
G18, H18	Assume all accident costs are internalised (both E18 and F18 times 2).
C19, E19, G19	Built into access charges.

TABLE III.1 ROAD AND RAIL CHARGES UNDER THE *CURRENT PRE-ANTS* AND *POST-ANTS* SITUATIONS AND UNDER A *COMPETITIVELY NEUTRAL* SCENARIO

(cents per ntkm)

	Category	Current – pre-NTS		Current – post-ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD	RAIL	ROAD
	B	C	D	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.30	0.93	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.21	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.48	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]			-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]				-9		6

Note a. Percentage change from previous case, i.e. *pre-ANTS* to *post-ANTS* and *post-ANTS* to *competitive neutrality*.

Sources See opposite page and following notes.

NOTES TO TABLE III.1

Cell	*Notes*
H19	Heavy vehicle enforcement costs of $70 million (NRTC 1998, p. 17) times 0.446 (6-axle articulated trucks share of total esals – NRTC 1998, p. 77) divided by 59 700 million (total ntkm for 6-axle articulated trucks – appendix II) times 100 (for cents) times CPI adjustment (1.0141).
C20, E20, G20	Built into access charges.
H20	Assuming a congestion cost of 0.18 cents per pcu-km for rural dual carriageways (Maddison et al. 1996). If a 6-axle articulated truck is equivalent to 3 pcus, this figure becomes 0.54 (cents per vkt). Divide by 20 tonnes (average load) times CPI adjustment (1.0141).
C21, E21, G21	Built into access charges.
D21	Assumed to equal 10 per cent of $13 580 in administration costs to trucking operators (Austway 1998) divided by 189 000 km per year divided by 20 tonnes (average load) times 100 (for cents) times CPI adjustment (1.0141).
G22	Pollution costs for interstate road freight journey estimated at 0.279 cents per km (ISC 1990, vol. 2, p. 203, weighted average urban/rural – see H22). Fuel consumption for a 6-axle articulated truck is 0.53 litres per kilometre (NRTC 1998, p. 77), thus pollution cost per litre for road transport is 0.526 cents per litre. Applying this rate to rail gives 0.526 (cents per litre) times the rail fuel consumption of 0.0085 litres per ntkm. Greenhouse gas cost not included because of theoretical difficulties in specification. However, compared to road freight, rail freight produces less than one-third of the greenhouse gas emissions per ntkm (refer to calculations in C6, D6).
H22	0.016 cents per km for diesel/rural journeys and 2.357 cents per km for diesel/urban (ISC 1990, vol. 2, p. 203). Urban share of corridor freight task (between Sydney, Melbourne, and Brisbane) is 7 per cent. This gives a weighted average of 0.18 cents per km, equals 0.22 cents per km, adjusted for CPI (1.20) divided by average load (20 tonnes). Note that greenhouse gas costs not included because of degree of cost uncertainty.
G23	Assume locomotives, wagons and trucks generate the same noise levels and each wagon carries 40 tonnes. Then rail carries 1.85 as much freight ‘per noise’ as road (after adjusting for locomotives that carry no freight). Hence, if road noise cost is 0.034 cents per ntkm then rail costs are 0.018 cents per ntkm.
H23	Aggregate noise costs for heavy trucks over 15 tonnes estimated at 7.06 cents per km for urban (ISC 1990, vol. 2, p. 200). BTE estimates rural noise costs at one-hundredth of this figure. Adjusting for urban share of corridor freight task (7 per cent with Sydney, Melbourne, Brisbane routes) and CPI (1.20) dividing by 20 tonnes (average load).
B24	Any line-haul costs not separately enumerated.
E24	Other rail line-haul costs were assumed to remain unchanged.
F24	Main inputs are fuel, vehicles, maintenance and repairs, tyres, administration and labour. Fuel and vehicle costs changes are accounted for above. Maintenance and repairs account for 16.7 per cent of line haul costs (TransEco 1999), and are assumed to fall 10 per cent (half of total maintenance and repair costs are assumed to be labour input). It was assumed that tyre costs fall 20 per cent and account for 5 per cent of line-haul costs. Labour and administration costs are assumed to remain unchanged. These assumptions imply a net reduction in other line-haul costs of 3 per cent.

TABLE III.1 ROAD AND RAIL CHARGES UNDER THE *CURRENT PRE-ANTS* AND *POST-ANTS* SITUATIONS AND UNDER A *COMPETITIVELY NEUTRAL* SCENARIO

(cents per ntkm)

	Category	Current – pre-NTS		Current – post-ANTS		Competitively Neutral	
		RAIL	ROAD	RAIL	ROAD	RAIL	ROAD
	B	C	D	E	F	G	H
6	**Non-excise fuel cost**	**0.21**	**0.77**	**0.21**	**0.77**	**0.21**	**0.77**
7	**Taxes paid on fuel**	**0.30**	**1.14**	**0.00**	**0.53**	**0.00**	**0.00**
8	Federal excise	0.30	0.93	0.00	0.53	0.00	0.00
9	State franchise fees	0.00	0.21	0.00	0.00	0.00	0.00
10	**Excise credit**	**0.00**	**-0.48**	**0.00**	**-0.53**	**0.00**	**0.00**
11	**Infrastructure use fees**	**0.87**	**0.59**	**0.87**	**0.64**	**0.87**	**0.97**
12	Mass-distance charge	0.87	0.00	0.87	0.00	0.87	0.63
13	Imputed fuel charge	0.00	0.48	0.00	0.53	0.00	0.00
14	Vehicle registration fees	0.00	0.11	0.00	0.11	0.00	0.34
15	**Sales taxes**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**
16	**Tariffs on vehicles**	**0.002**	**0.11**	**0.002**	**0.11**	**0.005**	**0.11**
17	**Stamp duty**	**0.00**	**0.03**	**0.00**	**0.03**	**0.002**	**0.03**
18	**Accident costs**	**0.01**	**0.16**	**0.01**	**0.16**	**0.03**	**0.32**
19	**Enforcement costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.05**
20	**Congestion costs**	**n.a.**	**0.00**	**n.a.**	**0.00**	**n.a.**	**0.03**
21	**Cost of regulations**	**n.a.**	**0.04**	**n.a.**	**0.04**	**n.a.**	**0.04**
22	**Pollution costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.004**	**0.01**
23	**Noise costs**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.034**
24	**Other line-haul costs**	**1.01**	**3.17**	**1.01**	**3.07**	**1.01**	**3.07**
25	**Line-haul profit**	**-0.04**	**0.10**	**-0.04**	**0.10**	**0.10**	**0.10**
26	**Rail line-haul costs**	**2.36**		**2.06**		**2.25**	
27	**Rail terminal costs**	**0.95**		**0.95**		**0.95**	
28	**Rail pickup/delivery**	**1.75**		**1.62**		**1.62**	
29	**Door-to-door FCL rate**	**5.06**	**5.83**	**4.63**	**4.92**	**4.82**	**5.53**
30	Change FCL rate (per cent)[a]			-8	-16	4	12
31	**Road terminal costs**		**2.18**		**2.18**		**2.18**
32	**Road pickup/delivery**		**3.29**		**3.16**		**3.16**
33	**Door-to-door LCL rate**		**11.30**		**10.26**		**10.87**
34	Change LCL rate (per cent)[a]				-9		6

Note a. Percentage change from previous case, i.e. *pre-ANTS* to *post-ANTS* and *post-ANTS* to *competitive neutrality*.

Sources See opposite page and following notes.

Cell	*Notes*
C25	$5 million loss (NR 1997, p. 10) divided by 16 000 million (ntkm) divided by 0.85 (box adjustment) times 100 (for cents).
D25–H25	A nominal profit was assumed for the road freight industry due to its extremely competitive nature (D25, H25). A similar nominal profit was assumed for rail in the *competitively neutral* scenario (G25).
C26	$444.5 million revenue (NR 1997, p. 10) divided by 16 000 million (ntkm) divided by 0.85 (box adjustment) times 100 (for cents) times CPI adjustment (1.0141) equals 3.31 cents per ntkm total for line-haul and terminal costs. Line-haul is then equal to 3.31 cents per ntkm minus the terminal cost of 0.95 cents per ntkm.
C27	$11.36 per tonne (BTCE 1993, p. 121) divided by 1200 km average corridor distance times 100 (for cents). This assumes terminals have become more efficient since 1990 and hence no increase in nominal costs.
C28	Assume $150 each end per container (personal communication with freight forwarders, adjusted to reflect average route/more efficient operators) and a payload of 14.3 tonnes (average across the 20-foot and 40-foot boxes). $150 times two (both ends) divided by 14.3, divided by 1200 km (average haul distance) times 100 (for cents).
E28	Main inputs to rail pickup/delivery (and percentage share of total cost - TransEco 1999) are fuel, oil and tyres (12), capital (15), maintenance (8), administration and labour (61), and registration and insurance (4). Assumed rail pickup/delivery generally performed by vehicles eligible for diesel rebate (that is, greater than 20 tonne GVM) in urban areas. Fuel input costs assumed to fall by 32 per cent under ANTS (from 72 to 49 cents/litre). Capital input costs assumed to fall by 20 per cent, maintenance costs by 10 per cent, and tyre input costs by 20 per cent. Labour and administration costs are assumed to remain unchanged. These assumptions imply a 7.4 per cent fall in rail pickup/delivery costs.
C29	Sum of C26 to C28.
D29	$49.63 per tonne each leg (pers. comm. Symonds-Hendersons 1997, Melbourne–Sydney freight rate for 6-axle articulated trucks) divided by 870 km times 100 (for cents) times TransEco long-haul rate adjustment of 1.022 equals 5.83 c/ntkm.
D31	$20 per tonne (BTCE 1993, p. 120) divided by 1125 km (average haul) times 100 (for cents) times CPI adjustment (1.226).
D32	Sydney–Melbourne pickup and delivery cost of $153.9 million divided by freight of 5.1 million tonnes, giving $30.18 per tonne in 1990 (BTCE 1993, p. 120). Divided by 1125 km (average haul) times 1.227 (TransEco 1999, short-haul rate change between 1990 and 1999) times 100 (for cents).
F32	Main inputs to LCL road pickup/delivery (and percentage share of total cost - TransEco 1999) are fuel, oil and tyres (12), capital (15), maintenance (8), administration and labour (61), and registration and insurance (4). Assume LCL road pickup/delivery performed by vehicles not eligible for diesel rebate (that is, less than 20 tonne GVM and predominantly urban use). Capital costs assumed to fall by 20 per cent, maintenance costs by 10 per cent, and tyre costs by 20 per cent. Labour and administration costs are assumed to remain unchanged. These assumptions imply a 4 per cent fall in LCL road pickup/delivery costs.

GLOSSARY

Allocated road track costs Assignment of the separable portion of annual road expenditure.

Attributable road track costs see Separable road track costs.

Capital costs (expenditure) The costs (expenditure) incurred in creating new road infrastructure or increasing the volume or load-carrying capacity of existing road infrastructure above its original design capacity (Martin 1994).

Cost-occasioned A cost-occasioned approach to road cost recovery attempts to allocate different elements of road expenditure among road users according to cost responsibility.

esal Equivalent standard axle load. Defined as a single axle with dual wheels with a load of 8.2 tonnes (18 000 pounds) weight (AUSTROADS 1992, p. 7.1).

Flexible pavement Pavement constructed of any material other than reinforced concrete, including lean concrete — concrete containing little cement and little water. Flexible pavements include asphaltic concrete, (hot) rolled asphalt, bituminous pavements (spray or chip seal) and unsealed surfaces (Lay 1990, Scott 1991 and Blake 1989).

Maintenance expenditure Expenditure incurred in preserving and retaining (repairing and rehabilitating) the existing road infrastructure at or to a predetermined level of performance. Routine maintenance and periodic maintenance (reseals, major patching and resheeting) comprise the majority of road maintenance expenditure (Martin 1994).

Non-separable road track costs Costs associated with roads that have little relation to road use, for example, mowing roadside verges, and the costs of building a minimum possible standard of road (NRTC 1998b, p. 12).

Overlay The addition of one or more courses of pavement material to an existing road surface, generally to increase strength, and/or improve riding quality (SA 1986).

PAYGO Pay-as-you-go approach for allocating road track costs. The PAYGO approach uses actual and budgeted annual road expenditure as a proxy for the cost of road use (NRTC 1993, p. 13).

Reconstruction See Rehabilitation.

Rehabilitation The restoration of a distressed pavement so that it may be expected to function at a satisfactory level of serviceability for a further design period (SA 1986).

Reseal A seal applied to an existing sealed surface (SA 1986).

Rigid pavement Pavement composed of reinforced concrete — concrete containing more than 0.6 per cent by volume of reinforcements consisting of steel rods or mesh. The steel takes all the tensile stresses (in theory) so that cracks that occur do not appreciably weaken the concrete (Lay 1990, Scott 1991 and Blake 1989).

Rutting A longitudinal vertical deformation of a pavement surface in a wheelpath measured relative to a straight-edge placed at right angles to the traffic flow and across the wheel path (SA 1986).

Seal A thin surface layer of bitumen, tar or epoxy resin material into which aggregate is usually incorporated (SA 1986).

Separable road track costs Costs associated with providing and maintaining roads that vary with the use of the road by vehicles of different types, for example, pavement repair.

Tonne-kilometre One tonne of freight moved one kilometre.

Transhipment time The time between the shipment leaving the supplier and arriving at the customer, excluding the transport time between the origin and destination.

Unallocated road track costs Those road agency expenditures that are not considered relevant to road use and thus not allocated to road users (NRTC 1998b).

REFERENCES

ABBREVIATIONS

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ABS	Australian Bureau of Statistics
AGPS	Australian Government Publishing Service
ARA	Australasian Railway Association Inc.
ARRB	ARRB Transport Research Ltd. (formerly Australian Road Research Board)
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
DoT	Department of Transport
DoTC	Department of Transport and Communications
DTRD	Department of Transport and Regional Development
DTRS	Department of Transport and Regional Services
FHA	Federal Highway Administration (US Department of Transportation)
FORS	Federal Office of Road Safety
HRB	Highway Research Board (USA)
ISC	Inter-State Commission
LTSA	Land Transport Safety Authority (New Zealand)
NAASRA	National Association of Australian State Road Authorities
NCA	Nicholas Clark and Associates
NR	National Rail
NRC	National Research Council (USA)
NRTC	National Road Transport Commission
SA	Standards Australia
SMEC	Snowy Mountains Engineering Corporation
TEC	Transport Economics Centre (University of Tasmania)
TRB	Transportation Research Board (USA)
UIC	International Union of Railways (Union Internationale des Chemins de Fer)

ABS 1996, *Survey of Motor Vehicle Use, Australia, 30 September 1995, Preliminary*, Catalogue no. 9202.0, ABS, Canberra.

—— 1997, *Year Book Australia 1997*, Catalogue no. 1301.0, ABS, Canberra.

Al-Suleiman, T.I., Basma, A.A. & Ksaibati, K. 1992, 'Examination of Pure Environmental Effects on Pavement Condition', *Transportation Research Record*, no. 1388, pp. 52-59, Transportation Research Board, National Research Council, National Academy Press, Washington, D.C.

ARA 1997, 'Rail Facts Sheet No. 3 – Competitive Neutrality', October 1997, Australasian Railway Association Inc., Melbourne.

—— 1998, *Submission to the House of Representatives Standing Committee on Communications, Transport and Microeconomic Reform's Inquiry into Federal Road Funding*, February 1997, Australasian Railway Association Inc, Melbourne.

Austway 1998, Commercial Road Transport Cost Model, updated 30 June 1998, Austway Consultants Pty Ltd, Stirling, South Australia.

Blake, L.S. (ed) 1989, *Civil Engineers Reference Book, 4th edition*, Butterworths, London.

BTCE 1990a, *Pavement Management: Development of a Life Cycle Costing Technique*, Occasional Paper 100, AGPS, Canberra.

—— 1990b, *Freight Flows in Australian Transport Corridors*, Occasional Paper 98, AGPS, Canberra.

—— 1992, *The Cost of Maintaining the Australian National Highway System*, Report 77, AGPS, Canberra.

—— 1993, *An Economic Evaluation of the Sydney–Melbourne Transport Corridor*, BTCE Discussion Paper, BTCE, Canberra.

—— 1994, *Costs of Road Crashes in Australia – 1993*, Information Sheet 4, BTCE, Canberra.

—— 1995a, *Costs of Rail Accidents in Australia – 1993*, Information Sheet 7, BTCE, Canberra.

—— 1995b, *Greenhouse Gas Emissions from Australian Transport: Long-Term Projections*, Report 88, BTCE, Canberra.

—— 1996a, *Transport and Greenhouse: Costs and Options for Reducing Emissions*, Report 94, AGPS, Canberra.

—— 1996b, *Trees and Greenhouse: Costs of Sequestering Australian Transport Emissions*, Working Paper 23, BTCE, Canberra.

—— 1997a, *Roads 2020*, Working Paper 35, BTCE, Canberra.

—— 1997b, *Public Road-Related Expenditure and Revenue in Australia, 1998*, Information Paper 11, BTCE, Canberra.

—— 1997c, *Taxes and Charges in Australian Transport: A Transmodal Overview*, Working Paper 34, BTCE, Canberra.

BTE 1988, *Review of Road Cost Recovery*, Luck, D.P. & Martin, I.J., Occasional Paper 90, AGPS, Canberra.

—— 1998, *Forecasting Light Vehicle Traffic*, Working Paper 38, BTE, Canberra.

—— 1999 (forthcoming), *The Equity and Access Component of Road Expenditures*, Report 100, AGPS, Canberra.

Costello, P. 1998, *A New Tax System*, White Paper circulated by The Honourable Peter Costello, M.P., Treasurer of the Commonwealth of Australia, August 1998.

DoT 1995, *Sea Transport Statistics: Coastal Freight, Australia 1994–95*, DoT, Canberra.

DoTC 1993, *The Length of the Land: Australia's National Highway*, DoTC, Canberra.

Friedlaender, A.F. & Mathur, S.C. 1982, 'Price Distortions, Financing Constraints and Second-Best Investment Rules in the Transportation Industries', *Journal of Public Economics*, vol. 18, no. 2, pp. 195–215.

Gomez-Ibanez, J.A. & O'Keefe, M.M. 1985, *The Benefits from Improved Investment Rules: A Case Study of the Interstate Highway System*, Report DOT/OST P-34/86/030, Department of Transportation, USA.

Griliches, Z. 1957, 'Hybrid Corn: An Exploration in the Economics of Technological Change', *Econometrica*, vol. 25, no. 4, pp. 501–522.

Hill, D. 1998, 'Unleashing Rail's Environmental Advantages', Paper presented at UIC Conference, Delhi, December 1998.

ISC 1990, *Road Use Charges and Vehicle Registration: A National Scheme*, vols. 1 and 2. 1 & 2 (appendixes), AGPS, Canberra.

Kwasnicki, W., and Kwasnicka, H. 1996, 'Long-term diffusion factors of technological development: an evolutionary model and case study', *Technological Forecasting and Social Change*, vol. 52, no. 1, pp. 31–57.

Lay, M.G. 1990, *Handbook of Road Technology, 2nd edition*, Gordon & Breach Science Publishers, London.

Maddison, D., Pearce, D., Johansson, O., Calthrop, E., Litman, T. & Verhoef, E. 1996, *The True Costs of Road Transport (Blueprint 5*), Earthscan Publications Ltd, London.

Marchetti, C. 1986, 'Fifty-year pulsations in human affairs: analysis of some physical indicators', *Futures*, vol. 18, no. 3, pp. 376–388, Butterworth & Co.

—— 1987, 'On Transport in Europe: The Last 50 Years and the Next 20', paper presented to the First Forum on Future European Transport, organised jointly by the Ludwig-Boelkow-Stiftung and Cesta, held at the Universität der Bundeswehr, Munich, 14–16 September 1987.

—— 1991, 'A Forecasting Model for Research and Innovation Activities in Selected Areas: A Support for Strategic Choices', paper presented at the International Course on Research and Innovation Management, organised by UNIDO and ICS, Venice, 13 September.

Marchetti, C. & Nakicenovic, N. 1979, *The Dynamics of Energy Systems and the Logistic Substitution Model*, RR79–13, International Institute for Applied Systems Analysis, Laxenberg, Austria.

Martin, T.C. 1994, *Estimating Australia's Attributable Road Track Costs*, ARRB Research Paper, ARR 254, Vermont South, Victoria.

Montroll, E.W. and Badger W.W. 1974, *Introduction to Quantitative Aspects of Social Phenomena*, Gordon and Breach, New York.

NAASRA 1976, *Economics of Road Vehicle Limits Study, Technical Report T4, Pavements*, NAASRA, Sydney.

Nakicenovic, N. 1987, *The Automobile Road to Technological Change: Diffusion of the Automobile as a Process of Technological Substitution*, RR-87-1, February, International Institute for Applied systems Analysis, Laxenburg, Austria.

Newbery, D.M. 1988, 'Road Damage Externalities and Road User Charges', *Econometrica,* vol. 56, no. 2, pp. 295–316.

NR 1997, *Annual Report*, National Rail Corporation, Melbourne.

NRTC 1998, *Updating Heavy Vehicle Charges: Technical Report*, September 1998, NRTC, Melbourne.

Paterson, W.D.O. 1987, *Road Deterioration and Maintenance Effects: Models for Planning and Management*, Highway Design and Maintenance Standards Series, Johns Hopkins University Press for the World Bank.

Perry, R. & Gargett, D. 1998, 'Interstate non-bulk freight', *22nd Australasian Road Transport Forum*, Sydney, September 1996, Transport Data Centre, NSW Department of Transport, Sydney.

RailRoad Technologies 1998, *Submission to the House of Representatives Standing Committee on Communications, Transport, and Microeconomic Reform's Inquiry into the Role of Rail in the National Transport Network*, RailRoad Technologies Pty Ltd.

Richards, F.J. 1969, 'The quantitative analysis of growth' in F.C. Steward (ed), *Plant Physiology: A Treatise*, vol. VA, pp. 3–76, Academic Publishers, New York.

Roth, G. 1996, *Roads in a Market Economy*, Ashgate Publishing Company Limited, Aldershot, England.

SA 1986, *Road and Traffic Engineering—Glossary of Terms, Part 1: Road Design and Construction*, AS 1348.1, Standards Australia.

Scott, J.S. 1991, *Dictionary of Civil Engineering, 4th edition*, Penguin Books, London.

Skene, P. 1996, 'The Financial Impact on Government of a Transfer of Freight from Rail to Road', *20th Australasian Road Transport Forum*, Wellington, September 1996, New Zealand Department of Transport, Wellington.

Small, K.A., Winston, C. & Evans, C.A. 1989, *Road Work – A New Highway Pricing and Investment Policy*, The Brookings Institution, Washington, D.C.

SMEC 1998, *Integration of National Road Databases*, Final Report prepared for BTCE, July 1998, SMEC Australia Pty Ltd.

Starrs, M. M. 1997, 'National Competition Policy and Competitive Neutrality', IBC Conference, *Rail versus Road: Towards competitive neutrality and open access for rail freight services*, Melbourne, September 1997, IBC Conferences.

TransEco 1999, *TransEco Road Freight Cost Indices*, TransEco Pty Ltd, Melbourne.

SUPPORTING MATERIAL

TABLE FIGURE SOURCES

Figure no.	*Source file*
1.1	p:\findem\docs\wp38\fig2_4.xls
1.2	p:\findem\docs\wp38\fig1_2.xls
1.3	p:\findem\data\msplit.xls
1.4	p:\findem\freight\msabs.xls[Ch.InterstateNon-bulk]
1.5	p:\findem\freight\msabs.xls[Ch.ModeShareChange(CN)]
1.6	p:\findem\freight\fmsplit.xls[Ch.Syd-Mel]
1.7	p:\findem\freight\fmsplit.xls[Ch.ES-Per]
1.8	p:\findem\freight\fmsplit.xls[Ch.Syd-Cbr]
4.1	p:\findem\freight\msabs.xls[Ch.ModeShareChange(CN) (2)]
5.1	p:\findem\freight\fmsplit.xls[Ch.Mel-Syd(NewTech)]
I.1	p:\findem\freight\msabs.xls[Ch.SMVUNon-bulk]
II.1	p:\compneut\lccmodl2.xls[Ch.DamageCostvsLoad]
II.2	p:\compneut\CostRec.xls[Ch.CostperESAL]

TABLE TABLE SOURCES

Figure no.	*Source file*
2.1	
2.2	p:\findem\freight\msabs.xls
II.2	p:\compneut\NRTC accounting.xls[NRTC]
II.3	p:\compneut\NRTC accounting.xls[Luck&Martin}
II.4	p:\compneut\NRTC accounting.xls[BTE]

BUREAU OF TRANSPORT ECONOMICS

RECENT PUBLICATIONS

REPORTS

96 *Quality of rail freight service: The customer's perspective* (1997) $11.95 (96 1017 0)

97 *Transport synergies between eastern Indonesia and Northern Australia* (1998) $12.95 (0 642 30504 8)

98 *Cost of Civil Aviation Accidents and Incidents* (1998) $11.95 (0 642 47601 2)

99 *Adequacy of Tourism Transport Infrastructure in Eastern Indonesia* (1998) $24.95 (0 642 70420 1)

OCCASIONAL PAPERS

108 *Greenhouse Gas Emissions and the Demand for Urban Passenger Transport: Design of the Overall Approach* (1993) (0 642 20012 2)

110 *Greenhouse Gas Emissions in Australian Transport in 1900 and 2000* (1995) 0 642 22681 4

115 *Trading Greenhouse Emissions: Some Australian Perspectives* (1998) $19.95 (0 642 47622 5)

INFORMATION PAPERS

41 *BTCE road construction and maintenance price index* (1997)

42 *Coastal Freight in Australia, 1995-96* (1998)

43 *Coastal Freight in Australia, 1996-97* (1998)

44 *Australian Transport Data: A Compendium of Sources* (1999)

WORKING PAPERS (Free from the BTE)

33 *Roads 2020* (1997)

37 *Tradable permits in transport?* (1998)

38 *Forecasting Light Vehicle Traffic* (1998)

39 *Urban Transport Models: A Review* (1998)

ELECTRONIC BULLETINS

Available from http://www.dotrs.gov.au/programs/bte/btehome.htm

Transport Indicators (Quarterly)

Waterline (Quarterly)

INTERNET

http://www.dotrs.gov.au/programs/bte/btehome.htm

To order free publications contact the BTE at GPO Box 501, Canberra ACT 2601, Australia, Phone 02 6274 6846, or email bte@dotrs.gov.au. Other titles are on sale from AusInfo, GPO Box 84, Canberra ACT 2601, Australia, Phone toll-free 132 447 (AusInfo catalogue number or ISBN is in brackets).