Bureau of Transport Economics

WORKING PAPER 38

FORECASTING LIGHT VEHICLE TRAFFIC

PREFACE

BTCE (1997) presented estimates of funding requirements for the non-urban sections of the National Highway System to the year 2020. These estimates were used by the House of Representatives Standing Committee on Communications, Transport and Microeconomic Reform Inquiry into Federal Road Funding for its report *Planning Not Patching* (HORSCCTMR 1997).

The BTE's detailed projections of light vehicle travel on national highways were a major input to the modelling of long-term funding needs of the National Highway system. Projections of traffic levels permit assessment of the future needs for maintenance of highways, expansion of capacity (in terms of road width), and construction of bypasses around towns. A brief summary of the methodology and results was published as chapter 2 in BTCE (1997). Further work has since been undertaken to refine the modelling, and to check the accuracy of the BTE projections. This Working Paper reports the results of that work.

The BTE is conscious that there is currently no comprehensive set of long-term projections of freight flows on a national basis to complement its projections of light vehicle demand for the use of road infrastructure. It is hoped that work can commence shortly on the development of projections of freight flows along non-urban sections of the National Highway System and other corridors.

The BTE would like to thank the many people and organisations that contributed data and ideas to this project. Particular thanks are due to the Bureau of Tourism Research, the Roy Morgan Research Centre and Tourism Tasmania for access to their data holdings on tourism; Arnulf Gruebler of the International Institute for Applied Systems Analysis (Laxenberg, Austria) for his help with logistic substitution models; the State and Territory road authorities for access to traffic data; BTE Corporate Services and the Trace Library for patience in the face of voluminous requests for files and publications.

Members of the team that produced the projections of light vehicle traffic flows include Dr David Gargett (team leader), David Cosgrove, David Mitchell, Seu Cheng and Tony Carmody.

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UNITS

AADT	average annual daily traffic (both ways past a point on a highway)
CPI	consumer price index
ERP	estimated resident population
OD	origin-destination
PKM	passenger-kilometres
SD	statistical division
SLA	statistical local area
SSD	statistical sub-division
TKM	tonne-kilometres
VKT	vehicle-kilometres travelled

ABSTRACT

The BTE has developed and applied methods for forecasting light vehicle traffic on the nation's roads. This paper describes the methods and provides estimates and projections of light vehicle traffic within major Australian cities and on Australia's principal non-urban highways.

A simple model was developed to predict the growth of total light vehicle traffic in each of Australia's major cities. When linked to congestion models, the BTE results presage a looming congestion problem in our cities.

The most significant contribution of the Working Paper is the development of new models for long-term forecasting of light vehicle traffic on Australia's non-urban highways. As far as the BTE is aware, its methodology has not previously been used in Australian studies. Data from a number of different sources have been utilised to estimate interregional passenger travel by domestic residents and light vehicle highway traffic. The traffic projections indicate that growth in traffic volumes on the National Highway system will be greatest on those sections linking the major capitals; Adelaide Melbourne, Sydney, Brisbane and regional centres in between.

CHAPTER 1 INNOVATION IN TRAFFIC DEMAND FORECASTING

The car plays an important role in Australian transport. It is by far the most common mode of passenger travel, and constitutes a large part of the traffic stream on our roads. Light commercial vehicles form a smaller fraction of the traffic, but are growing more rapidly as the service economy expands. Together these form 'light vehicle traffic'.

Because of the importance of light vehicle traffic, the BTE has applied innovative methods to estimate traffic levels over the next two decades.

For example, a simple, yet powerful, equation has been developed in chapter 2 to predict the growth of total light vehicle traffic in each of Australia's major cities. Growth in city traffic can be portrayed as a simple function of population growth and growth in vehicle ownership. The equation allows checks by State road authorities of likely future traffic demand. When linked to congestion models, the broad outlines of a looming congestion problem in our cities can be discerned. For example, it is possible that the cost of congestion in Melbourne could triple by the year 2015 (see chapter 2).

But the most significant contribution of this Working Paper is the development of new models for long-term forecasting of light vehicle traffic on Australia's highways. As far as the BTE is aware, the methods presented below have not previously been used in Australian studies.

A gravity model has been derived to allow prediction of the rate of growth in total passenger travel (car, coach, rail and air) between any two regions or cities in Australia. Growth in total travel is shown to be a simple function of the two endpoint populations and the generalised cost of travel between them (chapter 3). Using this equation, forecasts of total travel between all pairs of regions can be derived.

Forecasts of total travel were converted to forecasts for specific modes by using another innovative suite of models: logistic substitution models of mode split (box 1.1). These models capture long-term trends in model shares, as well as any sudden shifts due to relative price changes, generated historically by factors such as market deregulation.

BOX 1.1 LOGISTIC SUBSTITUTION MODELS

Logistic substitution models are derived from biological antecedents, where species compete within a niche. They are a specific form, part of a wider class of models referred to as *diffusion processes* (box 1.2). Developed and applied mainly at the International Institute for Applied Systems Analysis at Laxenberg, Austria, they have been applied to phenomena as diverse as energy sources, transport mode shares and competition between technologies (Marchetti & Nakicenovic 1979, Gruebler 1990, and Kwasnicki & Kwasnicka 1996).

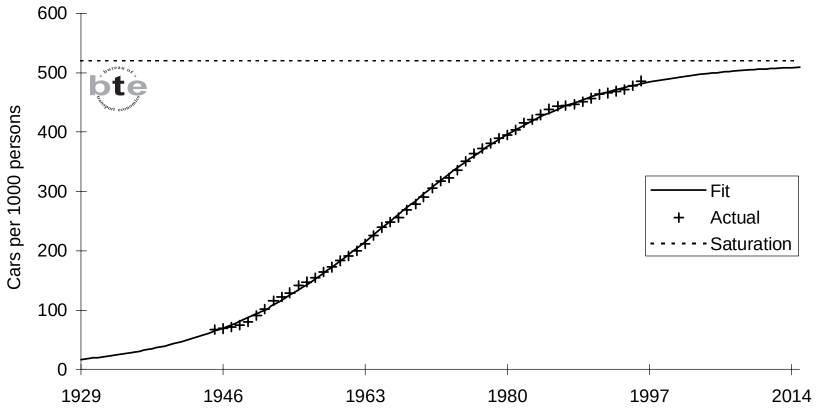
The models are called 'logistic' because, if there is only one species (energy source, transport mode, etc.), it grows in a logistic fashion (an S-shaped curve). For example, 'cars per thousand people' in Australia has grown in a logistic pattern (figure 1.1). After World War II, car ownership expanded rapidly, exhibiting exponential growth. In the 1980s, growth began to decelerate, and is currently moving towards a saturation level of about 520 cars per thousand people (assuming no change in the current age profile of the population).

The 'substitution' part of the name arises when there is more than one species competing for a 'niche'. For example, figure 1.2 shows the sequential logistic growth of canals, railroads, roads, and airways in the USA (normalised in size on their midpoints). When a competing mode appears, it contributes to the saturation (and eventual decline) of the previous occupants of the niche. Given a progressive substitution of modes, a graph of mode share would show a succession of bell-shaped curves. As a new mode grows, the share of the previous dominant mode declines. The 'winning' mode loses in turn to another, more successful mode.

Figure 1.3 shows the mode substitution that has occurred in non-urban travel in Australia since 1939. Post World War II, the mode with the highest share of non-urban travel (ignoring horse-powered travel) was rail, with car a poor second. Special train services were also run to carry supporters of football teams between country towns for local Saturday matches.

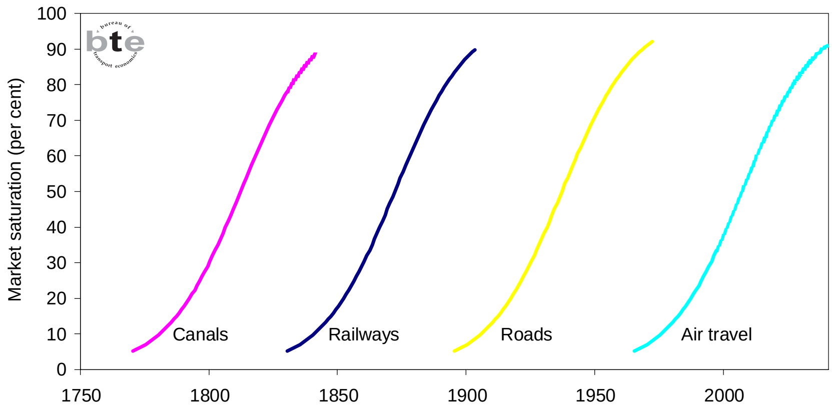
All that changed with the widespread introduction of motor vehicles and sealed roads in the immediate post-War period. Rail declined to very low levels by the 1980s, being replaced mostly by the car. At the same time, air travel steadily gained ground. Air travel lost some market share when coach travel was deregulated in the early 1980s, and coach fares halved. But in the 1990s, with its own deregulation and a 20 per cent fare cut, air travel re-established itself as the dominant growth mode. Its growth at the expense of other modes is expected to last to about the end of the first decade of the new century, at which time it is likely to run up against a lack of suitable non-urban car travel to replace (leaving mostly the rural local traffic as a residual).

FIGURE 1.1 PROJECTED PER CAPITA AUSTRALIAN MOTOR VEHICLE OWNERSHIP



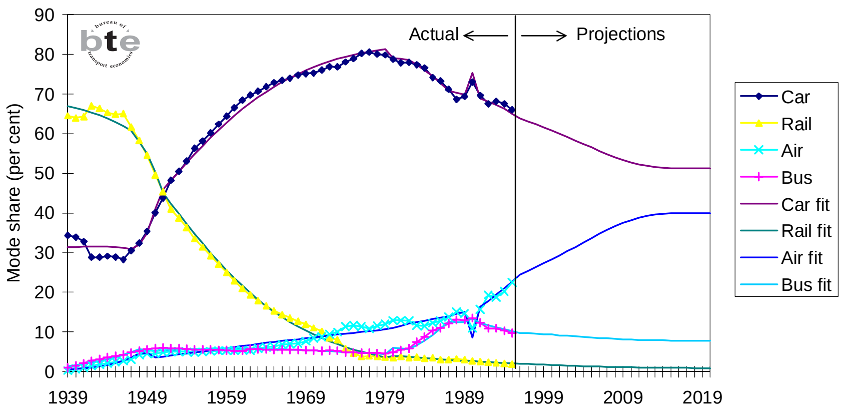
Source BTCE 1996b, p.6.

FIGURE 1.2 STYLISED SEQUENTIAL GROWTH OF US TRANSPORT MODES



Source Marchetti 1986, p. 381.

FIGURE 1.3 MODAL SHARES OF AUSTRALIAN NON-URBAN TRAVEL (PKM USING FARE VARIABLES AND IMPOSED SATURATION OF AIR SHARE)



Source BTE

BOX 1.2 TECHNOLOGY DIFFUSION PROCESSES

‘In science, the term *diffusion* refers to the phenomenon of the spread in space or the acceptance in a social environment, over time, of some specific term or pattern’ (Kwasnicki & Kwasnicka 1996, p. 31). In economics, diffusion processes have been used to model the rate of take-up or demand for new technologies: for example, the installation of new telephones and communications services.

Generally, in the absence of superior technologies, the diffusion of a single technology follows an S-shaped (sigmoidal) curve. The diffusion process consists of three phases: an introductory phase, where the rate of diffusion is not very high; a rapid take-up phase, when the rate of diffusion is at its highest; and a mature phase, when the technology has saturated the market, and the rate of diffusion is again relatively slow.

The logistic function is a commonly used, symmetric, diffusion process. It has the form:

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

where: f = ‘a function of’;

k = the saturation level;

t = time;

exp = ‘the exponential of’; and

a, b = constants.

Non-symmetric diffusion processes can be portrayed using functions such as the Gompertz and Flexible Logistic curves.

Multi–technology diffusion (or substitution) processes involve cases two or more technologies compete. In multi-technology diffusion models, the diffusion process of any single technology has the form of a bell-shaped curve, with four characteristic phases. The first three phases are similar to a simple diffusion model, while in the fourth phase the market share of the technology declines because of the emergence of a new, superior technology.

The fitted logistic substitution models (complemented by several rules of thumb) were used to forecast travel by car between all regions of Australia. Assigning these forecasts of car trips into a model of the Australian road network permits forecasts of 'through' traffic at all points on the nation's highway system. For example, on the Pacific Highway between Sydney and the Central Coast, the nature of the current and future through traffic can be examined – how many cars travel between Sydney and Brisbane, Melbourne and the Gold Coast, etc.

The size of the 'local' component of the traffic can also be determined. One might ask how much of the traffic on the Sydney to Central Coast section of the Pacific Highway is local traffic (e.g. commuter traffic from the Central Coast to Sydney). Given the projected growth of population along the Central Coast, how fast will this traffic grow? A rural local model has been developed by the BTE (and validated on 20 years of historical Western Australian data) to answer such questions.

Used in concert, the suite of BTE models for highway traffic allow consistent, long-term forecasts to be produced for growth in light vehicle traffic at all points on the Australian highway network.

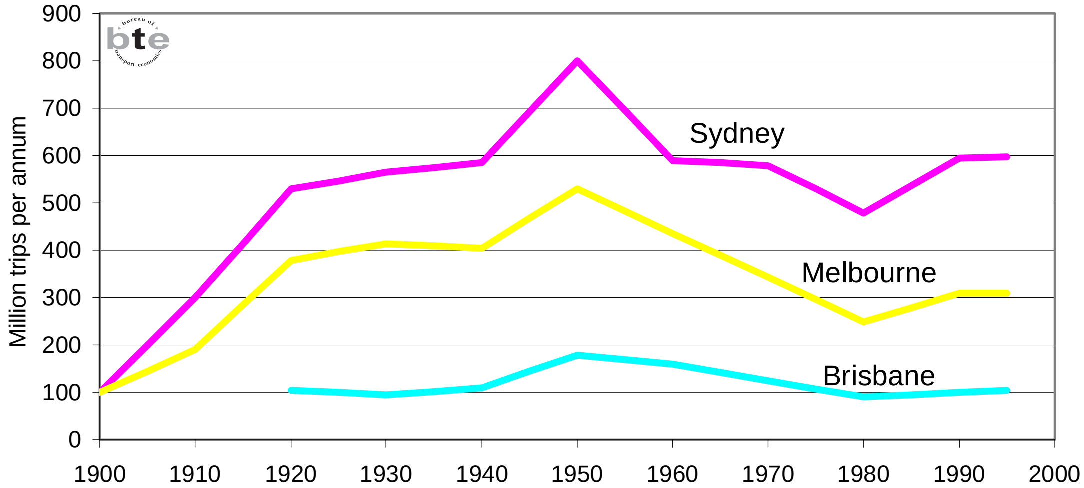
In addition, the models contain many explanatory factors, the values of which can be varied to produce any number of scenarios (as opposed to forecasts). Prices, fares, incomes, mode competitiveness, the road network and population can be varied to produce 'what if ?' analyses. For example, what if the trend shift of population from the south eastern states to the northern 'sun belt' accelerated markedly? What if average airfares halved? What would be the effect on car traffic on the Hume Highway (or any highway in Australia)? The models presented in this paper allow consistent and logical answers to these sorts of questions.

CHAPTER 2 AN URBAN CAR TRAVEL MODEL

By 1996, about 85 per cent of Australians were living in urban centres. Urban passenger transport problems are therefore 'mainstream' problems in the Australian passenger transport sector.

Use of urban public transport (UPT) in the cities reached its peak after the Second World War, declining in absolute level over the next three decades, before stabilising in the 1980s and 1990s. Figure 2.1 illustrates the trend in UPT patronage for Sydney, Melbourne and Brisbane, and figure 2.2 shows the size of the 'non-car' task (passenger-km) since 1945 for bus, rail, and other (primarily light commercial vehicles and motorcycles).

FIGURE 2.1 URBAN PUBLIC TRANSPORT PASSENGERS: SYDNEY, MELBOURNE AND BRISBANE, 1900 TO 1995

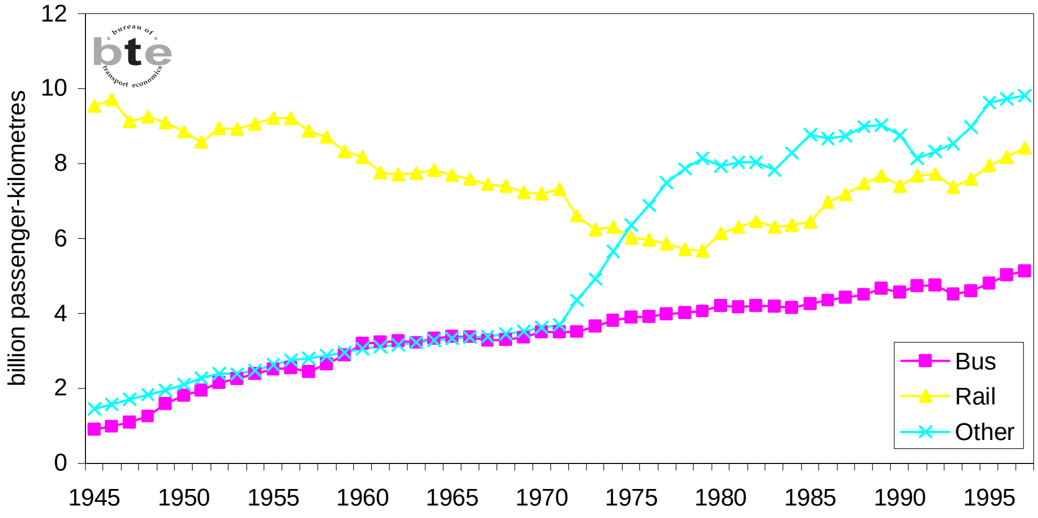


Sources BTE estimates; BTCE 1991; Neutze 1977.

By the 1980s, however, the largest mode of passenger transport in our cities was the car (figure 2.3). Cars currently account for almost 90 per cent of the total urban passenger kilometre task (figure 2.4). Many of the problems of passenger transport in cities are thus really problems associated with car usage.

Moreover, since UPT has such a small share of the urban passenger travel market, urban car travel can legitimately be analysed in isolation from UPT.

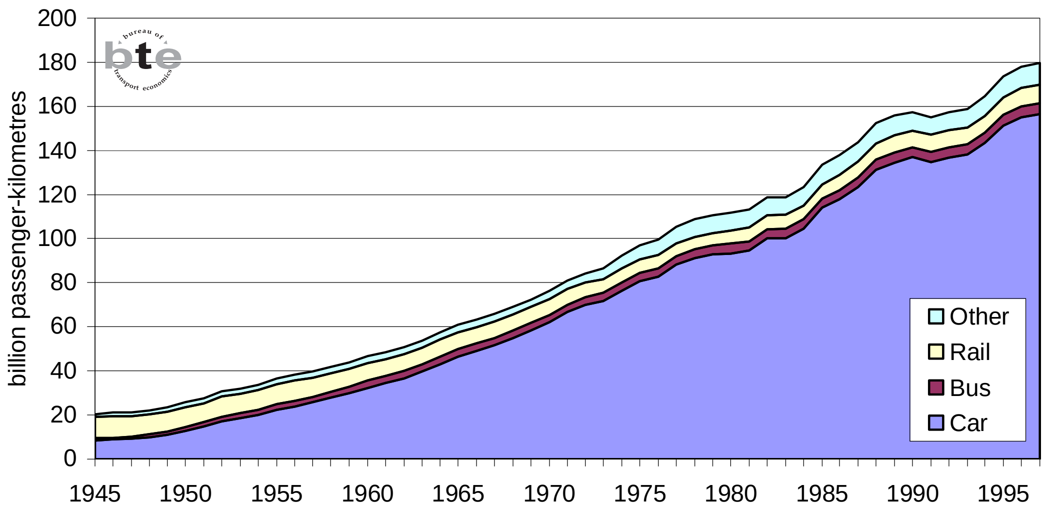
FIGURE 2.2 AUSTRALIAN URBAN 'NON-CAR' TRANSPORT – SIZE OF TASK, 1945 TO 1997



Note 'Other' is primarily light commercial vehicles and motorcycles.

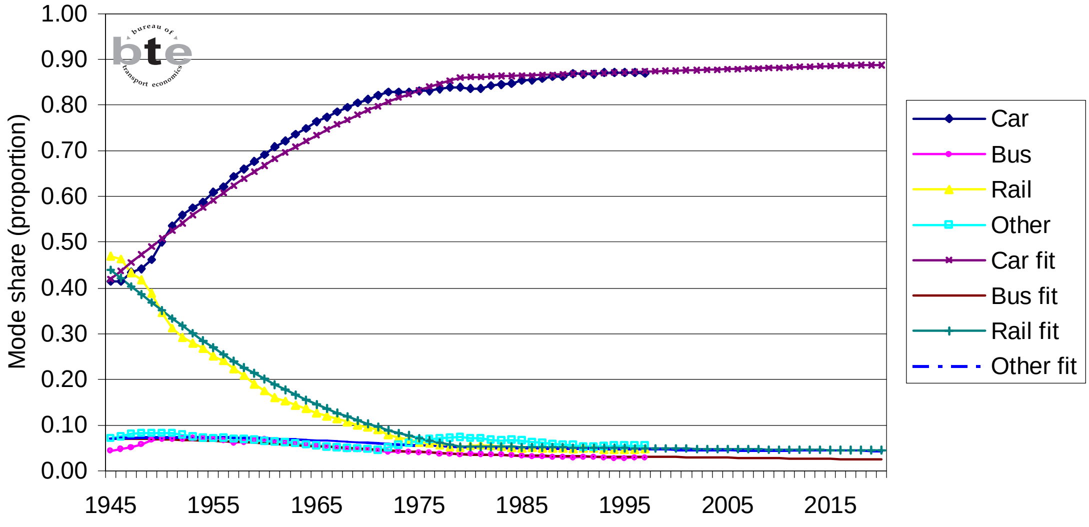
Sources BTE estimates; BTE Indicators database 1997; Cosgrove & Gargett 1992; ABS 1998a, 1998b, 1997b, 1974 and earlier issues.

FIGURE 2.3 AGGREGATE AUSTRALIAN URBAN PASSENGER TRANSPORT TASK, 1945 TO 1997



Sources BTE estimates; BTE Indicators database 1997; Cosgrove & Gargett 1992; ABS 1998a, 1998b, 1997b, 1974 and earlier issues.

FIGURE 2.4 MODE SPLIT: AGGREGATE AUSTRALIAN URBAN PASSENGER TRANSPORT TASK, 1945 TO 1997



Sources BTE estimates; BTE Indicators database 1997; Cosgrove & Gargett 1992; ABS 1998a, 1998b, 1997b, 1974 and earlier issues.

A CITY VKT MODEL

Previous modelling at a national level (BTCE 1995, 1996b) portrayed vehicle kilometres travelled (VKT) by car as the product of trends in:

- cars per thousand persons;
- VKT per car; and
- population.

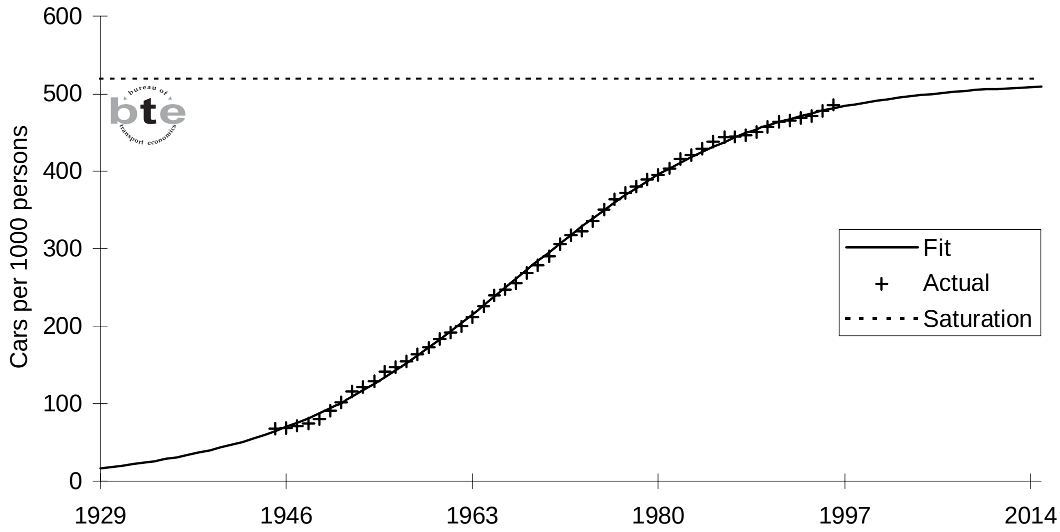
The number of cars per person in Australia was found to follow a logistic (S-shaped) curve (figure 2.5).

Although car ownership and use soared in the post-War period, a saturation level in *per person* ownership of cars was becoming evident by the 1990s. The ownership rate is currently approaching an estimated limit of 520 cars per thousand of total population. Similar patterns of saturation are evident in most other developed countries (Gruebler 1990).

It can be expected that this S-shaped logistic relationship would also hold in Australia's cities, where most of the population resides. Thus one should see the growth in car ownership per city resident continue to slow as we move into the next century, due to an increasing saturation of the demand for personal motor vehicle transport. In the cities, there is the additional negative influence of congestion, the cost of which should increase significantly over the next 25 years (BTCE 1996c).

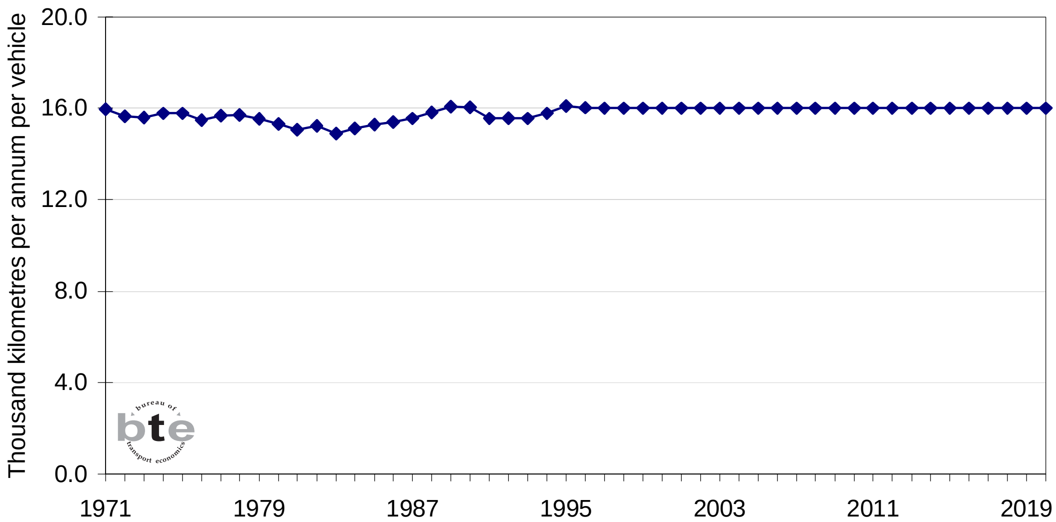
Forecasting average VKT per car was straightforward. The average distance driven per car in Australia appears to have been largely unchanged over the last 25 years (figure 2.6). Any increases in personal travel demand appear to have been spread over an increased number of cars per household to produce this result.

FIGURE 2.5 PROJECTED PER CAPITA AUSTRALIAN PASSENGER CAR OWNERSHIP



Sources BTE estimates; BTCE 1996b.

FIGURE 2.6 AVERAGE ANNUAL KILOMETRES TRAVELLED PER VEHICLE: AUSTRALIAN PASSENGER CAR FLEET, 1971 TO 2020



Sources BTE estimates; BTCE 1996b.

Thus the model of car VKT adopted at the national level applied a logistic function to predict cars per person, assumed VKT per car to be constant, and used ABS mid-range forecasts of national population growth.

The methodology adopted for modelling VKT in urban centres was identical, except that city-specific populations were substituted.

The product of city population, 'cars per person' and VKT per car yielded an 'implied city VKT' which was then regressed against the actual city VKT (VKT_i) as follows:

$$VKT_i = \text{Constant} + \beta_1 (nvp * avk * pop_i) + \varepsilon_i \tag{2.1}$$

where:

VKT_i = total vehicle kilometres travelled in city i;

nvp = vehicles per thousand persons nationally;

avk = annual average kilometres travelled per vehicle nationally;

pop_i = population of city i;

Constant and β_1 = model parameters; and

ε_i = error term.

The model specification was designed to provide an estimate of the amount of travel associated with implied VKT (with the theoretically expected value being 1.0). The fit was fairly good (figure 2.7) and the estimated coefficient on 'implied VKT' was 0.97. Consistent differences between cities in the *level* of actual versus predicted VKT were observed.

A second model of city VKT was derived, using implied VKT, as well as city dummy variables, introduced to 'fine tune' the levels of VKT in the different cities. The model was specified as follows:

$$VKT_i = \alpha_i dcity_i + \beta_1 (nvp * avk * pop_i) + \varepsilon_i \tag{2.2}$$

where:

VKT_i = total vehicle kilometres travelled in city i;

nvp = vehicles per thousand persons nationally;

avk = average kilometres travelled per vehicle nationally;

pop_i = population of city i;

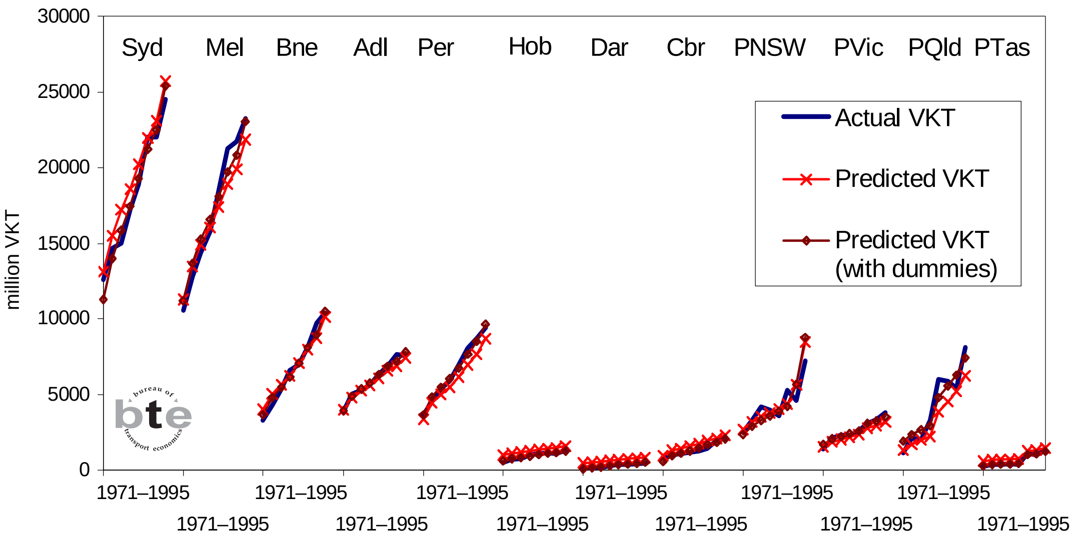
$dcity_i$ = dummy variable for city i;

α_i , β_1 = model parameters; and

ε_i = error term.

The results of least squares regression of equations (2.1) and (2.2) are listed in table 2.1. The regression results indicate that there are significant differences between cities, measured by the dummy variable parameters, in the level of traffic predicted by population and vehicle ownership growth. The dummy variable parameter estimate may reflect different levels of availability of public transport and / or differences in the propensity to travel by car. The growth in traffic in all cities is well explained by trends in vehicle ownership, average VKT per vehicle and population growth. (Appendix I describes in more detail the analysis of urban car passenger travel, and the definition of provincial urban areas.)

FIGURE 2.7 ACTUAL AND PREDICTED URBAN PASSENGER VKT, 1971-1995



Note P before State equals 'Provincial', defined in appendix I.

Sources BTE estimates; ABS 1996b and earlier issues.

The model of city VKT expressed in equation 2.2 explains over 99 per cent of the variation in urban passenger vehicle VKT. The model permits accurate forecasts of city VKT growth, given accurate forecasts of city population growth.

The average coefficient on implied city VKT, approximately one, means that growth in urban VKT is directly proportional to growth in city population and the number of cars per person. This means, for example, that if population growth in Sydney is expected to be about 0.75 per cent per year to 2020 (appendix V), and the contribution of growth in cars per person is expected to fall from 1 per cent a year in 1995 to almost zero by 2020, then the growth rate of Sydney car VKT would be expected to fall from something like 1.75 per cent per year in 1995 to about 0.75 per cent per annum by 2020. Table 2.2 provides forecasts of VKT growth in each of the major capital cities and major provincial urban areas to the year 2020. Figure 2.8 shows the expected rates of growth in VKT in capital cities and provincial urban centres. Some of this growth will be carried on new suburban roads, but some of it will be carried on the existing road networks of the cities.

TABLE 2.1 URBAN PASSENGER VEHICLE VKT MODEL – PARAMETER ESTIMATES

	OLS equation (2.1)	Feasible GLS *equation (2.2)*
Dependent variable: Urban passenger travel (million VKT)		
Constant	302.76	..
	(101.9)	
Implied VKT parameter	0.860	0.968
	(0.011)	(0.015)
Dummy variable parameter estimates (million VKT)		
Sydney	..	-3149.4
Melbourne	..	-1258.2
Brisbane	..	-542.8
Adelaide	..	-161.4
Perth	..	181.3
Hobart	..	-166.7
Darwin	..	-99.1
Canberra	..	-166.7
Provincial NSW	..	-409.5
Provincial Vic.	..	298.5
Provincial Qld.	..	776.9
Provincial Tas.	..	-72.0
$\overline{R}^2$	.9857	.9980

Note Parameter estimates obtained by applying ordinary least squares (OLS) and feasible generalised least squares (GLS) to pooled cross section – time series of travel in 12 urban areas. Figures in parentheses are the estimated standard errors. $\overline{R}^2$ is the regression correlation coefficient adjusted for the number of regressors.

.. – Not applicable

Source BTE estimates.

The BTE forecasting models can be used to approximate the implications for congestion costs in our cities. Take Melbourne as an example:

(1) The number of cars per million persons nationally is expected to grow from about 0.475 in 1995 to about 0.509 in 2015.

(2) The population of Melbourne is projected to rise from about 3.2 million in 1995 to about 3.7 million in 2015.

(3) The distance travelled per car is expected to remain about 16 thousand kilometres per year.

(4) The city adjustment for Melbourne is just over -1.0 million VKT per year (table 2.1).

This means that car *usage* in Melbourne will rise from about 23.3 billion vehicle kilometres travelled (VKT) in 1995 ((0.475*3.2*16)-1) to about 29.1 billion VKT in 2015 ((0.509*3.7*16)-1). This represents a forecast growth of about 25 per cent over the 20 years.

To derive the implications for congestion, some assumptions are necessary:

(5) Assume that half the population growth will occur at the city fringe, that half the driving of ‘fringe’ residents will be confined to the new areas and that the fraction of non-urban driving by city populations will not change.

This means that 3/4 of the growth in car usage (1-1/2*1/2) will be concentrated on the existing city network – i.e. a growth in *car traffic* of 20 per cent over the next 20 years in the Melbourne of today, to 27.6 billion VKT.

(6) Assume that light commercial vehicles (LCVs) currently comprise 12 per cent of the vehicle stream, rigid trucks 4 per cent and articulated trucks 1 per cent. (3.3, 1.1 and 0.3 billion VKT respectively). As rigid trucks are equal (for congestion purposes) to about 2 car equivalents and articulated trucks to 3 car equivalents, current Melbourne commercial vehicle traffic levels are about 6.4 billion car equivalents (3.3 + 2.2 + 0.9). In 20 years time, urban LCV vehicle kilometres travelled are expected to be 1.8 times current levels, rigid truck VKT 1.6 times, and articulated truck VKT 2.2 times. But again, some of this will be restricted to the new areas - perhaps 10 per cent of the growth. So, by the year 2015, truck traffic within Melbourne’s current boundaries in billions of car equivalent VKT is likely to be about 5.3 for LCVs, 3.2 for rigid trucks and 1.8 for articulated trucks.

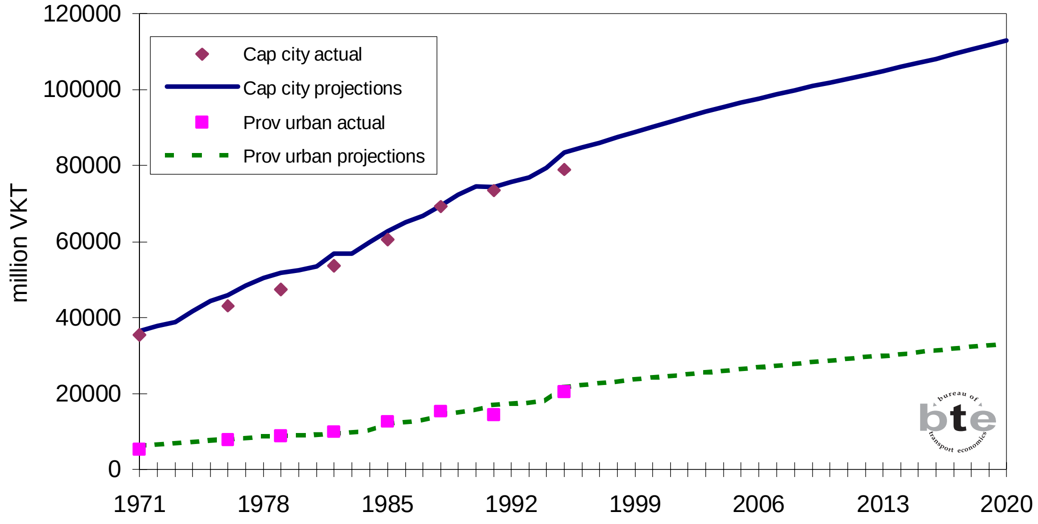
This means that total traffic volume in the existing city will rise by about 33 per cent, from 29.7 billion car equivalent VKT to about 39.4 billion car equivalent VKT. A significant amount of this total growth will come from growing commercial vehicle usage.

(7) Lastly, assume that there is a 5 per cent increase in the capacity of the road system, due to various infrastructure improvements and refinements.

Thus by 2015 in Melbourne the volume-capacity ratio for the existing network should rise by a net 28 per cent. BTCE (1996a, table XIII.2, pp. 480-481) provides a look–up table for calculating the effects of such growth on congestion costs. For Melbourne, the *annual* cost of congestion in 2015 is $0.25 per vehicle kilometre travelled (at 1996 price levels). As Melbourne will have 39.4 *billion* car equivalent VKT in 2015, the annual cost of congestion (above economically optimal levels) is likely to be of the order of $10 billion - for Melbourne alone. This would represent a tripling of congestion costs over current levels.

Congestion and its related issues - infrastructure spending and road pricing - are likely to remain major issues for Australian cities, and thus for the nation, in the next 20 years. Additionally, the increase in traffic volume will intensify the levels of emissions, noise, and safety hazards.

FIGURE 2.8 PROJECTED URBAN PASSENGER VEHICLE VKT IN CAPITAL CITIES AND PROVINCIAL URBAN AREAS, 1971 TO 2020



Sources BTE estimates; BTCE 1996b; ABS 1997a; ABS 1996b, 1993a and earlier issues.

TABLE 2.2 URBAN PASSENGER VEHICLE VKT ESTIMATES FROM 1971 TO 1995, AND PROJECTIONS FROM 1996 TO 2020

(million vehicle kilometres)

Year	*Capital cities*								*Provincial urban areas*				*Total*	
	Syd	*Mel*	*Bne*	*Adl*	*Per*	*Hob*	*Dar*	*Cbr*	*NSW*	*Vic*	*Qld*	*Tas*	*Capital cities*	*Provincial urban areas*
1971	11286	11192	3662	3947	3666	596	83	540	2363	1701	1915	274	34972	6253
1972	11631	11516	3823	4078	3844	619	93	610	2435	1750	1982	283	36215	6449
1973	11917	11789	3969	4194	4011	639	103	678	2496	1793	2045	290	37301	6625
1974	12760	12545	4285	4473	4326	688	121	782	2663	1893	2157	311	39980	7025
1975	13569	13273	4597	4745	4640	736	139	888	2825	1991	2270	331	42588	7417
1976	13977	13656	4790	4901	4854	763	152	973	2910	2050	2350	342	44066	7651
1977	14778	14338	5076	5111	5107	802	171	1032	3067	2132	2467	359	46416	8025
1978	15454	14910	5326	5283	5326	835	189	1083	3200	2201	2575	373	48406	8349
1979	15868	15255	5494	5377	5475	853	204	1117	3284	2243	2659	381	49642	8567
1980	16095	15438	5603	5415	5572	861	215	1138	3332	2266	2725	384	50338	8707
1981	16413	15700	5741	5480	5695	874	229	1165	3397	2298	2800	390	51296	8886
1982	17440	16561	6168	5777	6048	926	261	1257	3577	2405	2956	414	54437	9352
1983	17469	16561	6273	5786	6119	925	277	1280	3567	2410	3007	414	54690	9398
1984	18375	17314	6670	6048	6444	971	308	1365	3722	2504	3155	435	57496	9816
1985	19279	18065	7073	6309	6772	1017	341	1452	3876	2599	4790	455	60308	11720
1986	19927	18594	7393	6496	7028	1049	370	1522	3981	2667	4983	470	62379	12101
1987	20438	19041	7696	6637	7314	1072	383	1583	4078	2727	5237	482	64165	12525
1988	21225	19726	8100	6858	7688	1110	402	1666	4227	3087	5549	1025	66776	13888
1989	22063	20455	8528	7094	8084	1151	422	1754	4386	3196	5878	1060	69551	14520
1990	22629	20950	8863	7250	8400	1177	437	1822	4494	3274	6158	1083	71529	15009
1991	22486	20837	8938	7203	8490	1166	437	1836	5662	3271	6290	1074	71393	16296

TABLE 2.2 URBAN PASSENGER VEHICLE ACTUAL VKT ESTIMATES FROM 1971 TO 1995, AND PROJECTIONS FROM 1996 TO 2020 (CONTINUED)

(million vehicle kilometres)

Year	*Capital cities*								*Provincial urban areas*				*Total*	
	Syd	*Mel*	*Bne*	*Adl*	*Per*	*Hob*	*Dar*	*Cbr*	*NSW*	*Vic*	*Qld*	*Tas*	*Capital cities*	*Provincial urban areas*
1992	22918	21133	9186	7276	8671	1181	446	1866	5760	3302	6485	1084	72678	16632
1993	23297	21384	9427	7334	8842	1193	455	1894	5846	3327	6682	1092	73825	16946
1994	24138	22031	9861	7520	9171	1228	474	1963	6039	3405	6998	1119	76387	17562
1995	25388	23026	10479	7818	9647	1284	504	2070	8782	3528	7431	1248	80215	20988
1996	25772	23288	10794	7870	9847	1295	516	2118	8917	3552	7684	1255	81500	21408
1997	26140	23561	11059	7940	10046	1306	524	2158	9107	3598	7900	1264	82734	21869
1998	26552	23884	11326	8025	10260	1320	533	2206	9311	3651	8114	1276	84108	22352
1999	26954	24195	11591	8107	10472	1334	542	2254	9513	3703	8326	1287	85448	22828
2000	27345	24495	11852	8183	10680	1346	550	2301	9711	3753	8537	1298	86753	23299
2001	27724	24784	12110	8255	10887	1358	558	2348	9907	3803	8745	1307	88023	23762
2002	28092	25060	12364	8322	11090	1368	566	2394	10099	3851	8952	1316	89258	24218
2003	28449	25325	12615	8386	11292	1378	573	2440	10287	3898	9158	1325	90459	24668
2004	28796	25578	12862	8446	11491	1387	580	2485	10473	3944	9362	1332	91625	25112
2005	29132	25820	13105	8503	11687	1396	586	2530	10657	3989	9564	1339	92759	25549
2006	29457	26051	13344	8555	11881	1403	592	2574	10838	4033	9763	1345	93857	25979
2007	29770	26270	13579	8604	12071	1410	598	2617	11016	4076	9961	1351	94919	26403
2008	30074	26477	13809	8649	12259	1417	603	2660	11192	4117	10156	1356	95949	26822
2009	30369	26676	14037	8692	12445	1422	609	2701	11366	4158	10350	1361	96951	27235
2010	30655	26865	14262	8733	12628	1428	614	2742	11538	4197	10543	1365	97925	27643
2011	30933	27046	14483	8770	12810	1432	619	2782	11709	4236	10734	1368	98874	28047

TABLE 2.2 URBAN PASSENGER VEHICLE ACTUAL VKT ESTIMATES FROM 1971 TO 1995, AND PROJECTIONS FROM 1996 TO 2020 (CONTINUED)

(million vehicle kilometres)

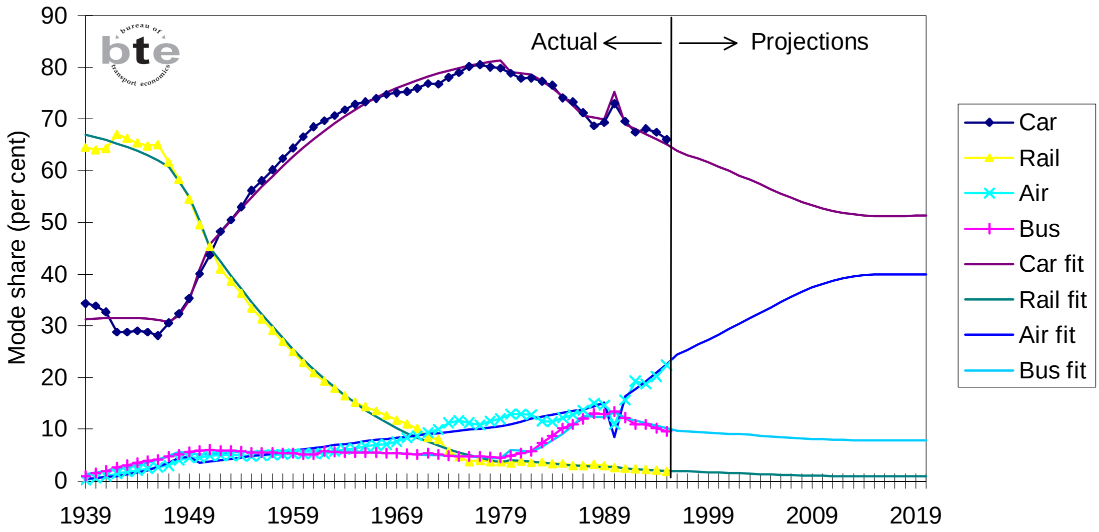
Year	*Capital cities*								*Provincial urban areas*				*Total*	
	Syd	*Mel*	*Bne*	*Adl*	*Per*	*Hob*	*Dar*	*Cbr*	*NSW*	*Vic*	*Qld*	*Tas*	*Capital cities*	*Provincial urban areas*
2012	31203	27220	14701	8806	12989	1437	623	2821	11878	4274	10923	1371	99800	28447
2013	31487	27419	14938	8845	13181	1441	629	2874	12055	4314	11128	1375	100815	28872
2014	31772	27622	15181	8883	13377	1446	635	2933	12234	4354	11336	1378	101848	29303
2015	32057	27830	15428	8921	13576	1450	640	2998	12415	4395	11550	1382	102900	29741
2016	32342	28042	15681	8959	13778	1455	646	3070	12598	4436	11768	1385	103974	30186
2017	32629	28261	15940	8997	13984	1459	653	3149	12783	4477	11991	1388	105073	30639
2018	32918	28485	16205	9035	14195	1463	659	3237	12970	4519	12220	1391	106197	31099
2019	33208	28716	16476	9073	14410	1467	666	3335	13160	4561	12454	1394	107351	31568
2020	33499	28954	16754	9111	14629	1471	673	3444	13352	4604	12693	1397	108535	32046

Sources BTE estimates, based on population projections for city Statistical Divisions; ABS 1997a.

CHAPTER 3 INTERREGIONAL PASSENGER TRAVEL MODELS

Changes in mode of travel have not been very significant in urban areas. The car has been the main mode of urban travel since the 1950s and will continue to be so in the foreseeable future. However, long-term mode shift patterns are much more important when considering non-urban travel. Figure 3.1 shows that the mode with the highest share of non-urban passenger travel (ignoring horse-drawn transport) in the immediate pre-War period was rail, with car a poor second.

FIGURE 3.1 MODAL SHARES OF AUSTRALIAN NON-URBAN TRAVEL (PKM USING FARE VARIABLES AND IMPOSED SATURATION OF AIR SHARE), 1939 TO 2020



Source BTE estimates.

Choice of mode changed markedly in the post-War period. Rail travel declined to a very low level by the 1980s, being mostly replaced by car travel. At the same time, air travel had been steadily gaining ground. Its growth slowed when coach travel was deregulated in the early 1980s and coach fares halved. But in the 1990s, with its own deregulation and a 20 per cent cut in real average air fares, air travel reestablished itself as the dominant growth mode. Air travel's growth at the expense of other modes is expected to last to about the end of the first decade of the new century. It is then likely to run up against a lack of suitable longer-distance non-urban car travel to replace, leaving mostly the shorter–distance and rural local traffic as residual. The constraint on air share shown in figure 3.1 (40 per cent) was specified after consideration of the likely volume of this 'shorter and local' traffic component.

As implied in the preceding discussion, not only is non-urban passenger travel more affected by continuing mode shift than urban travel, it is also less homogeneous than urban travel. It has two distinct components:

(1) intercity/interregional travel; and

(2) rural local travel.

The rest of this chapter details the methodology adopted in modelling interregional travel. Chapter 4 covers the models for rural local travel.

METHODOLOGY

For simplicity, the regional structure adopted was that used by the Bureau of Tourism Research (BTR 1996). The location of regions in each state are shown in figures 3.2 to 3.8. On this basis, interregional travel constitutes about half of total non-urban travel.

Modelling interregional travel by car involved three key steps:

(1) origin-destination passenger travel data by mode were collected for 10 interregional corridors: Melbourne–Sydney, Sydney–Brisbane, Sydney–Adelaide, Sydney–Canberra, Melbourne–Brisbane, Melbourne–Adelaide, Eastern Capitals–Perth, Eastern Capitals–Northern Territory, Eastern Capitals–Tasmania and Melbourne/Sydney–Gold Coast;

(2) a 'total demand' (all modes) gravity model for passenger travel was derived for each of the 10 interregional corridors; and

(3) 'logistic substitution' mode split models were developed for each corridor.

For the first of these steps, transport data from a wide variety of sources were collected separately for three modes (air, bus, and train) and used to validate tourism data. Transport and tourism data supported each other on all 10 interregional corridors.

In the case of travel to and from Tasmania, there were three separate sources of passenger travel data: Commonwealth Department of Transport and Regional Development census statistics, the Bureau of Tourism Research national home interview survey (the Domestic Tourism Monitor) and the Tasmanian Visitors Survey (an in-vehicle survey). Figure 3.9 shows that, for the air passenger origin-destination data, all three sources showed general agreement in level and trend. This and similar results provided confidence in the use of existing data sources to reconstruct historical series for travel demand in the ten corridors.

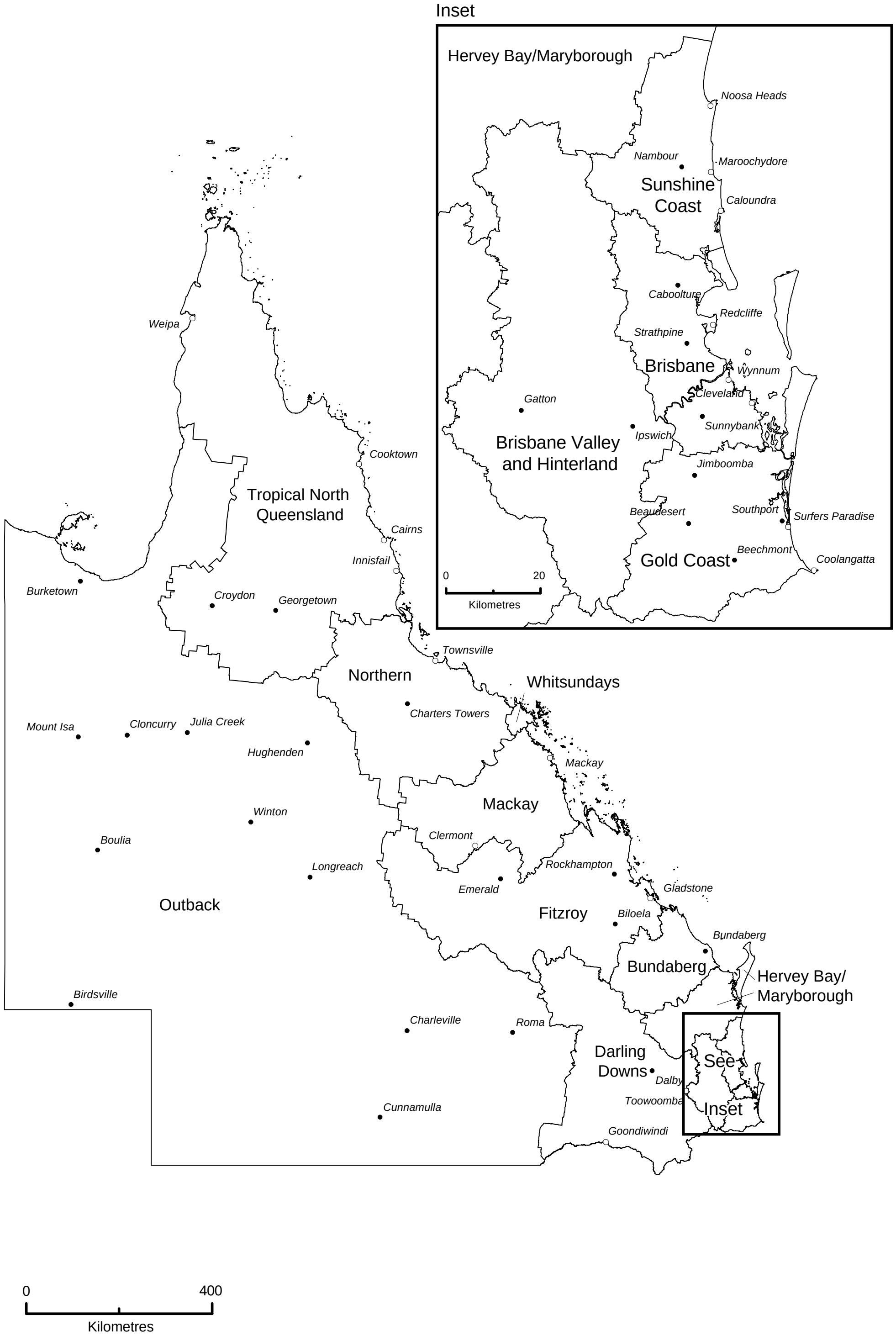
FIGURE 3.2 DTM SURVEY REGIONS – NEW SOUTH WALES

Source ABS 1998c.

FIGURE 3.3 DTM SURVEY REGIONS – VICTORIA

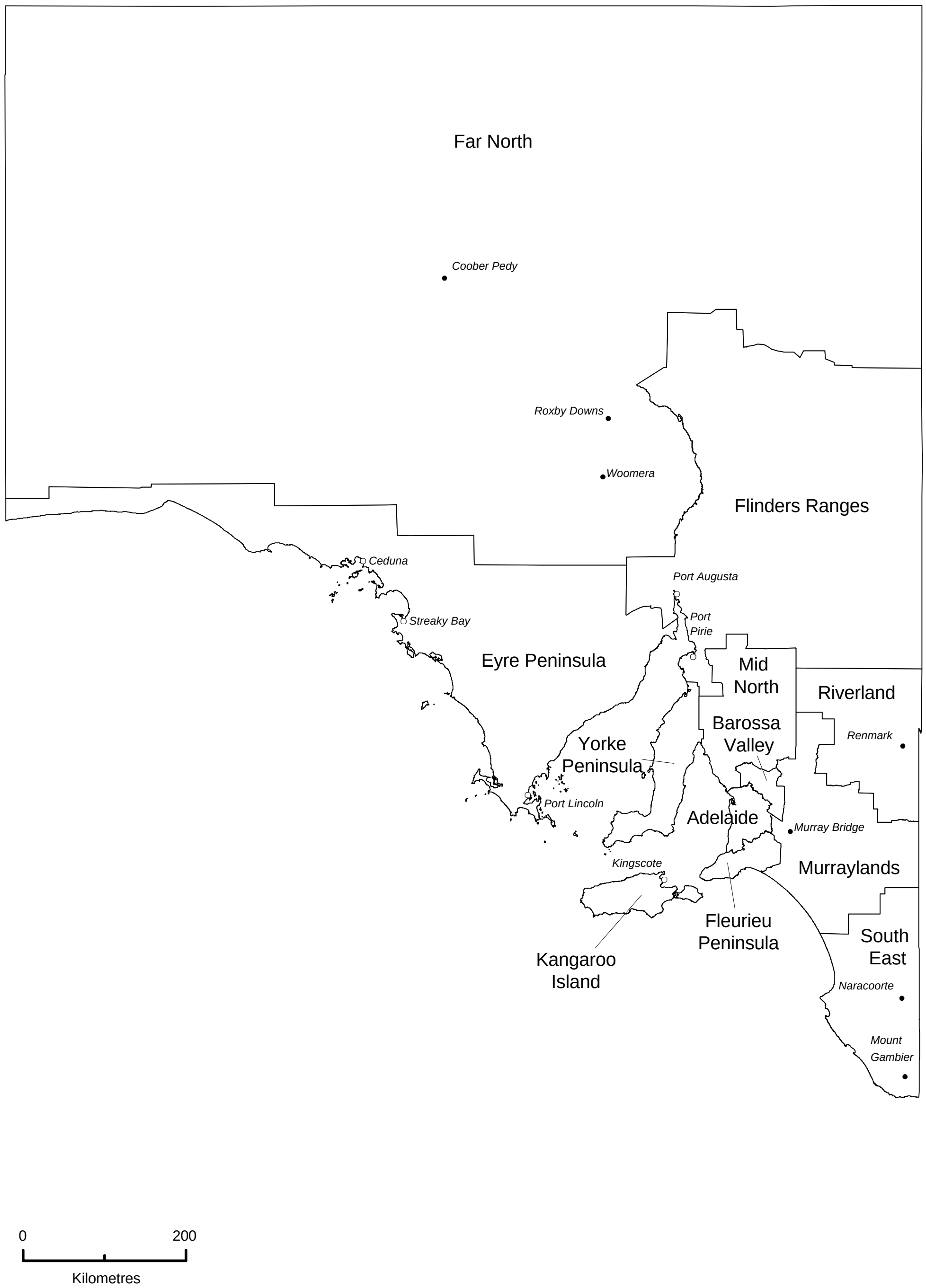
Source ABS 1998c.

FIGURE 3.4 DTM SURVEY REGIONS – QUEENSLAND



Source ABS 1998c.

FIGURE 3.5 DTM SURVEY REGIONS – SOUTH AUSTRALIA



Source ABS 1998c.

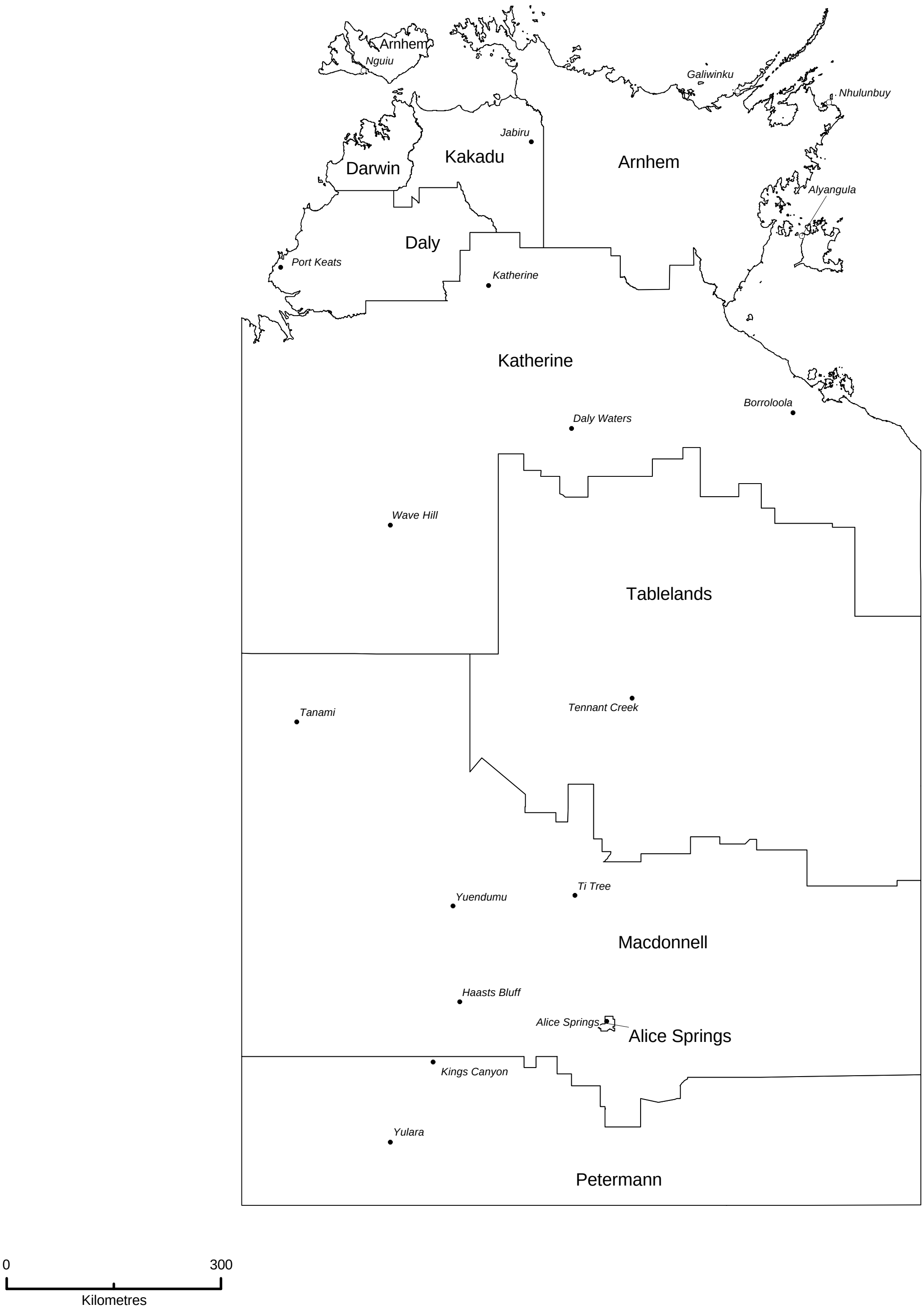
FIGURE 3.6 DTM SURVEY REGIONS – WESTERN AUSTRALIA

Source ABS 1998c.

FIGURE 3.7 DTM SURVEY REGIONS – TASMANIA

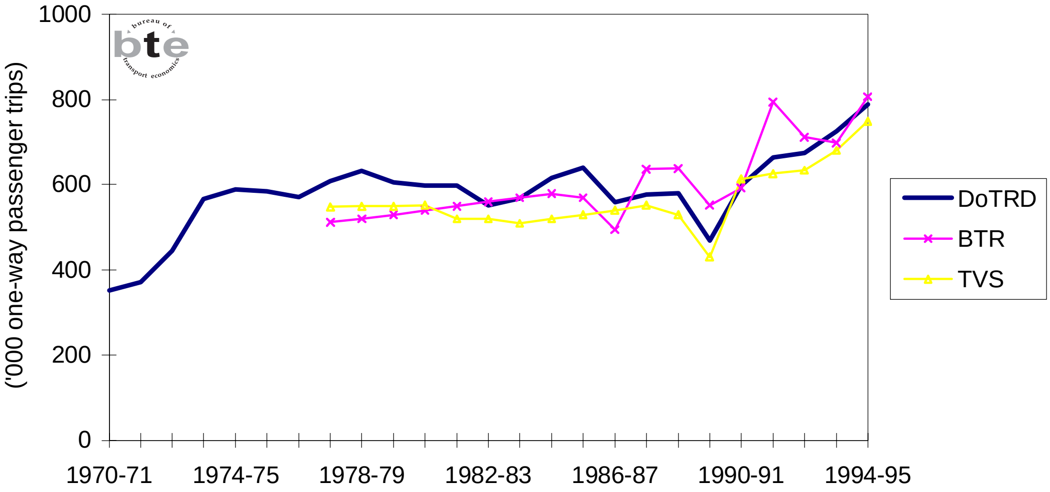
Source ABS 1998c.

FIGURE 3.8 DTM SURVEY REGIONS – NORTHERN TERRITORY



Source ABS 1998c.

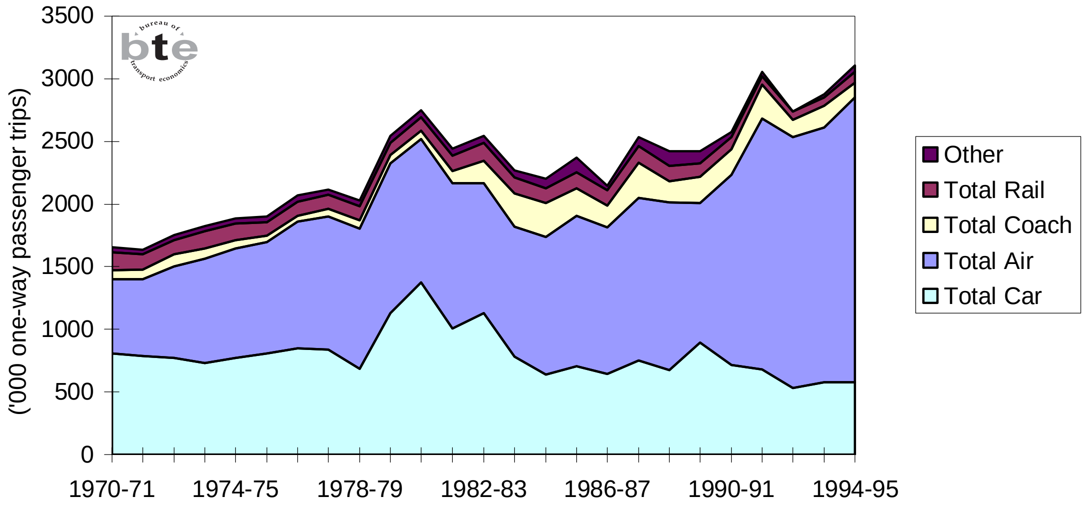
FIGURE 3.9 AIR PASSENGER TRAVEL, EASTERN CAPITALS TO TASMANIA,1970–71 TO 1994–95 (ORIGIN – DESTINATION BASIS)



Sources BTE estimates, DoTRD 1997 and earlier issues; BTR 1996 and earlier issues; Tourism Tasmania 1996 and earlier issues.

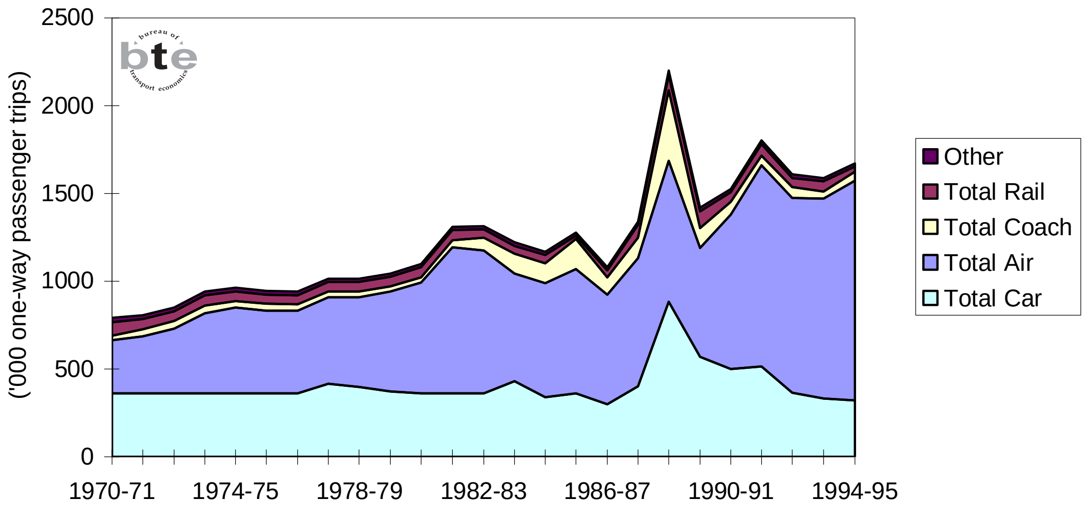
BTE estimates of historical origin-destination passenger traffic for the ten corridors are presented in figures 3.10 to 3.19. They are based on a mix of transport data and tourism data from the Domestic Tourism Monitor and the International Visitor Surveys, both conducted by the Bureau of Tourism Research. Passenger travel estimates are measured as thousands of one-way domestic passenger trips on an origin–destination basis (including children and people taking day trips between regions). Origin–Destination (OD) trips include only those trips made by residents of the region of origin to the destination region. For example, Sydney–Melbourne OD trips include only trips by Sydney residents to Melbourne and by Melbourne residents to Sydney. A trip by a resident of Wollongong to Sydney airport, by car, and from Sydney to Melbourne by air is not counted as a Sydney–Melbourne OD trip.

FIGURE 3.10 TOTAL PASSENGER TRIPS, SYDNEY–MELBOURNE 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



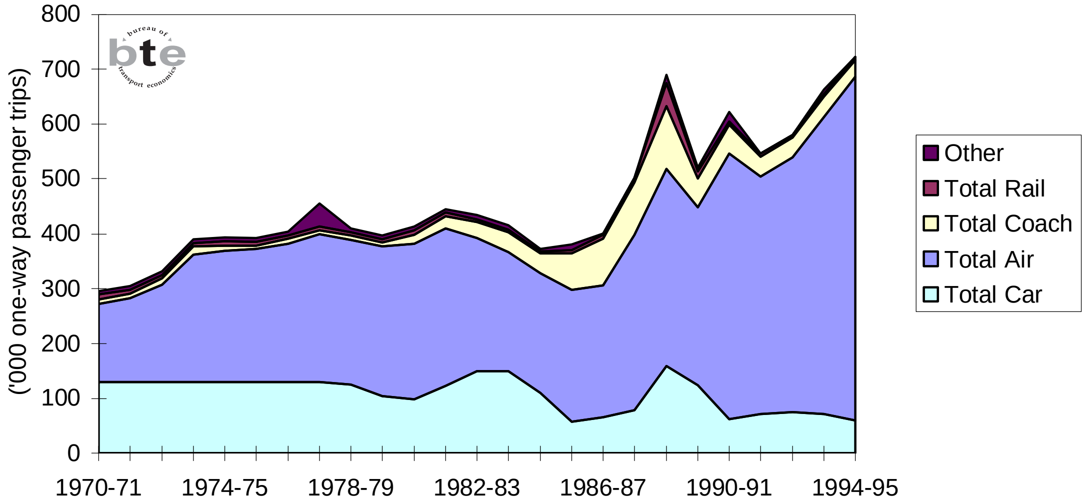
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.11 TOTAL PASSENGER TRIPS, SYDNEY–BRISBANE 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



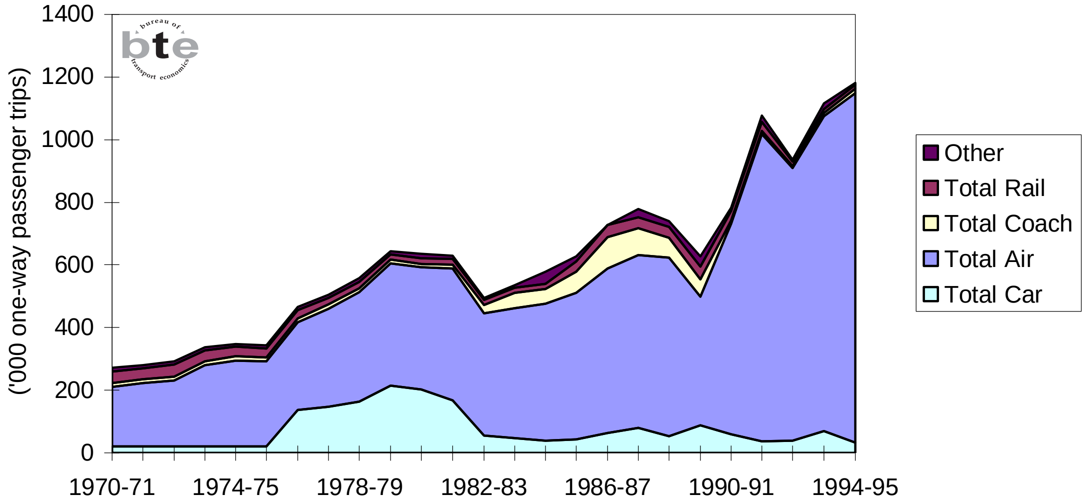
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues;AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.12 TOTAL PASSENGER TRIPS, MELBOURNE–BRISBANE 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



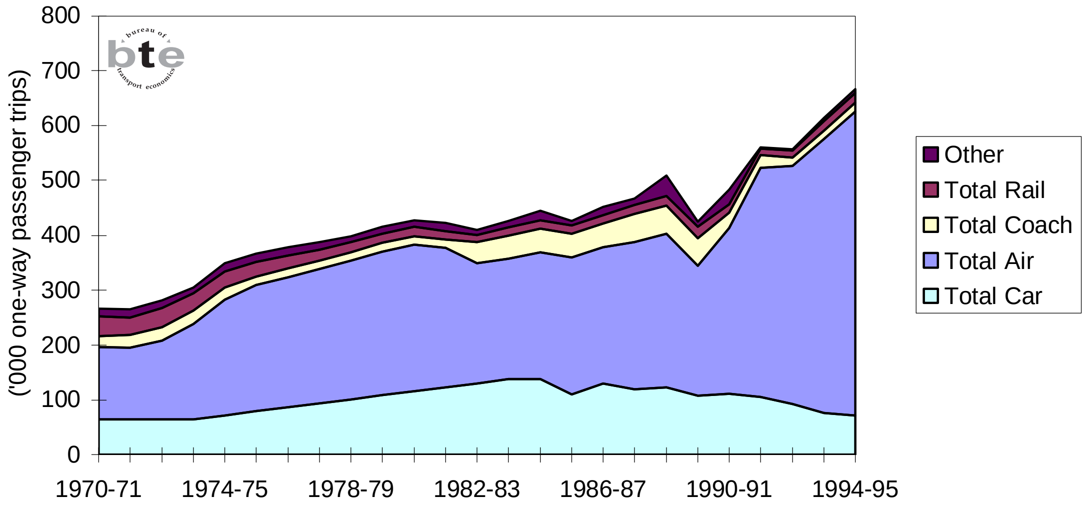
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.13 TOTAL PASSENGER TRIPS, EASTERN STATE CAPITALS–PERTH 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



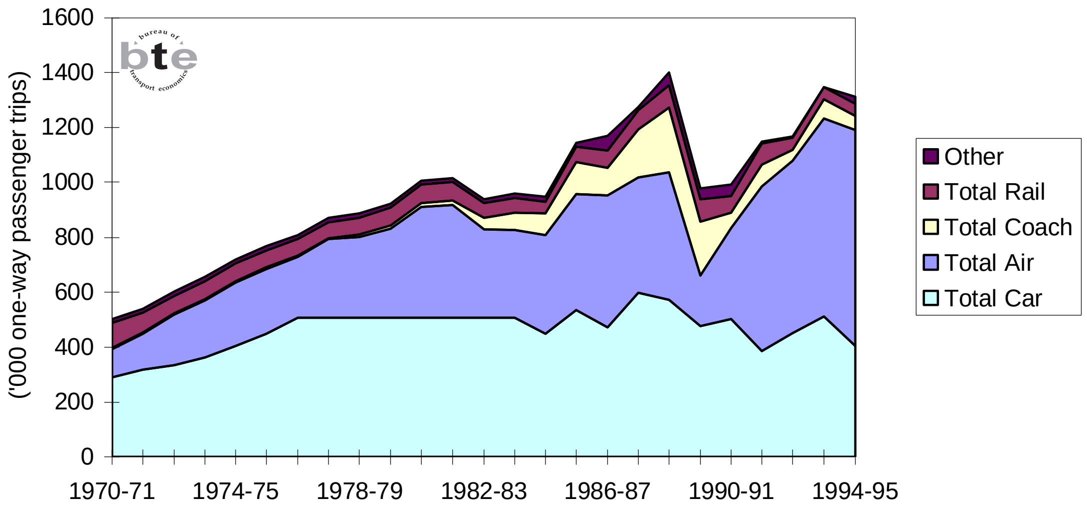
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.14 TOTAL PASSENGER TRIPS, SYDNEY–ADELAIDE 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



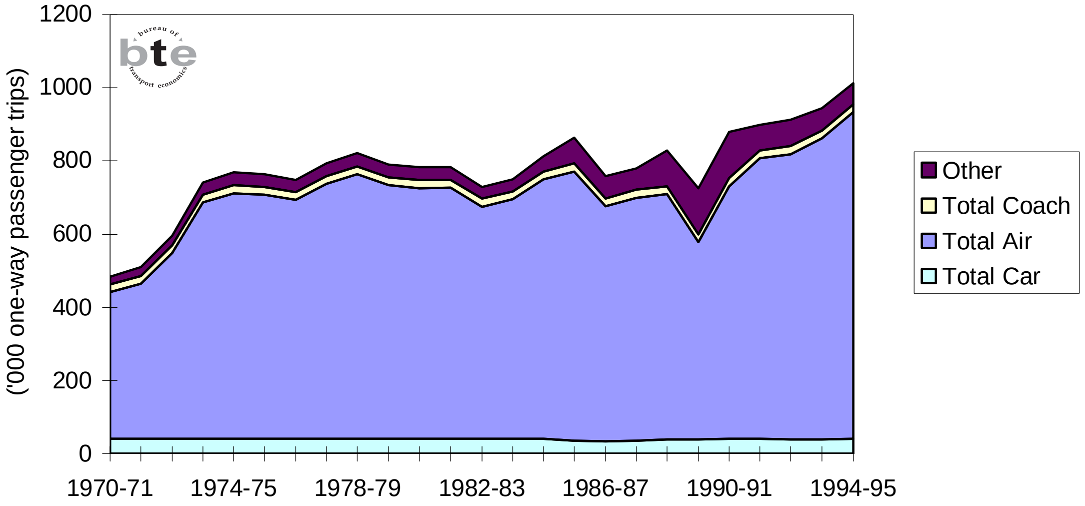
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.15 TOTAL PASSENGER TRIPS, SYDNEY & MELBOURNE–COOLANGATTA 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



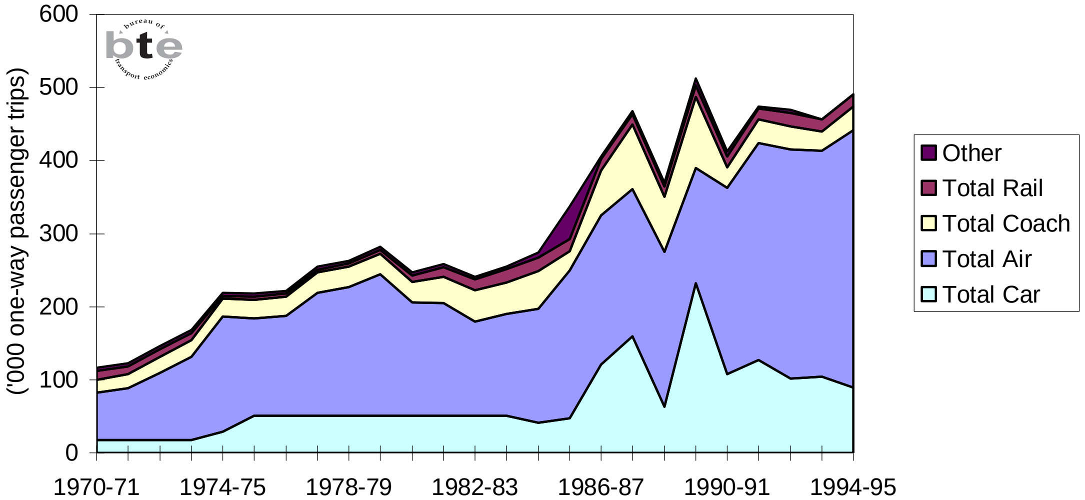
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.16 TOTAL PASSENGER TRIPS, EASTERN STATE CAPITALS–TASMANIA 1970-71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



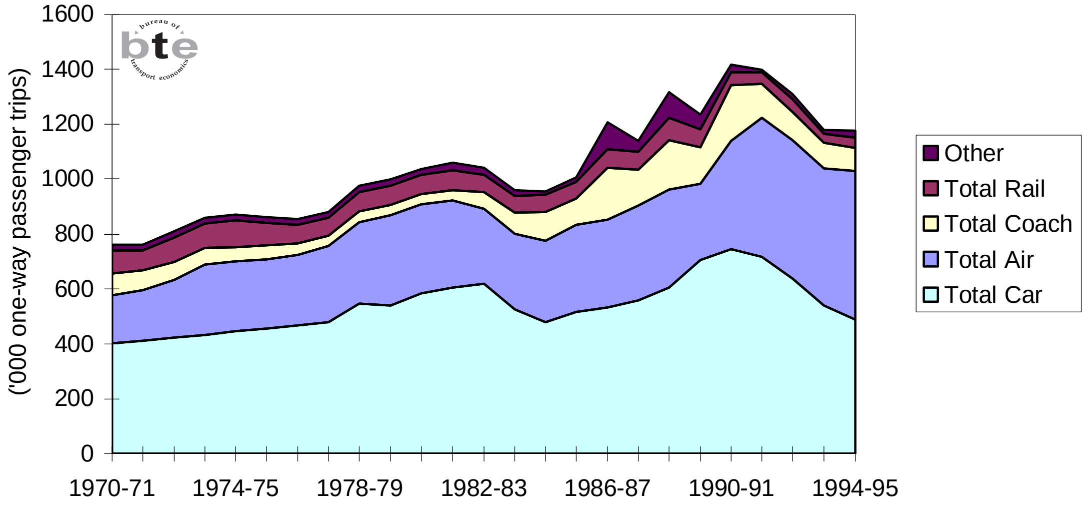
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; Tourism Tasmania 1996.

FIGURE 3.17 TOTAL PASSENGER TRIPS, EASTERN STATE CAPITALS–NORTHERN TERRITORY 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



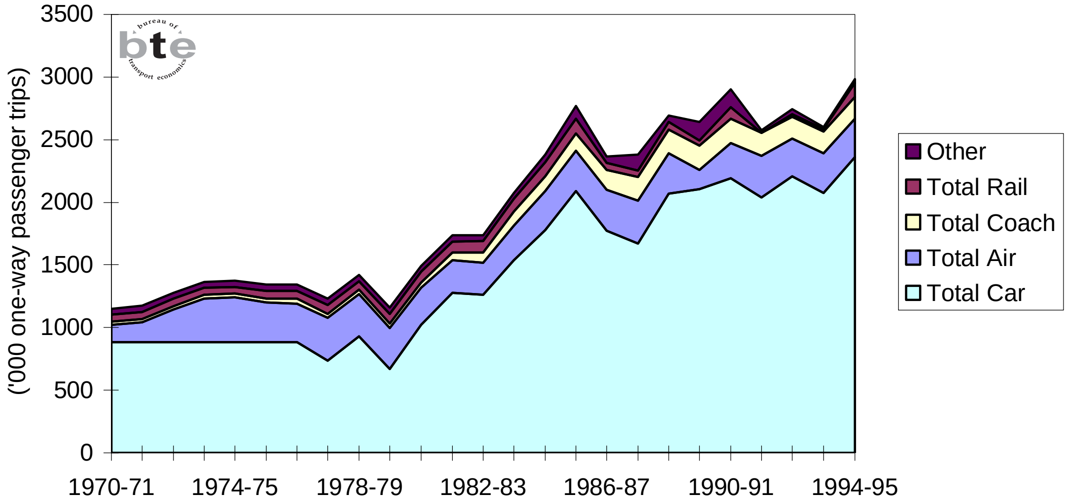
Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.18 TOTAL PASSENGER TRIPS, MELBOURNE–ADELAIDE 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996, QR 1997, SRA 1985, VicRail 1983 and WestRail 1996 and earlier issues.

FIGURE 3.19 TOTAL PASSENGER TRIPS, SYDNEY–CANBERRA 1970–71 TO 1994–95 (ORIGIN–DESTINATION BASIS)



Sources BTE estimates, BTE 1985, 1997; ABS 1984; BTR 1997 and earlier issues; DoTRD 1993 and earlier issues; AN 1996 and earlier issues.

Gravity Model Specification

The second step in the modelling process was to fit a single equation gravity model to the pooled data for total passenger travel in the ten corridors over 25 years. The number of one-way passenger trips in the 10 major transport corridors were modelled by the following single equation:

$$\text{Passenger travel}_{\text{ij}} = \frac{A_{ij}\left(\text{Population}_{\text{i}} \times \text{Population}_{\text{j}}\right)^{0.5}}{\left(\text{Real generalised travel cost}_{\text{ij}} / \text{Real earnings}\right)^{1.25}} \qquad (3.1)$$

where:

Passenger travel$_{i,j}$ = origin-destination passenger travel (number of one-way trips) between city *i* and city *j*;

Population$_i$ = the population of city *i* (adjusted for specialisation in tourism);

Population$_j$ = the population of city *j* (adjusted for specialisation in tourism);

Real generalised travel cost$_{i,j}$ = the generalised, weighted (by mode) cost of travel between cities *i* and *j*, (including the cost of access, egress, travel time, fares and fuel costs) deflated by the Consumer Price Index (CPI);

Real earnings = Average Weekly Ordinary Time Earnings, all persons, deflated by the CPI; and

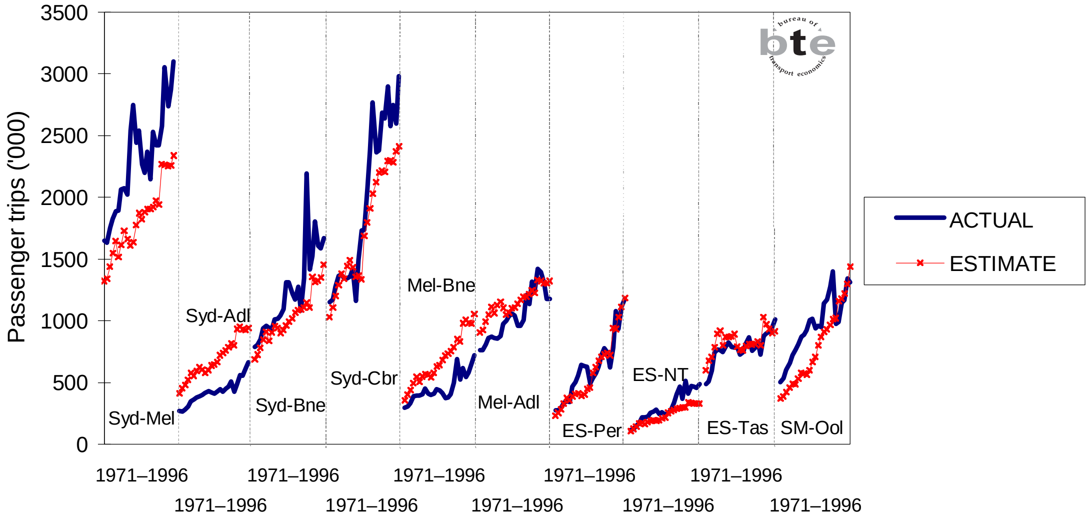
A_{ij} = Intercity pair *i,j* specific multiplicative factor.

The adjustment for specialisation in tourism is to account for the higher domestic passenger trips to tourist destinations, such as Alice Springs and the Gold Coast, for example, which a resident population-based gravity model does not capture. The adjustment was based on the ratio of employment in the accomodation sector to total employment, with the major capital city ratios taken as the deflator. On this basis, the Gold Coast is almost three times as specialised in tourism as the major cities.

The initial model estimated included a constant multiplicative factor, *A*, for all intercity pairs in equation (3.1). The fit is shown in figure 3.20. Some regional pairs generated less traffic than predicted, especially where either Melbourne or Sydney ‘intervened’ (eg Melbourne-Brisbane, Sydney-Adelaide). The Melbourne-Sydney pair generated more traffic than predicted, possibly because of the ‘complementary’ nature of each city’s production.

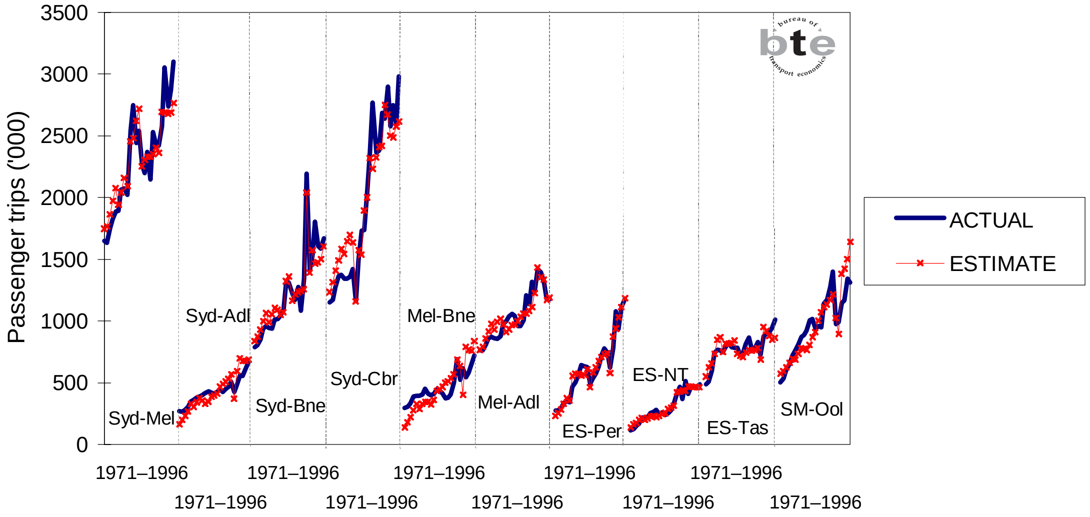
Re-estimation of equation (3.1), with intercity specific multiplicative factors, to take into account differences in traffic levels for different routes, and dummy variables for special events (e.g. Expo in Brisbane in 1988) was undertaken to explain the difference in predicted levels between different routes. With the dummy variables, the fit was very good (figure 3.21), with 97 per cent of the variation in observed data being explained. It should be noted that the intercity specific multiplicative factors only make minor adjustments in the *levels* of travel, they do not affect the relative *growth rates*. Thus the single equation 3.1 can be used to predict growth in total interregional travel (by all modes). Once forecasts of growth in *total* travel were derived from the gravity model, predictions of growth in *car* travel were constructed using models of trends in mode split.

FIGURE 3.20 ACTUAL AND ESTIMATED INTERREGIONAL PASSENGER TRAVEL, 10 INTERCITY CORRIDORS 1970-71 TO 1995-96 (NO DUMMY VARIABLES)



Note ES denotes Eastern State capitals and Ool denotes Coolangatta (Gold Coast).
Source BTE estimates.

FIGURE 3.21 ACTUAL AND ESTIMATED INTERREGIONAL PASSENGER TRAVEL, 10 INTERCITY CORRIDORS 1970-71 TO 1995-96 (WITH DUMMY VARIABLES)

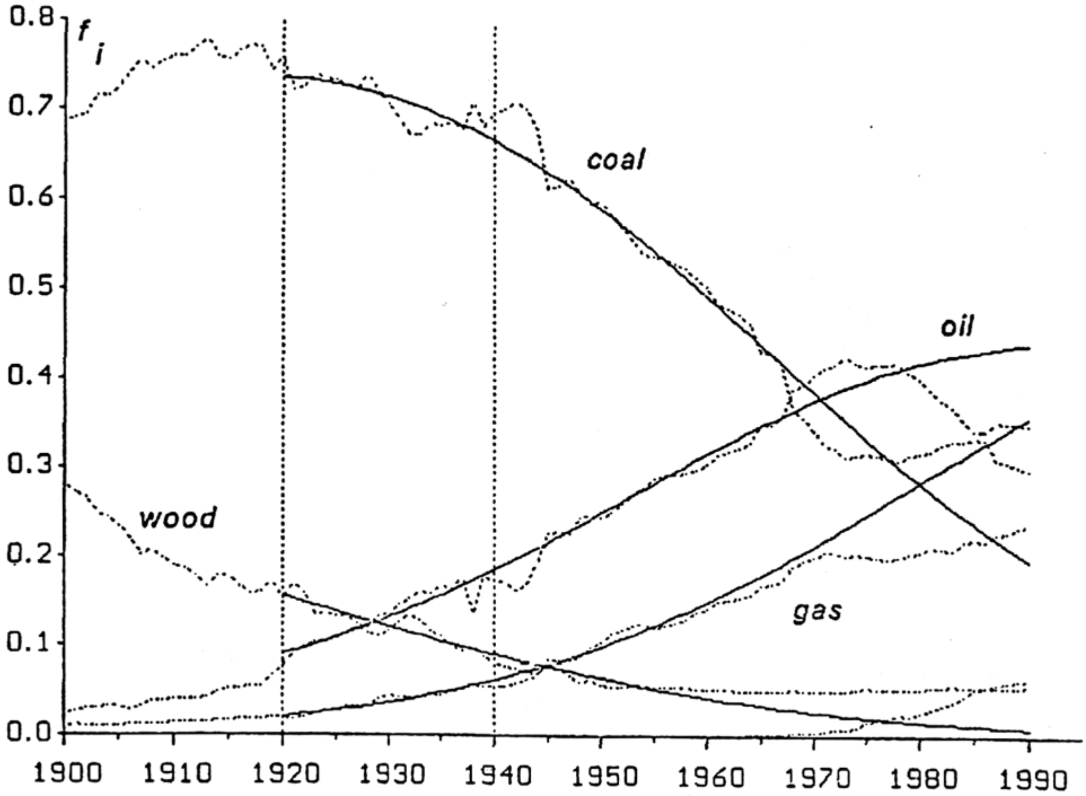


Note ES denotes Eastern State capitals and Ool denotes Coolangatta (Gold Coast).
Source BTE estimates.

Mode Split Models

The third step in the modelling process involved fitting 'logistic substitution' models of mode split. Logistic growth is a normal process of growth that can be represented by an S-shaped curve, such as in figure 2.5. When two or more modes compete for growth within a total market, a series of inverted U-shaped share curves is generated. Figure 3.22 shows such market share curves for the world primary energy market. It has been found that, even based on 10 to 20 years of this energy data, share models can be derived that successfully forecast shares for 30 to 40 years (Kwasnicki & Kwasnicka 1996). For example, using the data for 1920 to 1940 for the world energy market, the actual shares from 1920 to 1960 are well predicted, despite the severe disturbances of depression and war during the estimation period.

FIGURE 3.22 RETROPROGNOSIS OF WORLD ENERGY STRUCTURE – IDENTIFICATION PERIOD 1920 TO 1940



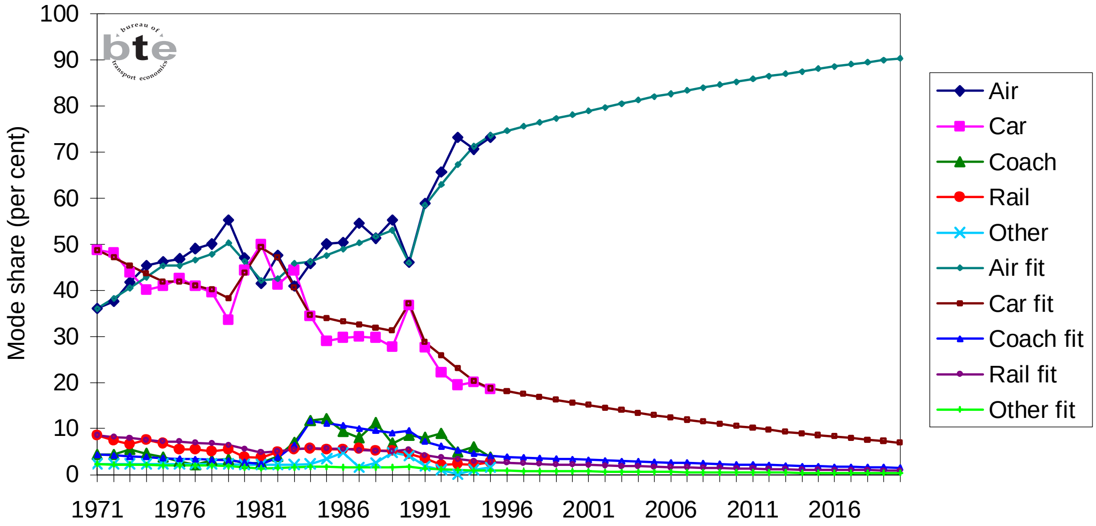
Source Kwasnicki & Kwasnicka 1996.

Such ‘logistic substitution’ models applied to passenger transport allowed forecasts to be made of the likely future course of intermodal competition (given assumptions about fare relativities, etc.). Forecasts for mode split in the 10 regional corridors are shown in figures 3.23 to 3.32. There is a clear pattern as far as mode share of cars is concerned.

(1) On all the longer routes (figures 3.23 to 3.31) the car has been losing modal share. All the growth has been going to air (bar a temporary increase in long-distance bus travel after deregulation halved fares). On longer routes, car travel has not increased at all over the last 25 years (except where new road links have been opened or substantially upgraded, especially the Eyre Highway linking Western Australia with the Eastern States, and some highways in the Northern Territory).

Travel between the Eastern States and Perth (figure 3.27) is illustrative of the increasing dominance of air travel as the mode of choice on longer distance routes. Figure 3.27 also illustrates the impact that singular events and price changes have had on mode choice. Prior to 1975, air's share of total passenger travel was growing, a result of all growth in total passenger travel on that route going by air. The large drop in air's share in 1976 to 1980 was due to the completion of sealing of the Eyre Highway resulting in a fall in car travel times and an increase in ease and safety of driving. Figure 3.13 suggests that the large increase in car passenger travel between 1975-76 and 1981-82 was primarily induced car travel — there appears to have been little shift from air travel to car travel. A revised fare structure for domestic airline fares was implemented in 1981, with fares for long-haul routes declining significantly relative to fares for short-haul and medium-haul routes. The fare change, together with the increase in car travel costs due to petrol price rises, was responsible for the surge in air travel's market share in 1982 and 1983. Deregulation of scheduled interstate coach travel in the mid 1980s resulted in an increase in coach passenger travel. Figure 3.27 shows an increase in coach travel's share at the expense of air travel. The drop in air travel's share in 1989-90 is attributable to the domestic pilot's strike. In October 1990 the domestic air market was deregulated and air fares on many routes declined in real terms. The rapid increase in air travel's market share was due to the resulting fare decreases; which were especially large on longer routes such as that to Perth.

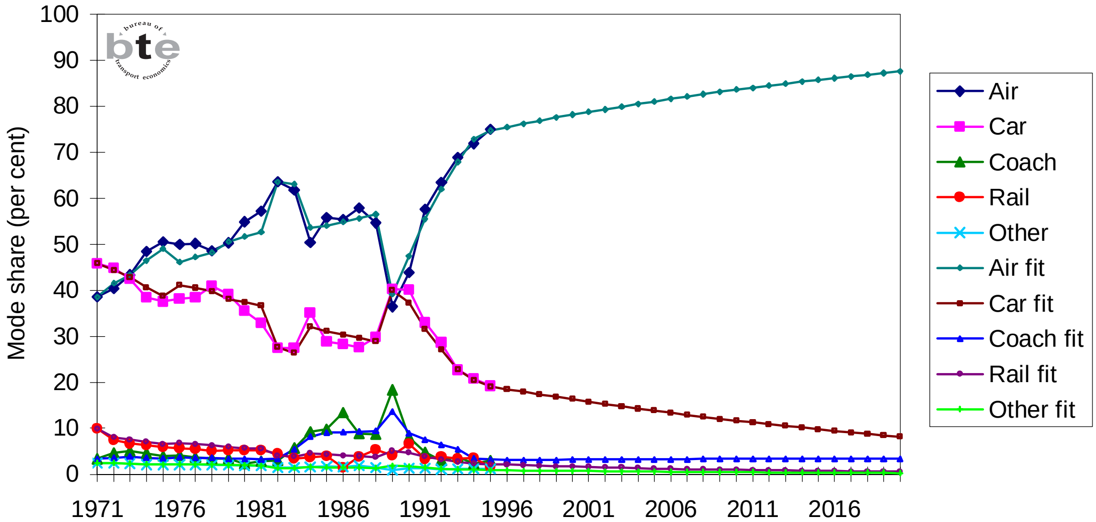
FIGURE 3.23 MODE SHARE PROJECTIONS, SYDNEY – MELBOURNE



Note Forecasts are from 1996.

Source BTE estimates.

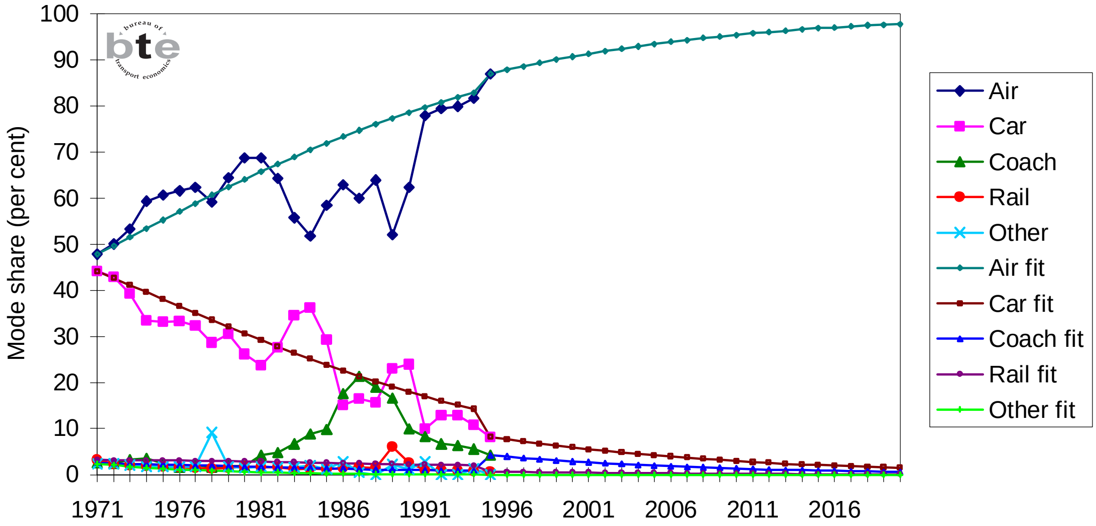
FIGURE 3.24 MODE SHARE PROJECTIONS, SYDNEY – BRISBANE



Note Forecasts are from 1996.

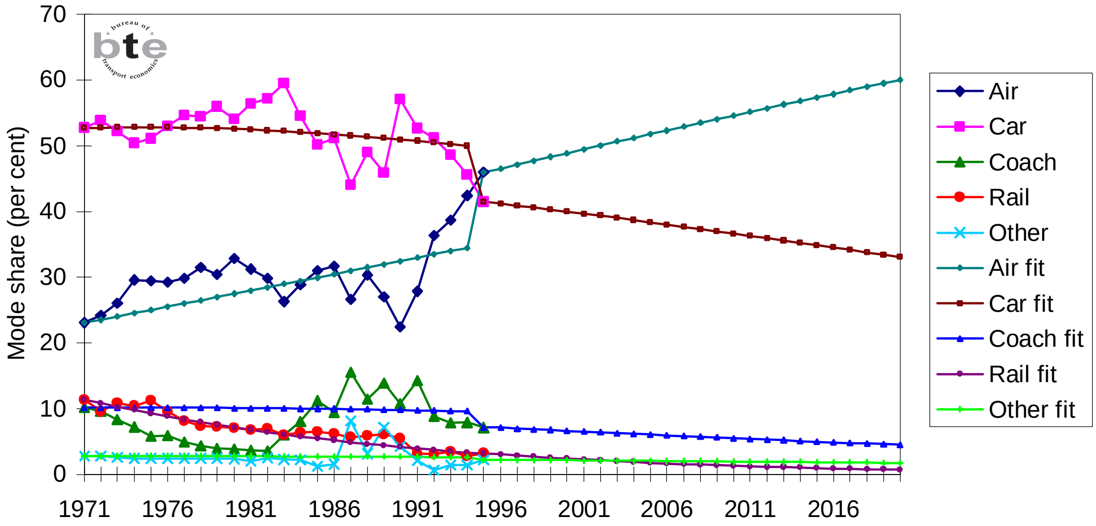
Source BTE estimates.

FIGURE 3.25 MODE SHARE PROJECTIONS, MELBOURNE – BRISBANE



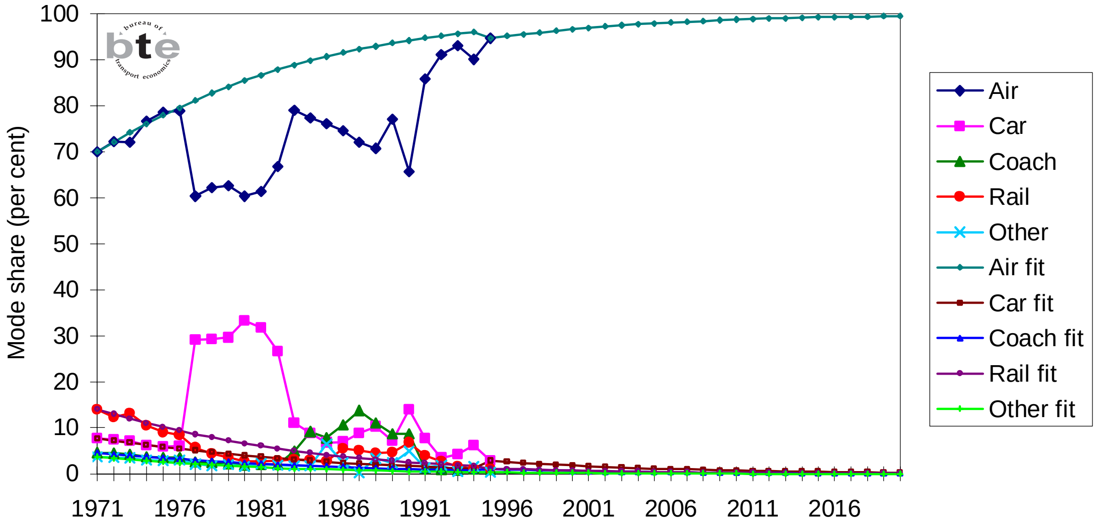
Note Forecasts are from 1996.
Source BTE estimates.

FIGURE 3.26 MODE SHARE PROJECTIONS, MELBOURNE – ADELAIDE



Note Forecasts are from 1996.
Source BTE estimates.

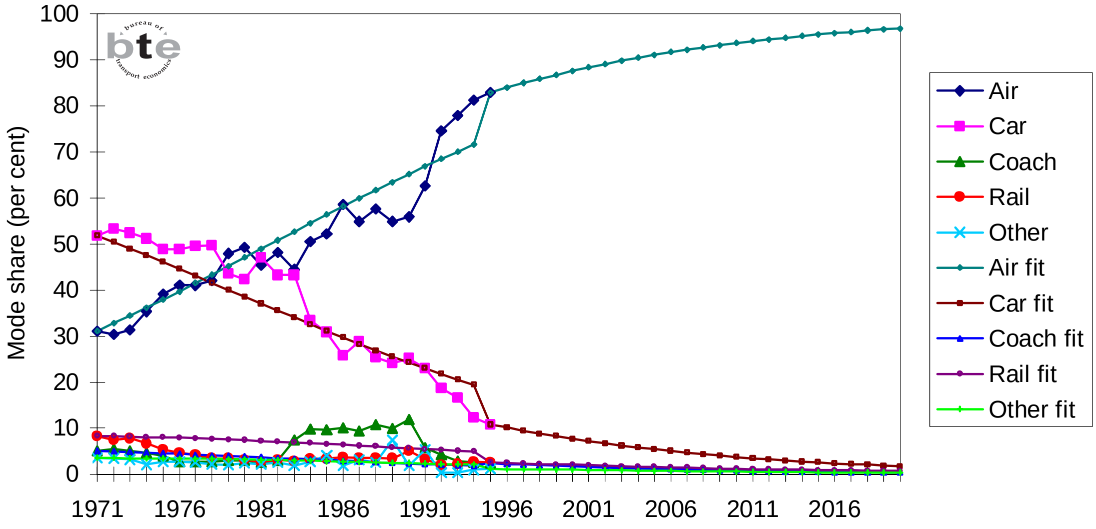
FIGURE 3.27 MODE SHARE PROJECTIONS, EASTERN STATE CAPITALS – PERTH



Note Forecasts are from 1996.

Source BTE estimates.

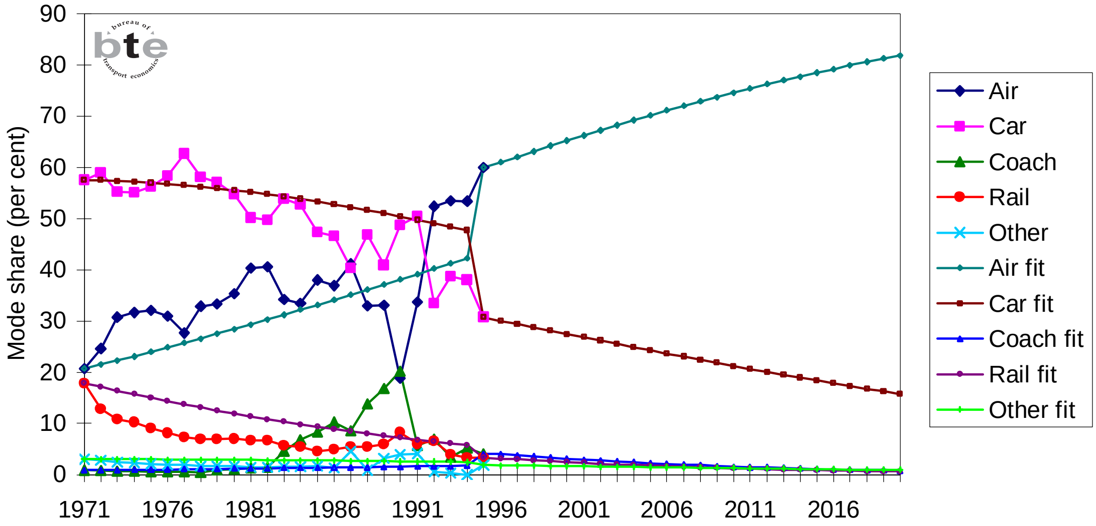
FIGURE 3.28 MODE SHARE PROJECTIONS, SYDNEY – ADELAIDE



Note Forecasts are from 1996.

Source BTE estimates.

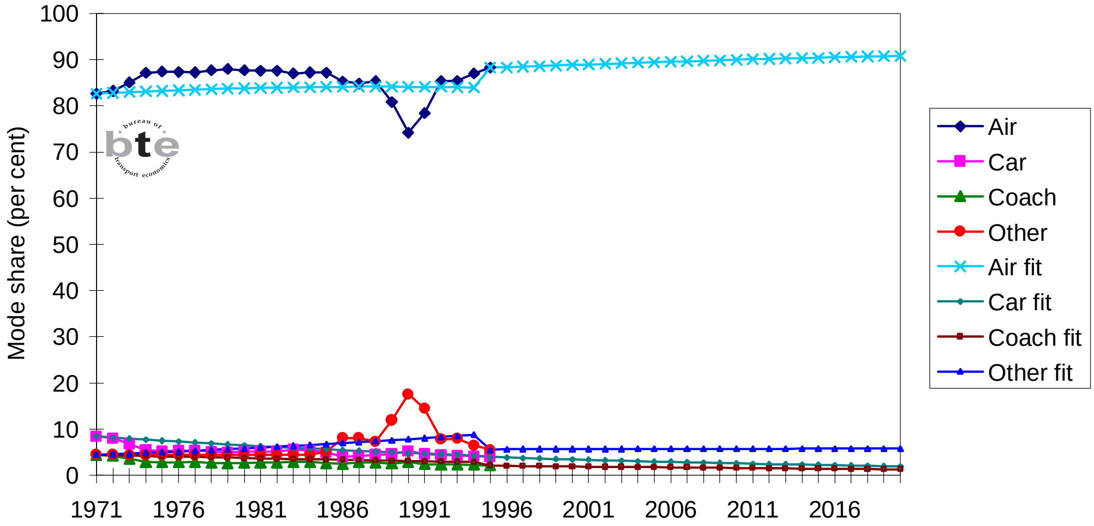
FIGURE 3.29 MODE SHARE PROJECTIONS, SYDNEY & MELBOURNE – COOLANGATTA



Note Forecasts are from 1996.

Source BTE estimates.

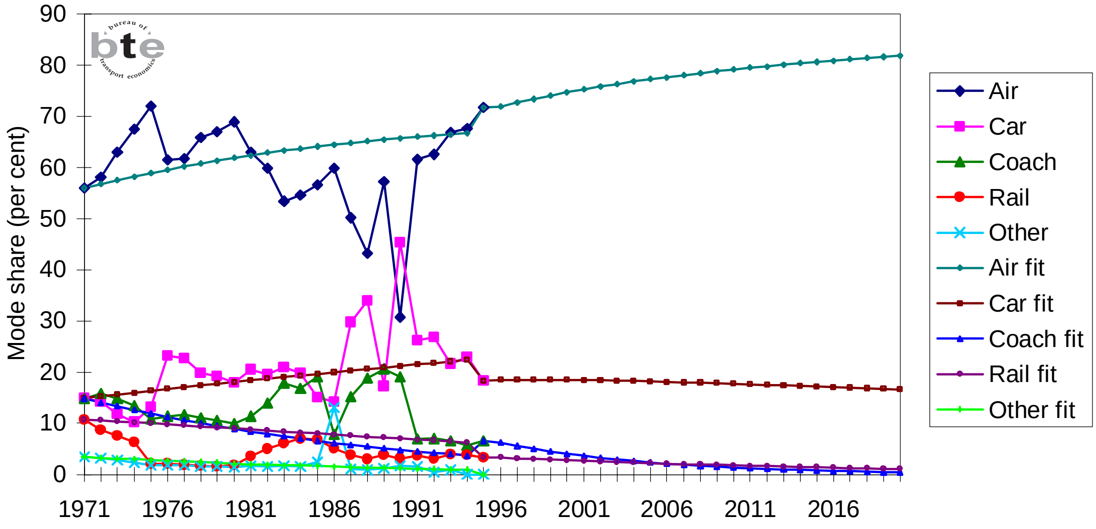
FIGURE 3.30 MODE SHARE PROJECTIONS, EASTERN STATE CAPITALS – TASMANIA



Note Forecasts are from 1996.

Source BTE estimates.

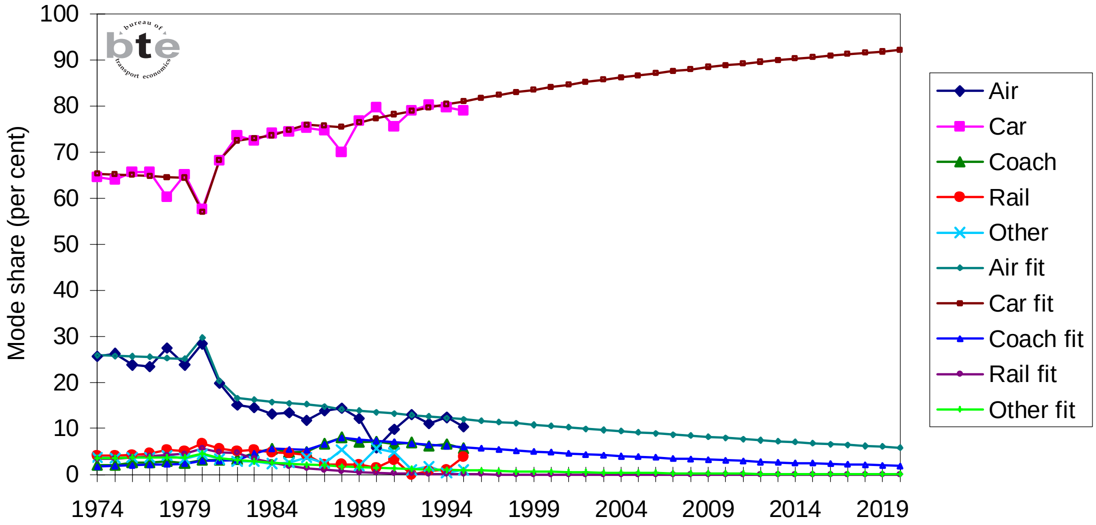
FIGURE 3.31 MODE SHARE PROJECTIONS, EASTERN STATE CAPITALS – NORTHERN TERRITORY



Note Forecasts are from 1996.

Source BTE estimates.

FIGURE 3.32 MODE SHARE PROJECTIONS, SYDNEY – CANBERRA



Note Forecasts are from 1996.

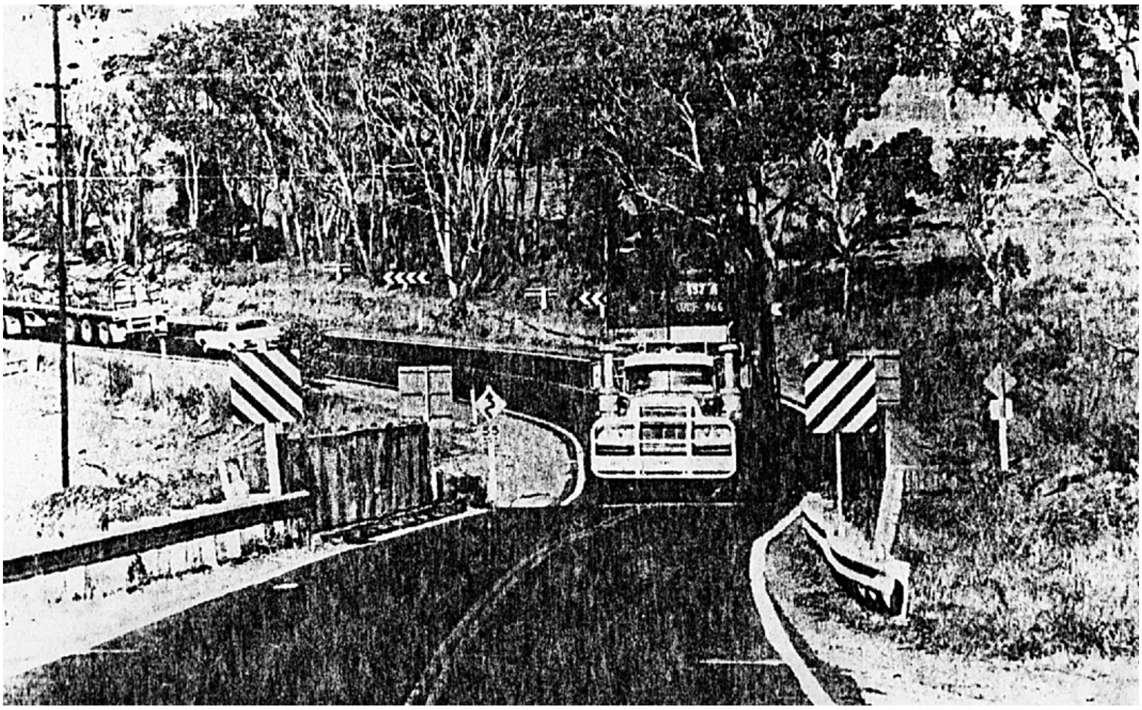
Source BTE estimates.

(2) On medium-distance routes, such as Melbourne to Adelaide, there is a clear tendency for car's share to grow in absolute terms (while still drifting down in mode share and with a one-off decline after airline deregulation). In other words car growth is less than total growth on such corridors, but still positive.

(3) On short routes (200-400 km), the car is winning modal share and is thus growing faster than total travel (mainly at the expense of air).

An example is the Canberra-Sydney route where the car is the dominant mode. There is consistent growth in car's modal share, including a one-off increase following the opening of the F4 freeway, which reduced travel time from almost 5 hours to about 3 hours, and improved safety and convenience for car travel. It is now hard to imagine just how bad the old road was, even up to the late 1970s. Figure 3.33 shows a bridge on the old Hume Highway in 1980. It was a narrow 2-lane bridge, and semi-trailers (articulated trucks) took up 1½ lanes, forcing car drivers to time their approach in order to cross the bridge between semi-trailers.

FIGURE 3.33 TWO–LANE BRIDGE, OLD HUME HIGHWAY, 1980, CULLERIN RANGE, NSW.



Source NRMA 1980.

(4) On extremely short routes (less than 200 km), cars account for almost all travel, and thus car and total travel growth rates are equivalent.

For the purposes of forecasting interregional car traffic, the following simplification of modal trends thus suggests itself:

- Long routes (greater than 800 km) - no growth in car travel;
- Medium routes (400-800 km) - car travel growth equals 0.7 times growth in total travel;
- Short routes (200-400 km) - car travel growth equals 1.25 times total travel growth; and
- Very short routes (less than 200 km) - car travel growth equals 1.0 times growth in total travel.

These 'rules of thumb' are based on judgements about the appropriate ratios in each of the distance cases.

Based on the above reasoning, a forecasting procedure for interregional car travel was applied as follows:

(1) The growth in *total* passenger travel between all pairs of tourism regions was calculated from equation (3.1):
   (a) Assuming no change in real cost of travel. (This is a base-case assumption which can be varied if it is thought to be realistic or desirable to forecast future travel cost changes.);
   (b) assuming 1 per cent annual growth in real average weekly ordinary time earnings; and
   (c) using the growth in the ABS (1997a) population projections of the origin and destination tourism regions.

(2) The growth in *car* travel between all pairs of tourism regions was calculated by multiplying total growth by the assumed distance-based fractions (0, 0.7, 1.25, 1.0).

(3) Car travel forecasts for travel between all pairs of tourism regions were calculated by multiplying the 1995-96 base matrix of interregional car travel from the Domestic Tourism Monitor survey of the Bureau of Tourism Research by the relevant growth rates.

By making an assumption of 1.8 adults per car on long-distance trips (BTR 1997), these forecasts of interregional passenger movements were turned into forecasts of car trips. The trip matrix was assigned to the highway system using the *TransCAD*® (Caliper Corporation 1996) computer program to produce forecasts of 'through' traffic on each highway section.

This method for forecasting interregional car traffic was used in the analysis of warranted road infrastructure expenditure presented in BTCE (1997). The next chapter describes the modelling of the second component of non-urban travel - rural local passenger travel.

CHAPTER 4 RURAL LOCAL LIGHT VEHICLE TRAVEL MODELS

Rural local car travel accounts for about half of total non-urban car VKT. This is consistent with the magnitude derived using the model of urban local VKT. In other words, if rural population is multiplied by the national average cars per person and rural VKT per car, one obtains about 20 billion VKT in 1995-96. The 1995-96 interregional car traffic matrix, when assigned to the road system in *TransCAD*® (Caliper Corporation 1996), generated about 20 billion VKT. Finally, the ABS Survey of Motor Vehicle Usage for 1995 (ABS 1996) gives total non-urban VKT of about 40 billion. Hence, the magnitudes agree.

METHODOLOGY

For the purpose of forecasting, it was assumed that rural local traffic growth has a similar functional form to the urban traffic growth model. Rural local traffic growth is assumed to grow according to:

$$\begin{aligned}\text{Growth in rural local traffic}_i = \{ & \left(1+\text{Growth in Population}_i\right) \\ & \times\left(1+\text{Growth in Non-urban VKT/light vehicle}\right) \\ & \times\left(1+\text{Growth in light vehicles/person}\right) - 1\} \times 100\end{aligned} \tag{4.1}$$

where subscript i denotes rural SLA i.

It is often simpler to think in terms additive growth. To a first order of approximation growth in rural local traffic can be approximated by:

$$\begin{aligned}\text{Growth in rural local traffic}_i \cong\ & \text{Growth in Population}_i \\ & +\text{Growth in Non-urban VKT/light vehicle} \\ & +\text{Growth in light vehicles/person}\end{aligned} \tag{4.2}$$

For long-term forecasting, the VKT per light vehicle can be assumed constant, so the middle term in equation 4.1 equals one.

Forecasts of rural local traffic were therefore calculated as follows:

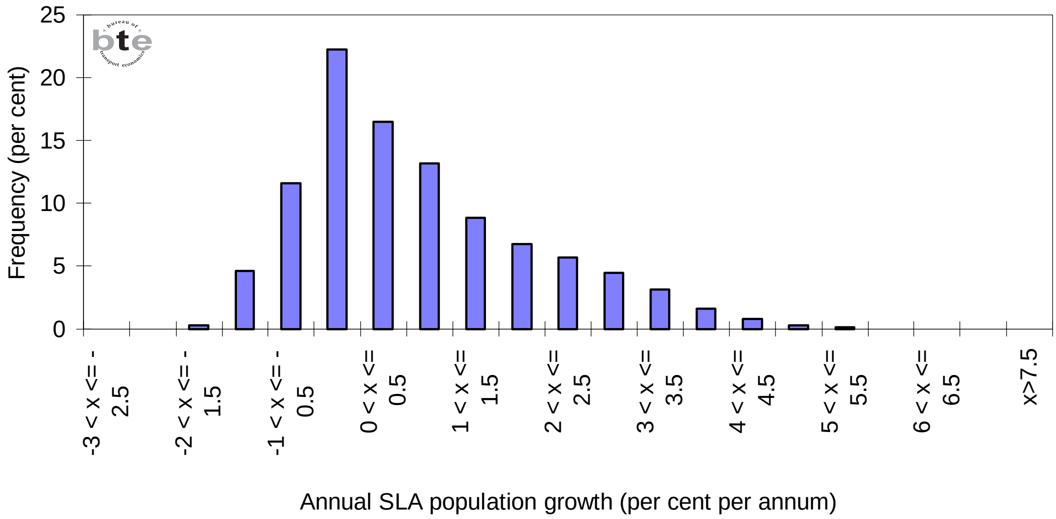
(1) the populations of rural SLAs (there are approximately 250 rural SLAs) were forecast to the year 2020. Figures 4.1 and 4.2 show the distribution of projected SLA annual growth rates, to 2020, for ‘non-capital city’ and ‘all’ SLAs (ABS 1997a).

(2) growth in national 'light vehicles per person' was projected to grow by 20 per cent over the period 1995 to 2020. Forecasts of cars, LCVs and light vehicles per person are detailed in table 4.1. The implicit assumption here is that, although the *levels* of light vehicles per person may differ between city and country, the logistic *growth rate* trends are similar. Thus, national level logistic curves can be used to forecast *growth* in vehicles per person in each area.

(3) the product of the two growth rates was applied to the estimated 1995-96 local light vehicle AADTs on each section of road (equal to the 1995-96 light vehicle AADT on each section minus the interregional car AADT derived from assignment of the 1995-96 interregional car travel matrix).

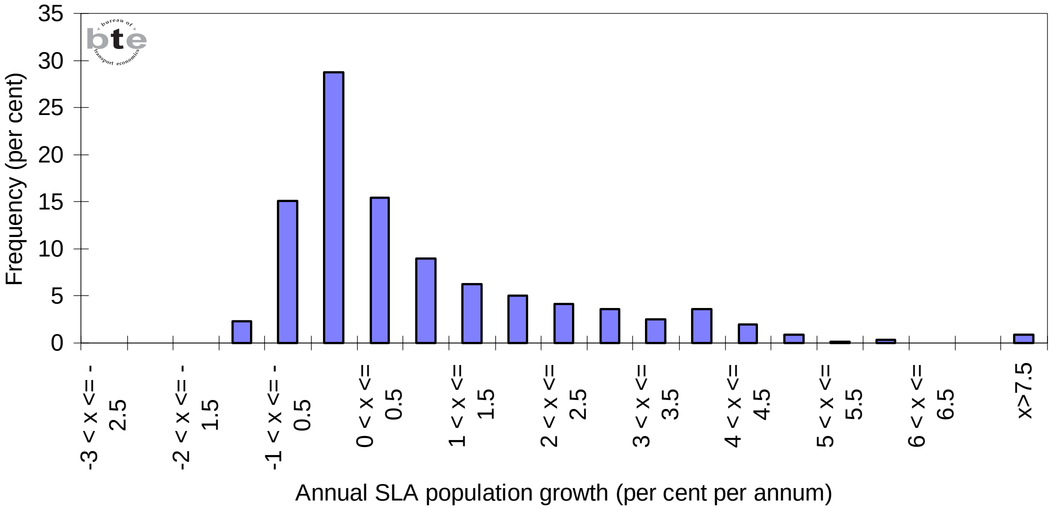
Figures 4.4 and 4.5 show the distribution of rural local and through light vehicle traffic growth forecasts.

FIGURE 4.1 HISTOGRAM – PROJECTED POPULATION GROWTH NON-CAPITAL CITY SLAS, 1996 TO 2020



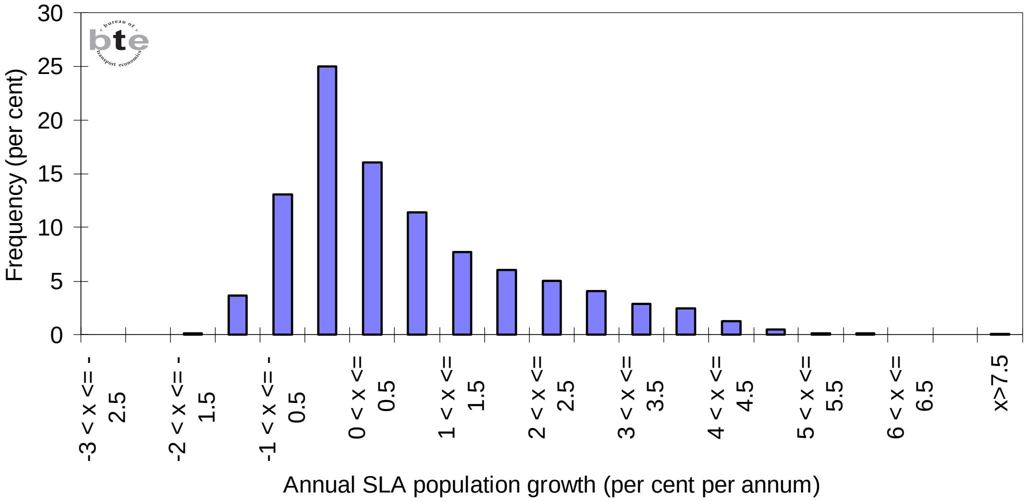
Sources BTE estimates; ABS 1997a.

FIGURE 4.2 HISTOGRAM – PROJECTED POPULATION GROWTH CAPITAL CITY SLAs, 1996 TO 2020



Sources BTE estimates; ABS 1997a.

FIGURE 4.3 HISTOGRAM – PROJECTED POPULATION GROWTH ALL SLAs, 1996 TO 2020



Sources BTE estimates; ABS 1997a.

TABLE 4.1 FORECAST LIGHT VEHICLES PER PERSON, 1996 TO 2020

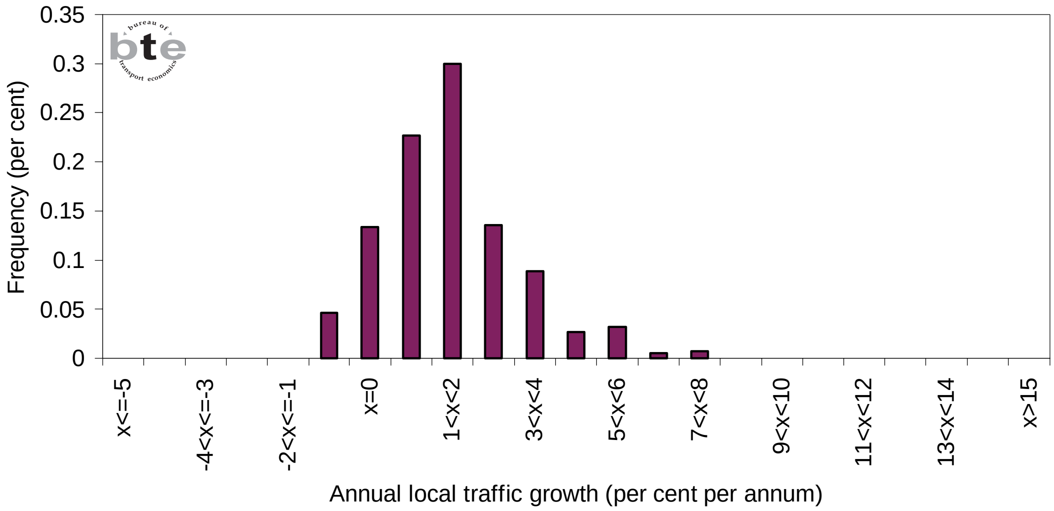
Year	Total passenger cars	Total LCVs	Total light vehicles	Population	Light vehicles per capita
	('000 vehicles)			(million persons)	(vehicles / '000 persons)
1971	4000	611	4611	13.07	352.81
1972	4220	645	4865	13.30	365.75
1973	4330	667	4997	13.51	369.89
1974	4730	726	5456	13.72	397.69
1975	4980	777	5757	13.89	414.44
1976	5110	805	5915	14.03	421.59
1977	5350	892	6242	14.19	439.86
1978	5460	951	6411	14.36	446.45
1979	5650	1013	6663	14.52	458.87
1980	5790	1012	6802	14.69	463.03
1981	6020	1043	7063	14.92	473.42
1982	6290	1092	7382	15.18	486.33
1983	6480	1138	7618	15.39	494.99
1984	6680	1177	7857	15.58	504.33
1985	6930	1222	8152	15.79	516.26
1986	7110	1243	8353	16.02	521.43
1987	7230	1253	8483	16.26	521.74
1988	7380	1258	8638	16.52	522.87
1989	7570	1293	8863	16.81	527.25
1990	7800	1315	9115	17.07	533.97
1991	8010	1346	9356	17.28	541.34
1992	8190	1415	9605	17.46	549.95
1993	8330	1450	9780	17.66	553.91
1994	8400	1513	9913	17.86	555.03
1995	8550	1581	10131	18.08	560.44
1996	8700	1621	10321	18.31	563.71
1997	8970	1661	10631	18.53	573.73
1998	9120	1703	10823	18.75	577.21
1999	9270	1745	11015	18.97	580.71
2000	9420	1789	11209	19.19	584.25
2001	9570	1834	11404	19.40	587.83
2002	9710	1880	11590	19.61	590.95
2003	9850	1927	11777	19.82	594.13
2004	9980	1975	11955	20.03	596.87
2005	10110	2024	12134	20.23	599.70
2006	10240	2075	12315	20.44	602.61
2007	10370	2127	12497	20.63	605.61
2008	10490	2180	12670	20.83	608.21
2009	10610	2234	12844	21.03	610.89
2010	10730	2290	13020	21.22	613.65
2011	10840	2347	13187	21.41	616.01

TABLE 4.1 FORECAST LIGHT VEHICLES PER PERSON, 1996 TO 2020 (CONTINUED)

Year	*Total passenger cars*	*Total LCVs*	*Total light vehicles*	*Population*	*Light vehicles per capita*
	('000 vehicles)			*(million persons)*	*(vehicles / '000 persons)*
2012	10950	2406	13356	21.60	618.46
2013	11080	2466	13546	21.80	621.26
2014	11200	2528	13728	22.02	623.46
2015	11330	2591	13921	22.24	625.96
2016	11450	2656	14106	22.47	627.86
2017	11590	2722	14312	22.70	630.49
2018	11720	2790	14510	22.94	632.52
2019	11860	2860	14720	23.19	634.81
2020	12000	2931	14931	23.44	636.93

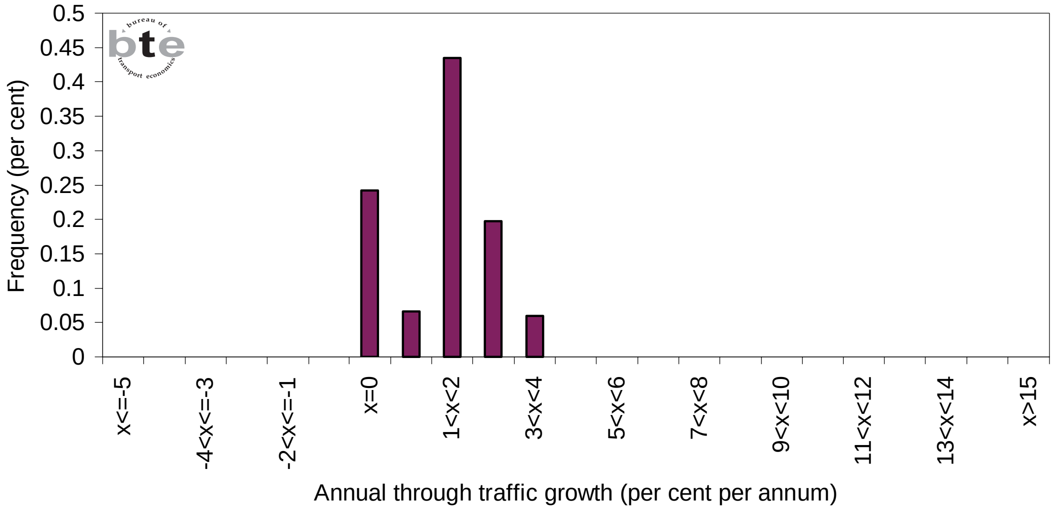
Sources BTE estimates; BTCE 1995; ABS 1997a.

FIGURE 4.4 HISTOGRAM – FORECAST RURAL LOCAL TRAFFIC GROWTH, 1996 TO 2005



Source BTE estimates.

FIGURE 4.5 HISTOGRAM – FORECAST THROUGH TRAFFIC GROWTH, 1996 TO 2005



Source BTE estimates.

WA COUNT STATIONS

The validity of the rural model was tested using information collected from WA rural permanent traffic count stations. The data span almost two decades from 1978 to 1996. The base year of 1978 was chosen because a major OD passenger travel survey permitted estimation of through traffic in that year (and, therefore, the local traffic component). The WA rural count stations were set up in the late 1960s and early 1970s to provide a representative sample of traffic on the rural highway system. The WA rural permanent traffic count data were the most easily accessible data, providing continuity and adequate geographic coverage, available in Australia to retrospectively test the accuracy of the BTE's rural local highway traffic methodology.

To test the validity of the rural local model, in predicting local traffic growth between 1978 and 1996, the following test procedure was performed:

(1) 1978 estimated rural local traffic = 1978 actual AADT – 1978 actual commercial vehicles – 1978 estimated through traffic;

(2) 1996 estimated rural local traffic = 1996 actual AADT – 1996 actual commercial vehicles – 1996 estimated through traffic;

(3) 1978 to 1996 forecast rural local traffic growth = (1 + growth in local population) $\times$ (1 + growth in national light vehicles per person) - 1.

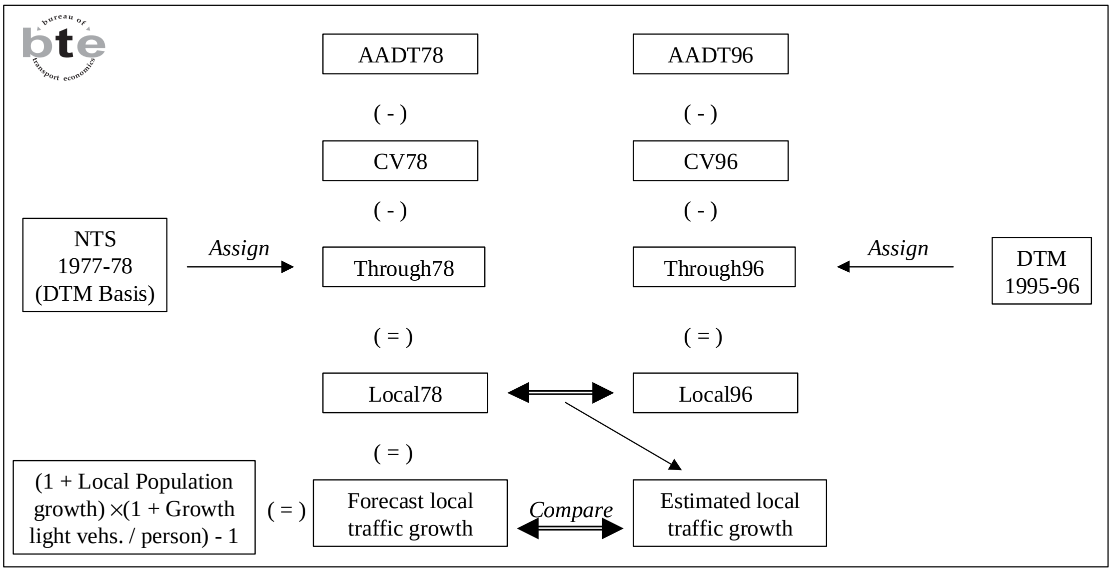
The estimated rural local traffic for 1978 was calculated in step (1), using the National Travel Survey (NTS) OD passenger travel data (BTE 1981) assigned to the highway network to derive 1978 through traffic estimates.

Estimated 1996 rural local traffic levels were calculated as in step (2), using the 1996 DTM (BTR 1996) OD data assigned to the highway network to derive 1996 through traffic estimates.

Forecast 1978 to 1996 rural local traffic growth was calculated according to step (3), with adjustments to take into account singular shifts in traffic levels, caused by road upgrades, road sealing, and urban expansion into previously non-urban areas.

Finally, forecast 1978 to 1996 rural local growth was compared to the estimated growth in local rural traffic over the period. The validation test procedure is outlined in figure 4.6.

FIGURE 4.6 PROCEDURE TO VALIDATE HIGHWAY TRAFFIC FORECAST METHODOLOGY

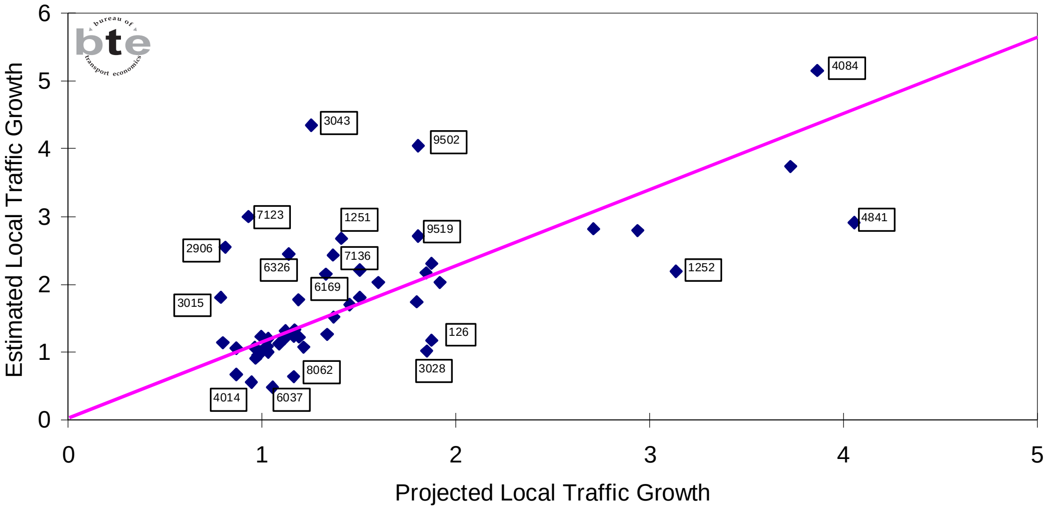


Source BTE.

The results given in figure 4.7 indicate the forecasting methodology used by the BTE was fairly accurate, with growth in local rural light vehicle traffic tending to be somewhat under-predicted by the projection method (regression line has a slope above one), but not to a significant degree.

On the basis of this evidence (and the evidence of the match of VKT components), the rural local model was accepted as a valid method of forecasting the rural local component of highway traffic.

FIGURE 4.7 ESTIMATED AND PROJECTED LOCAL LIGHT VEHICLE TRAFFIC GROWTH AT SELECTED COUNT SITES ON WA HIGHWAYS, 1978 TO 1996



Note Diamonds represent individual count stations (outliers labelled); line represents regression fit.

Sources BTE estimates; Main Roads WA 1996.

CHAPTER 5 FORECASTING LIGHT VEHICLE HIGHWAY TRAFFIC

Applying the models outlined in chapters 3 and 4 provides forecasts of through and local traffic for each section of Australia's non-urban highway network. Combined with assumed growth in commercial vehicle traffic, the models can provide forecasts of total highway traffic. The following sections illustrate the application of the model using two case studies to illustrate results generated by the models.

FORECASTING ROAD TRAFFIC – A CASE STUDY

To illustrate the forecast methodology for light vehicle traffic, two permanent count sites in Western Australia were examined and traffic levels were 'forecast' from 1985-86 to 1995-96. In order to focus attention on the light vehicle forecasting methodology, actual 1995-96 truck movements (rather than forecasts) were used.

The Eyre Highway

The first count site selected by the BTE lies at the western end of the Eyre Highway (station no. 3038). It is situated in an isolated area, but carries almost all the traffic travelling east or west from Western Australia. Table 5.1 gives the details of the forecasting methodology applied to this site.

In 1985-86, total AADT was 344, while by 1995-96 it had grown to 407 (see numbers marked '(a)'). The proportion of truck traffic in 1985-86 was about 20 per cent, increasing to 31 per cent in 1995-96 (b). Subtracting truck traffic from total traffic yielded a light vehicle AADT of 275 and 281 respectively (c).

'Through' traffic in 1985-86 can be calculated from table 5.2. All passenger numbers boxed in table 5.2 were assumed to have travelled along the Eyre Highway. The numbers in the boxed section represent 75 000 round trips or 150 000 one-way journeys by car by adults (greater than 14 years old). Assuming an average of 1.8 adults per car on long-distance journeys, this translates to an annual traffic flow of 83 300 vehicles, or a through light vehicle AADT of about 228 (see number labelled 'd' in table 5.1). The comparable figure for 1995-96 is 237 (d).

Subtracting, one calculates local light vehicle AADT as 47 in 1985-86 and as 44 in 1995-96 (e).

Because light vehicle through traffic on the Eyre Highway is long-distance travel (>800 km), it is assumed for forecasting purposes that there will be no growth in this traffic (based on reasoning in chapter 3). On this basis, light vehicle through traffic can be forecast as being just 1.0 times (f) the base number (d), or 228 vehicles per day (g).

Growth in local traffic is influenced by two factors – the growth in the local SLA population (h), and the growth at the national level of 'light vehicles per person' (i). The population of the SLA of Dundas has fallen by 29 per cent over the period 1986 to 1996, and the number of light vehicles per person nationally has risen 9 per cent. Thus the forecast is for local traffic to be 0.77 of the base amount of 47 (j), giving an AADT of 36 (k). Adding in the through traffic, this gives a forecast for light vehicle AADT of 264 (l). Adding commercial vehicles gives a forecast AADT for 1995-96 of 383 (m).

The forecast annual growth in AADT is thus 1.1 per cent per year versus an actual figure of 1.7 per cent per year. As can be seen from figure 5.1, these are both in the 1 to 2 per cent per annum bar of a histogram that has a range from –5 per cent per annum to +14 per cent per annum. Total AADT is forecast to be 1.1 times the base 10 years ago versus the actual outcome of 1.2 times the base.

TABLE 5.1 FORECAST TRAFFIC GROWTH 1986 TO 1996: EYRE HIGHWAY (WA COUNT STATION NO. 3038)

	Actual 1985-86		*1996 on 1986*		*Forecast 1995-96*	*%/yr*	*Actual 1995-96*	*%/yr*
Total AADT	344 *(a)*				383 *(m)*	1.1	407 *(a)*	1.7
Commercial	20% *(b)*				119 *(b)*		31% *(b)*	
Light vehicle AADT	275 *(c)*				264 *(l)*		281 *(c)*	
Through AADT (light)	228 *(d)*	×	1.0 *(f)*	=	228 *(g)*		237 *(d)*	
Local AADT (light)	47 *(e)*	×	.77 *(j)*	=	36 *(k)*		44 *(e)*	
			↑					
SLA population	2323		0.71 *(h)*		1652			
			×					
National light vehicles/'000 persons	521		1.09 *(i)*		569			

Note (a) to (m) – see text.

Sources Main Roads WA 1996; BTR 1996; BTE estimates.

TABLE 5.2 DTM 1985-86 – TOTAL PASSENGER VEHICLE TRIPS BY STATE OF ORIGIN AND REGION OF MAIN DESTINATION

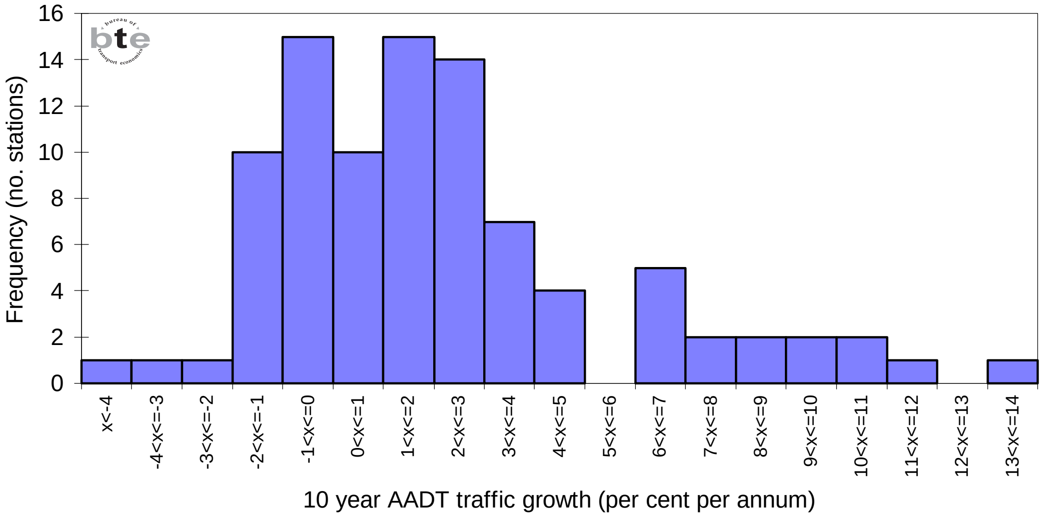
('000 passenger round trips)

Origin	*Destination*																			
	Syd	*Other NSW*	*ACT*	*Mel*	*Other Vic.*	*Bne*	*Gold Coast*	*Far North Qld*	*Whl*	*Mky*	*Other QLD*	*Adl*	*Other SA*	*Per*	*Other WA*	*Tas*	*Asp*	*Dar*	*Other NT*	*Total*
Sydney	461	5409	433	106	55	94	91	11	4	2	73	26	19	1	1	4	0	0	2	6792
ACT	224	608	8	19	43	5	5	0	0	0	12	3	4	0	0	0	0	0	2	933
NSW C'try	1020	3189	269	99	197	156	122	11	3	4	123	38	20	3	0	4	0	3	0	5261
Melbourne	111	546	59	120	4680	15	57	3	3	0	37	128	78	4	2	1	3	0	0	5847
Vic C'try	31	247	15	807	1768	4	8	4	0	1	17	54	70	3	1	5	5	2	0	3042
Brisbane	75	460	5	12	10	275	762	23	2	17	1442	5	8	0	0	5	0	0	0	3101
Qld C'try	32	244	15	25	1	690	196	265	2	229	1614	1	1	0	3	4	4	0	6	3332
Adelaide	14	43	10	75	115	4	1	2	0	0	4	97	1325	2	7	3	0	5	2	1709
SA C'try	23	15	2	12	51	6	0	1	0	0	2	478	373	0	1	0	3	1	1	969
Perth	3	4	0	4	1	0	0	0	0	0	0	5	6	149	1591	2	0	1	0	1766
WA C'try	1	6	0	1	0	0	0	0	0	0	0	1	15	811	841	0	0	0	1	1677
Tasmania	0	3	0	0	1	0	1	1	0	0	0	0	0	1	0	773	0	0	0	780
NT	0	1	0	0	0	2	0	2	0	7	15	1	1	0	3	0	4	1	36	73
Total	1995	10774	816	1280	6922	1251	1242	324	14	260	3341	836	1919	973	2450	801	18	12	49	35277

Notes Whl - Whitsunday Islands, Mky - Mackay, Asp - Alice Springs.

Source BTR 1986.

FIGURE 5.1 DISTRIBUTION OF 10–YEAR AADT GROWTH RATES AT WA RURAL PERMANENT TRAFFIC COUNT STATIONS



Source Main Roads WA 1996.

Table 5.3 gives the results of another case study using the BTE forecasting methodology, this time with a station that has more local traffic than through traffic. Permanent count station number 2905 is located north of Meekatharra on the Great Northern Highway.

Total AADT was 130 in 1985-86 and 313 in 1995-96 (a). Commercial vehicle proportions of total traffic were 12 per cent in 1985-86 and 16 per cent in 1995-96 (b). This left 'light vehicle AADT' of 114 and 263 respectively (c).

Through traffic was perhaps 15 cars per day in 1985-86 (based on limited tourism data) (d). By 1995-96 the road around the top end (Great Northern Highway) had been sealed, generating increased through traffic (including WA interregional traffic) of an estimated 68 vehicles per day by 1995-96 (d). This left local AADT in the two years of 99 and 195 (e).

For forecasting local AADT, there are again two influences. The population of Meekatharra SLA has increased by 65 per cent (g), and national 'light vehicles per person' has increased almost 9 per cent (h). This has resulted in a forecast local AADT that is 1.8 times (i) the base level, or 178 vehicles per day (j). Adding in the through traffic gives forecast light vehicle AADT of 238 (k) for 1995-96. Through traffic has not been forecast because of the one-off effect of sealing the top end highway. Instead, growth in through traffic has been estimated as a fraction of the increase in traffic at station 9000, which has the lowest increase of traffic on the round-Australia route, and by examining the increase in car traffic to the Northern Territory over the period. Adjusting for trucks gives a forecast for total AADT of 288 (l).

The forecast annual growth in AADT is thus 8.3 per cent per year versus an actual figure of 9.2 per cent per year. As can be seen from figure 5.1, these are in neighbouring bars in a histogram which stretches from –4 per cent per annum to +14 per cent per annum growth. Total AADT is forecast to be 2.2 times that 10 years ago, versus the actual figure of 2.4 times.

TABLE 5.3 FORECAST TRAFFIC GROWTH 1986 TO 1996: GREAT NORTHERN HIGHWAY (WA COUNT STATION NO. 2905)

	Actual 1985-86		*1996 on 1986*		*Forecast 1995-96*	*%/yr*	*Actual 1995-96*	*%/yr*
Total AADT	130 *(a)*				288 *(l)*	8.3	313 *(a)*	9.2
Commercial	12% *(b)*				50 *(b)*		16% *(b)*	
Light vehicle AADT	114 *(c)*				238 *(k)*		263 *(c)*	
Through AADT	15 *(d)*				60 *(f)*		68 *(d)*	
Local AADT	99 *(e)*	×	1.8 *(i)*	=	178 *(j)*		195 *(e)*	
			↑					
SLA population	1278		1.65 *(g)*		2100			
			×					
National light vehicles/'000 persons	521		1.09 *(h)*		569			

Note (a) to (l) – see text.

Sources Main Roads WA 1996; BTR 1996; BTE estimates.

SUMMARY - ROAD TRAFFIC FORECASTS

Road traffic forecasts were derived for each section of the National Highway system and for ‘other’ non-urban highways. The ‘other’ non-urban highways included in the database were determined by the data supplied to the BTE by the state road authorities. The BTE's road traffic forecasting database included traffic data for 69 885 separate sections on the National Highway system and an additional 57 508 sections on other non-urban highway links. Summary statistics on all road sections included in the BTE road traffic forecast database are listed in tables 5.4 to 5.6.

The National Highway traffic forecasts were based on growth in population and changes in the real cost of travel relative to real earnings applied to base 1996 traffic levels. Actual 1996 traffic flows on the National Highway System are shown in figure 5.2. The largest traffic flows are on highways linking the major east coast capital cities. There are also large traffic flows on the Bruce Highway, which runs between Brisbane and Cairns, and between Hobart and the population centres on the north west coast of Tasmania.

Figures 5.3 and 5.4 show through and local light vehicle traffic on the National Highway system in 1996. The largest through traffic flows are between Sydney and Melbourne, Melbourne and Adelaide, and Sydney and Brisbane. Large local traffic flows occur on the National Highway connectors to the capital cities and major provincial urban centres on the coast, and in some rural areas, especially in Victoria and New South Wales.

TABLE 5.4 SUMMARY STATISTICS - NATIONAL HIGHWAY ROAD SECTIONS IN BTE ROAD TRAFFIC FORECAST DATABASE

State	*No. Sections*	*Minimum Length*	*Maximum Length*	*Mean Length*	*StdDev Length*
		(kilometres)			
ACT	20	0.395	1.26	0.832	0.2064
NSW	253	0.098	111.17	11.948	13.9204
NT	954	0.070	9.94	2.819	2.3500
QLD	37222	0.001	5.55	0.110	0.1039
SA	2848	0.010	3.23	0.961	0.1782
TAS	276	0.010	3.94	1.183	0.6182
VIC	15965	0.001	27.01	0.076	0.3784
WA	12347	0.010	1.50	0.373	0.1773
Total	*69885*	0.001	111.17	nc	nc

Note nc – not calculated.

Source SMEC 1998.

TABLE 5.5 SUMMARY STATISTICS – NON-NATIONAL HIGHWAY ROAD SECTIONS IN BTE ROAD TRAFFIC FORECAST DATABASE

State	*No. Sections*	*Minimum Length*	*Maximum Length*	*Mean Length*	*StdDev Length*
		(kilometres)			
ACT	48	0.505	1.25	0.948	0.180
NSW	591	0.019	130.32	5.785	11.489
NT	208	0.100	10.00	2.261	2.047
QLD	5691	0.001	1.08	0.252	0.207
SA	1042	0.030	1.08	0.982	0.109
TAS	249	0.020	3.32	1.242	0.762
VIC	27977	0.001	1.48	0.081	0.032
WA	21702	0.010	99.50	0.363	1.169
Total	*57508*	0.001	130.32	nc	nc

Note nc – not calculated.

Source SMEC 1998.

Figure 5.5 shows the BTE's projected increase in traffic levels on the National Highway system between 1996 and 2005. The main growth in vehicle traffic is expected on roads linking the population centres on the south and eastern seaboard. Figure 5.6 shows that the largest amount of through traffic growth can be expected between Canberra and Sydney, Melbourne and northern Victoria, and Brisbane to the Queensland Sunshine and Gold Coasts. Sizeable through traffic growth is also predicted between Melbourne and Adelaide, Sydney and Melbourne, and Sydney and Brisbane (via the New England Highway). Figure 5.7 shows significant growth in local traffic will occur on National Highway links adjoining the capital cities and some provincial urban areas.

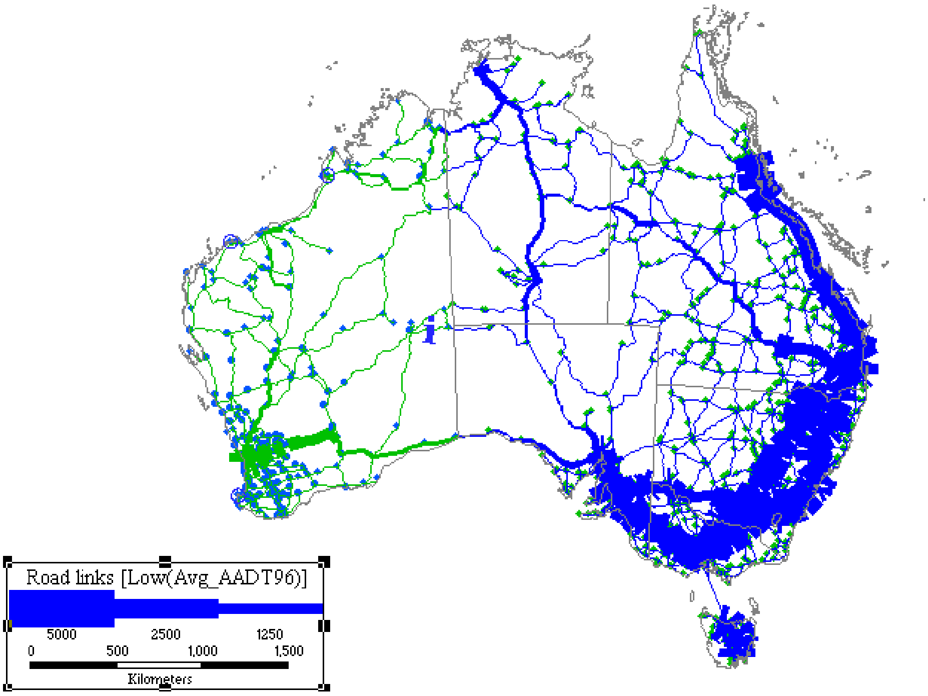
TABLE 5.6 SUMMARY STATISTICS – ALL NON-URBAN HIGHWAY ROAD SECTIONS IN BTE ROAD TRAFFIC FORECAST DATABASE

State	*No. Sections*	*Minimum Length*	*Maximum Length*	*Mean Length*	*StdDev Length*
			(kilometres)		
ACT	68	0.395	1.26	0.914	0.1942
NSW	844	0.019	130.32	7.632	12.5815
NT	1162	0.070	10.00	2.719	2.3078
QLD	42913	0.001	5.55	0.129	0.1319
SA	3890	0.010	3.23	0.967	0.1628
TAS	525	0.010	3.94	1.211	0.6902
VIC	43942	0.001	27.01	0.079	0.2295
WA	34049	0.010	99.50	0.367	0.9391
Total	*127393*	0.001	130.32	nc	nc

Note nc – not calculated.

Source SMEC 1998.

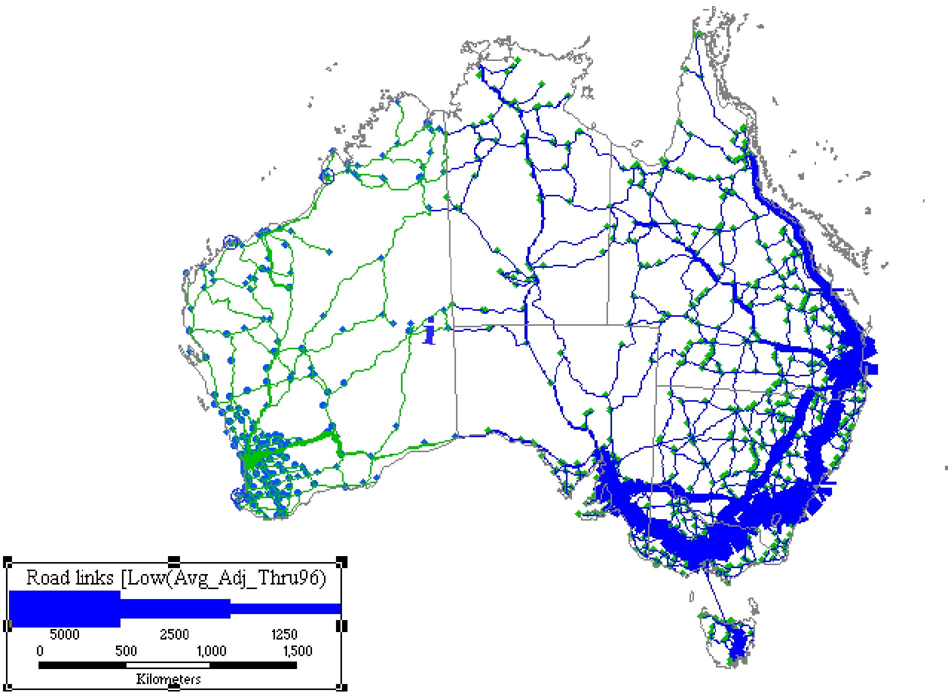
FIGURE 5.2 TOTAL TRAFFIC ON AUSTRALIAN NATIONAL HIGHWAY NETWORK 1996



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

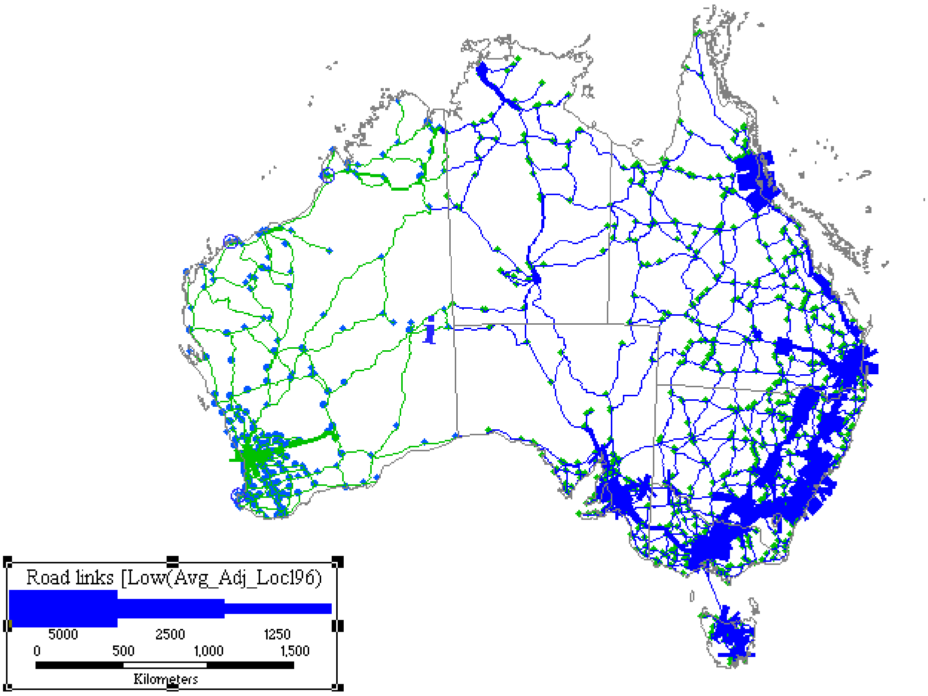
FIGURE 5.3 THROUGH TRAFFIC ON AUSTRALIAN NATIONAL HIGHWAY NETWORK 1996



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

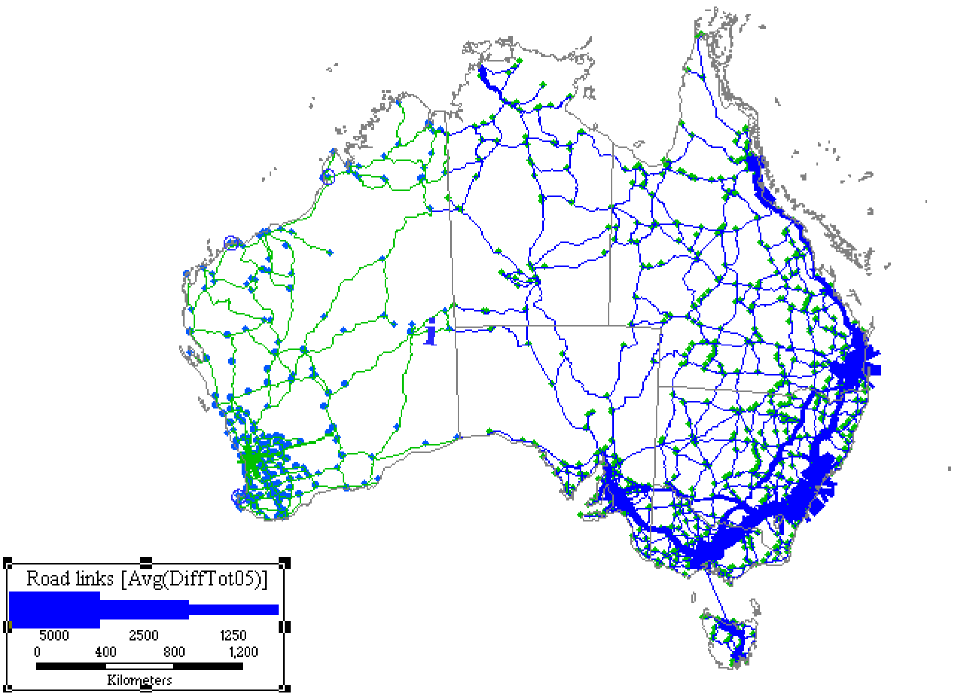
FIGURE 5.4 LOCAL TRAFFIC ON AUSTRALIAN NATIONAL HIGHWAY NETWORK 1996



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

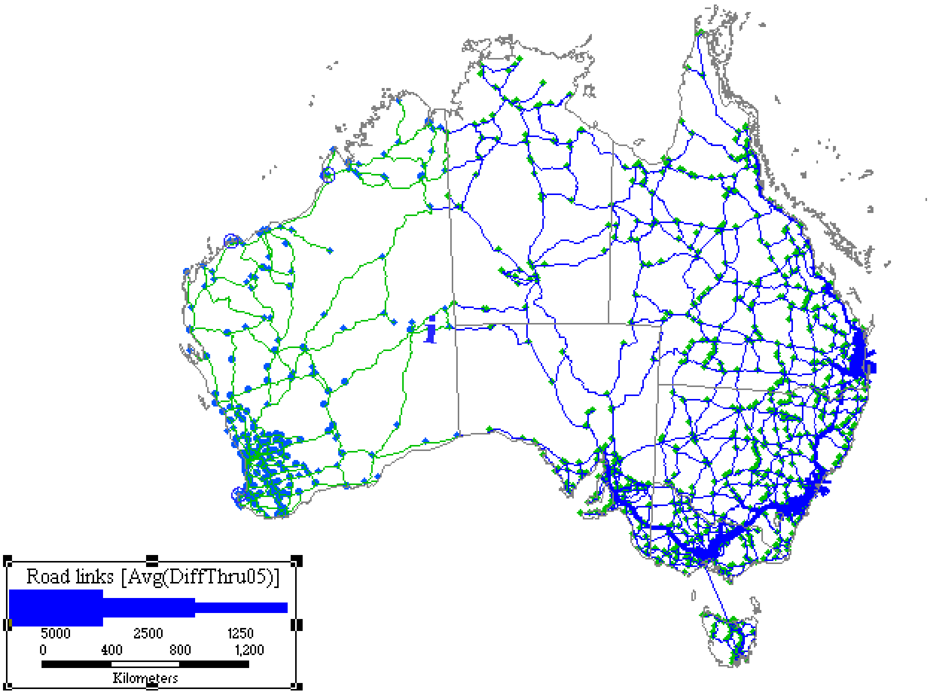
FIGURE 5.5 PROJECTED INCREASE IN TOTAL TRAFFIC ON THE AUSTRALIAN NATIONAL HIGHWAY NETWORK, 1996 TO 2005



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

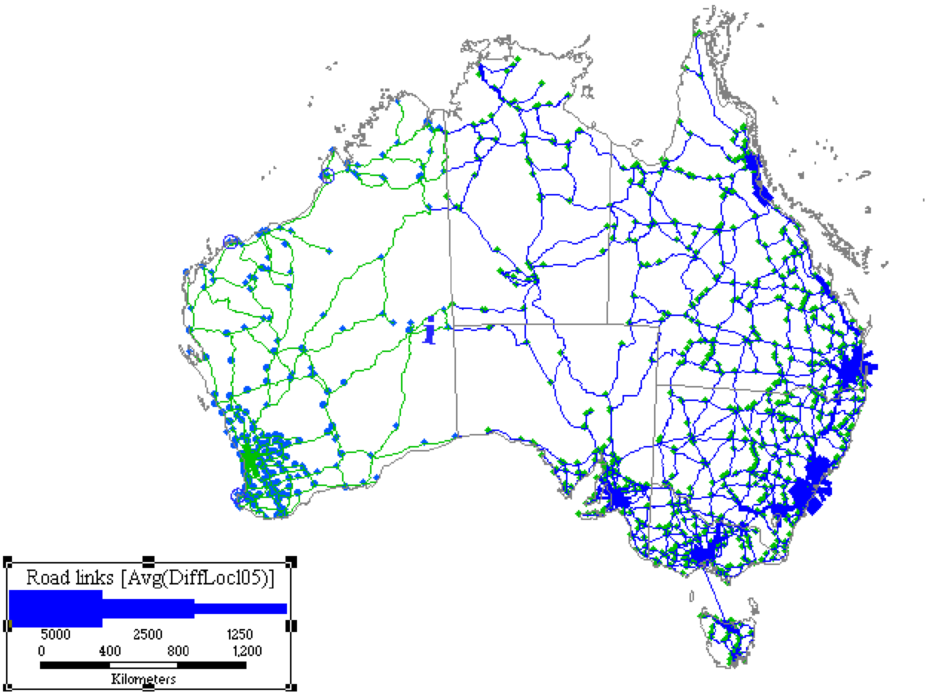
FIGURE 5.6 PROJECTED INCREASE IN THROUGH TRAFFIC ON THE AUSTRALIAN NATIONAL HIGHWAY NETWORK, 1996 TO 2005



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

FIGURE 5.7 PROJECTED INCREASE IN LOCAL TRAFFIC ON THE AUSTRALIAN NATIONAL HIGHWAY NETWORK, 1996 TO 2005



Note The link between Tasmania and the mainland is not part of the highway system, but was required in *TransCAD™* to model passenger vehicle travel on the highways by vehicles using the ferry service.

Sources BTE estimates; AUSLIG 1993; Caliper Corporation 1996; SMEC 1988.

CHAPTER 6 CONCLUSIONS

In the post-War period, car ownership per person has grown in a logistic (S-shaped) fashion. But growth in car ownership per person is currently slowing as it approaches its estimated saturation level of about 520 cars per 1000 population, a level it will reach by around the second decade of the new century. With immigration levels down, population growth is also slowing.

Slower growth in both cars per head and in total population will see the growth in car traffic in most cities halve from current levels by 2020. However, growth until then will still be enough to result in a major addition to traffic, and in several times the current level of congestion by 2020 (in a business-as-usual scenario). Urban public transport currently accounts for about 7 per cent of the urban passenger task, hence even a doubling of its size would not overcome the coming congestion problems.

Total (all modes) interregional passenger transport has been shown to increase as the product of the end-point populations increase, and decrease as the cost of travel (in terms of number of week's average earnings) increases. This formulation allows forecasts and scenarios to be derived that utilise various assumptions about the distribution of population growth, rates of income growth, fare increases or reductions, decreases in travel time due to infrastructure improvements, etc.

The trends in mode share are such that air travel is winning out over long distances and even over medium distances, while car travel is winning out over short distances. These trends can be incorporated into forecasting models using 'rules of thumb', allowing forecasts to be made of the long-term growth in interregional car traffic.

Rural local car traffic has been shown to respond to the same influences as urban car traffic, that is, population growth, and growth in the number of cars per head of population.

It is predicted that the largest growth in traffic volumes on the National Highway will be on sections of the system linking the major capitals Adelaide, Melbourne, Sydney and Brisbane, as well as regional centres in between. Most of the projected growth in traffic on the National Highway system is accounted for by growth in rural local traffic close to major urban centres, and by through traffic on the Adelaide–Melbourne, Melbourne–Sydney, Sydney–Brisbane and Brisbane–Maryborough corridors.

Combining all the models derived in this paper allows consistent forecasts of the growth of light vehicle traffic in Australia's cities and on each section of the country's highway system. The models also allow the simulation of various policy alternatives and of different scenarios about changes in future conditions that may affect traffic growth.

APPENDIX I EMPIRICAL ANALYSIS OF URBAN PASSENGER TRAVEL

This appendix provides a detailed description of the methodology and empirical results of the urban passenger vehicle travel demand model. The model covers Australian capital cities and major provincial urban areas, and was described briefly in chapter 2.

Aggregate urban passenger car travel

A linear relationship between total urban car vehicle kilometres travelled (VKT, derived from data in ABS 1996b and earlier) and a synthetic, or constructed, measure of total urban car VKT was used to model aggregate urban passenger car travel. Synthetic VKT was defined as the product of national average vehicle kilometre usage, the number of vehicles per 1000 persons and the population of the specific urban area. Implicit in this relationship are the influence of economic factors on urban passenger car travel, such as fuel prices, other vehicle operating costs and the cost of alternative urban passenger transport modes. The forecasts derived from the model are based on assumptions about future trends in average vehicle usage, vehicle stock growth and population, which are dependent on changes in socioeconomic factors.

The empirical model was of the form:

$$VKT_i = \text{Constant} + \beta_1 \left(nvp \times avk \times pop_i \right) + \varepsilon_i \tag{I.1}$$

where:

VKT_i = total vehicle kilometres travelled in city i;

nvp = vehicles per thousand persons nationally;

avk = annual average kilometres travelled per vehicle nationally;

pop_i = population of city i;

Constant, β_1 = model parameters; and

ε_i = error term.

A pooled cross-section time-series model was used to derive parameter estimates. The pooled cross-section time series model has the general form given in equation (I.2).

$$y_{it} = \alpha_{it} + \beta_{it} x_{it} + \varepsilon_{it}, \qquad i = 1, \ldots, N; \quad t = 1, \ldots, T \tag{I.2}$$

where N is the number of cross-sections and T is the number of time periods. For estimation purposes it was assumed that all structural differences between the cross-section terms were captured by different intercept terms but that the parameter on synthetic VKT was equal across different urban areas, equation (I.3). This model is also referred to as the *fixed effects* model.

$$y_{it} = \alpha_{it} + \beta x_{it} + \varepsilon_{it}, \qquad i = 1, \ldots, N; \quad t = 1, \ldots, T \tag{I.3}$$

For simplicity, the disturbances were assumed to be identically and independently normally distributed, with no contemporaneous correlation. These two assumptions imply that ordinary least squares (OLS) will generate the best linear unbiased estimator of y_{it}. The validity of these assumptions for urban passenger vehicle travel was not tested.

Twelve separate urban areas were used in the analysis: the eight capital cities and a collection of different provincial urban areas in each of four states; NSW, Victoria, Queensland and Tasmania. The selection of urban areas was constrained by the availability of time-series data on urban passenger travel.

Definition of urban areas

Data on passenger car travel in urban areas was obtained from the Survey of Motor Vehicle Use (ABS 1996b and earlier issues).

The capital city urban classification used in the SMVU corresponds with the capital city Statistical Division definition as defined in the Australian Standard Geographical Classification (ABS 1996a). Note that in 1971, the ACT was included in the capital city urban classification for New South Wales, but has since been identified separately. Table I.1 lists the capital city urban areas defined in the SMVU and the corresponding geographical area.

TABLE I.1 AUSTRALIAN STANDARD GEOGRAPHICAL AREAS FOR CAPITAL CITIES

Urban area (SMVU)	*Corresponding Geographical Area*
Sydney	Sydney SD (SD 105)
Melbourne	Melbourne SD (SD 205)
Brisbane	Brisbane SD (SD 305)
Adelaide	Adelaide SD (SD 405)
Perth	Perth SD (SD 505)
Hobart	Greater Hobart SD (SD 605)
Darwin	Darwin SD (SD 705)
Canberra	Canberra SD (SD 805)

Note SD denotes Statistical Division.

Source ABS 1996a; BTE.

The definition of provincial urban areas was more problematic. The provincial urban classification was adopted in the 1967-68 Australian Roads

Survey undertaken by State main road and local government authorities. It includes population centres (apart from those already included in the capital city urban classification) with populations greater than 40,000 persons in the most recent Population Census.

From 1988 onwards, the ABS definition of provincial urban areas was changed to: Statistical Districts with a population greater than 40,000, or Clusters of Collection Districts with a population greater than 40,000. Based on this definition, we have used Statistical Districts where possible and the appropriate cluster of Collection Districts where the Statistical District is inappropriate (ABS 1996b, and earlier issues). Table I.2 lists the urban areas included in the provincial urban classification and table I.3 lists the equivalent Australian Standard Geographical Classification areas used to measure population estimate.

What is urban area travel ?

The Survey of Motor Vehicle Use (SMVU) is the only reliable time series data set on urban passenger VKT in Australia. The SMVU defines urban VKT as all VKT travel (i) in a capital city and environs, and (ii) in other major provincial urban areas within state, by passenger vehicles registered within that state. All urban VKT within an urban area by a vehicle registered in another state is classified interstate VKT and is not counted as urban VKT. The measure of urban passenger VKT, therefore, is not strictly all urban passenger vehicle VKT, but it is reasonable to expect that a very large proportion of total urban passenger vehicle VKT is attributable to vehicles registered within the urban area.

The definition of urban area VKT used in the SMVU may pose more problems for the modelling of urban freight transport, as many interstate and interregional freight trips have a capital city travel component.

Urban areas population estimates

Estimated Resident Population (ERP) (ABS 1997a) was used for population estimates for the twelve urban areas. Deriving urban area population estimates for the twelve urban areas, for the period 1971 to 2020, required combining Population Census estimates and ERP estimates. The Population Census differs from the ERP because some residents are overseas on the night of the Census, and some are within the country but not present at their usual place of residence. The Census and ERP estimates were spliced together by assuming that prior to 1991 the annual growth in ERP equalled the growth in the Census in each region, taking the 1991 ERP estimate for the level of the population.

TABLE I.2 CITIES AND REGIONAL CENTRES INCLUDED IN PROVINCIAL URBAN CLASSIFICATION

Year of SMVU	NSW	Victoria	Queensland	Tasmania
1971	Newcastle, Port Kembla & Wollongong	Geelong, Ballarat & Bendigo	Gold Coast, Toowoomba, Rockhampton & Townsville	Launceston
1976	"	"	"	"
1979	"	"	"	"
1982	"	"	"	"
1985	"	"	Gold Coast, Toowoomba, Rockhampton, Townsville, Mackay, Bundaberg, Sunshine Coast & Cairns	"
1988	Newcastle, Wollongong, Bathurst-Orange, Maitland, Albury (excl. Wodonga), Tweed Heads (excl. Gold Coast) & Queanbeyan (excl. Canberra)	Geelong, Ballarat, Bendigo & Wodonga (excl. Albury)	"	Launceston, Burnie, Devonport, Penguin, Ulverstone & La Trobe
1991	"	"	"	"
1995	Newcastle, Wollongong, Bathurst-Orange, Maitland, Albury (excl. Wodonga), Wagga Wagga, Tweed Heads (excl. Gold Coast), Queanbeyan (excl. Canberra), Lismore, Coffs Harbour, Greater Taree, Hastings & Shoalhaven.	"	"	Launceston, Burnie, Devonport, Penguin, Ulverstone, Wynyard & La Trobe

Note " – denotes same as for the previous survey.

Source ABS 1996b.

TABLE I.3 AUSTRALIAN STANDARD GEOGRAPHICAL AREAS FOR PROVINCIAL URBAN AREAS

SMVU	NSW	Victoria	Queensland	Tasmania
1971	Newcastle SSD (SSD 11005)	Geelong – Barwon SD (SD 210)	Gold Coast SSD (SSD 31005)	Launceston SSD (SSD 61505)
	Wollongong SSD (SSD 11505)	Ballarat SSD (SSD 22005)	Toowoomba C (SSD 32001)	
		Bendigo SSD (SSD 23505)	Rockhampton SSD (SSD 33005)	
			Townsville SSD (SSD 34505)	
1976	"	"	"	"
1979	"	"	"	"
1982	"	"	"	"
1985	"	"	As for 1982 and:	"
			Mackay C (SSD 34005)	
			Bundaberg C (SSD 31505)	
			Sunshine Coast SSD (SSD 31015)	
			Cairns C (SSD(35005)	
1988	As for 1985 and:	As for 1985 and:	"	As for 1985 and:
	Bathurst-Orange SSD (SSD 14005)	Wodonga RC (SSD 24505)		Burnie, Devonport, Penguin, Ulverstone & La Trobe (SLA's 60611, 60811, 61610, 63811)
	Albury SSD (SSD 15505)			
	Tweed Heads SSD (SSD 12005)			
	Queanbeyan C (SSD 14505)			
1991	"	"	"	"
1995	As for 1991 and:	"	"	Launceston SSD (SSD 61505)
	Lismore C (SLA 14850)			Burnie-Devonport SSD (SSD 62005)
	Coffs Harbour C (SLA 11800)			
	Greater Taree C (SLA 13350)			
	Hastings A (SLA 13750)			
	Shoalhaven C (SLA 16950)			

Note " – denotes same as for the previous survey.
SSD – denotes Statistical Sub Division, SLA – denotes Statistical Local Area, C – denotes City, RC – denotes Rural City, and A – denotes Area.

Source ABS 1996a.

Estimation results - urban passenger travel

Two versions of the urban passenger travel model were estimated, one without city-specific dummy variables and one with city specific dummy variables. The estimation results are listed in table I.4. In both cases, with and without city-specific dummy variables, the regression is statistically significant. Statistical tests show that the urban area-specific dummy variables are jointly significant, suggesting there are variations in the level of urban passenger vehicle VKT across different urban areas. The dummy variables for the largest capital cities, Sydney, Melbourne and Brisbane, are large negative values, which suggests that there are factors specific to those cities that produce lower urban passenger vehicle VKT. Such factors might include congestion levels and/or higher availability of public transport. Overall, the model with city-specific dummy variables gives a better fit of aggregate urban passenger vehicle VKT.

Some additional statistical tests were undertaken to test the properties of the regression results. For both specifications, with and without city-specific dummy variables, Durbin–Watson statistics suggest that there might be positive autocorrelation present in the regression. Tests on the normality of the residuals suggest that the residuals are not normally distributed. This may be because the disturbance terms vary between cities. Estimation using generalised least squares would be more appropriate in this circumstance. Even if the disturbance terms differ between cities, the parameter estimates obtained using OLS are unbiased. Feasible generalised least squares gives parameter estimates similar to OLS. Furthermore, the test of normality of the residuals indicates that inference using the residuals follows classical test procedures.

Figure I.1 graphs actual VKT against predicted VKT derived from the models. The results suggest that, as expected, the parameter estimate on the synthetic VKT variable is not significantly different from unity. We have assumed that the parameter is equal to one in deriving projections of urban passenger VKT to 2020 shown in figure I.2.

TABLE I.4 URBAN PASSENGER VEHICLE VKT MODEL – PARAMETER ESTIMATES

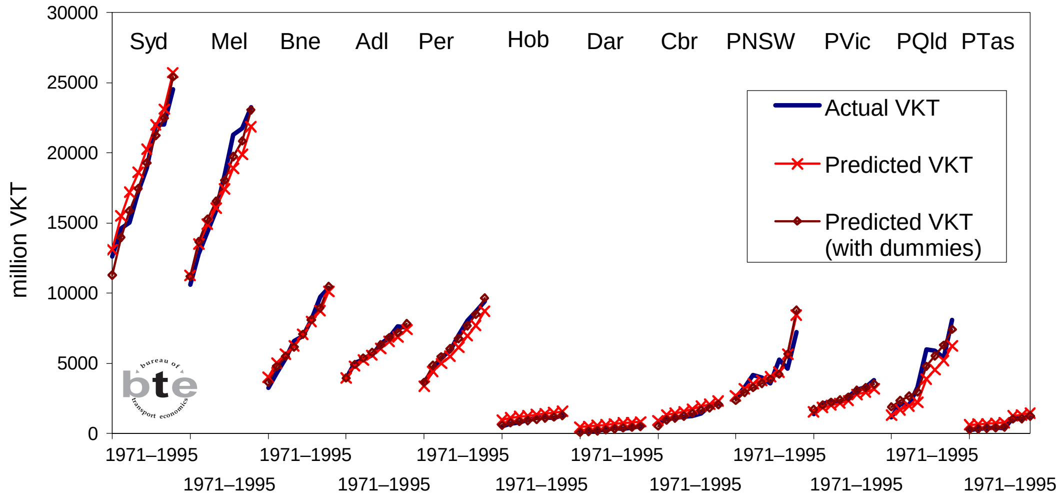
	OLS - No dummy variables	*OLS with dummy variables*	Feasible GLS with dummy variables
Dependent variable: Urban passenger travel (million VKT)			
No. observations	96	96	96
$\overline{R}^2$	.9857	.9929	.9980
Constant	302.76		
	(101.9)		
Implied VKT parameter	0.860	0.963	0.968
	(0.011)	(0.025)	(0.015)
Dummy variable parameter estimates (million VKT)			
Sydney		-3039.2	-3149.4
Melbourne		-1093.4	-1258.2
Brisbane		-499.2	-542.8
Adelaide		-144.3	-161.4
Perth		228.3	181.3
Hobart		-159.1	-166.7
Darwin		-96.1	-99.1
Canberra		-167.2	-166.7
Provincial NSW		-328.0	-409.5
Provincial Vic.		310.3	298.5
Provincial Qld.		795.6	776.9
Provincial Tas.		-67.3	-72.0
$\overline{R}^2$	.9857	.9929	.9980
DW	0.78	1.40	1.62
J–B statistic $\left(\chi^2_{df=2}\right)$	16.45	13.65	3.18

Note Parameter estimates obtained by applying ordinary least squares (OLS) to pooled cross section – time series of travel in 12 urban areas. Figures in parentheses are the estimated standard errors. $\overline{R}^2$ is the regression correlation coefficient adjusted for the number of regressors. DW is the Durbin–Watson statistic. J–B statistic is the Jarque–Bera test for normality of the residuals.

Source BTE estimates.

Passenger vehicle VKT in capital cities is forecast to grow by 1.2 per cent per annum from 1995 to 2020, in contrast to growth of 3.5 per cent per annum in the period 1971 to 1995. The difference in growth is due partly to a slower expected growth in capital city populations, but more importantly to the increased saturation of car ownership in Australia. The story is very similar for urban passenger VKT in the provincial urban areas. The projections of provincial urban VKT are based on the assumption that the geographic areas included in the ABS definition of an urban area are the same as for the 1995 SMVU definition.

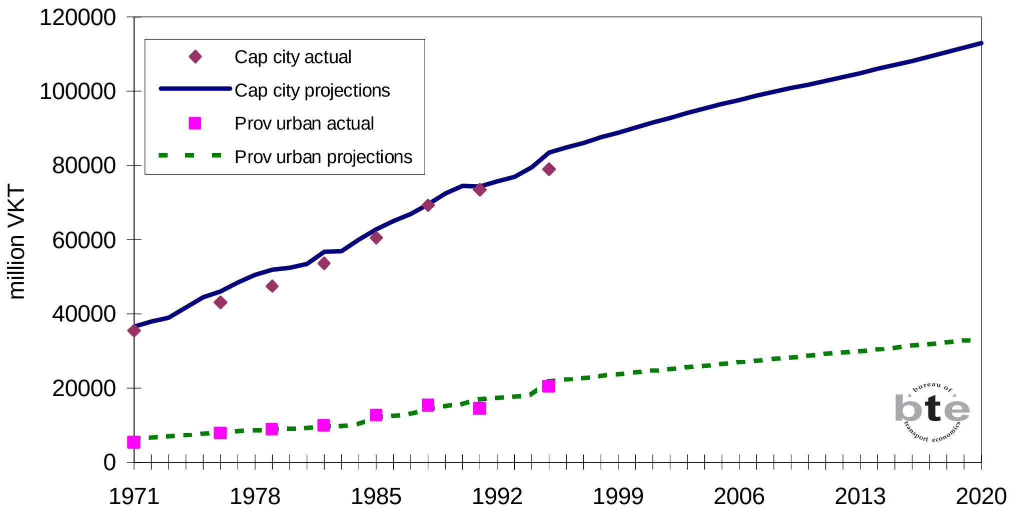
FIGURE I.1 URBAN PASSENGER VEHICLE VKT, CAPITAL CITIES AND PROVINCIAL URBAN AREAS, 1971 TO 1995



Note P before State equals 'Provincial', defined in appendix I.

Sources BTE estimates; ABS 1996b and earlier issues.

FIGURE I.2 ACTUAL AND PROJECTED TOTAL URBAN PASSENGER VKT, CAPITAL CITIES AND PROVINCIAL URBAN AREAS, 1971 TO 2020



Sources BTE estimates; BTCE 1996b; ABS 1997a, 1996b and earlier issues; 1993a and earlier issues.

APPENDIX II VALIDATION OF RURAL LOCAL MODEL

Validation of the traffic forecast methodology was undertaken to assess the reliability of average annual daily traffic (AADT) forecasts. This appendix describes the procedure used to validate the forecasting method.

Validation procedure

The validation procedure, illustrated in figure II.1, involved testing the relationship between actual historical growth in local traffic, and projected growth in local traffic based on the forecasting methodology.

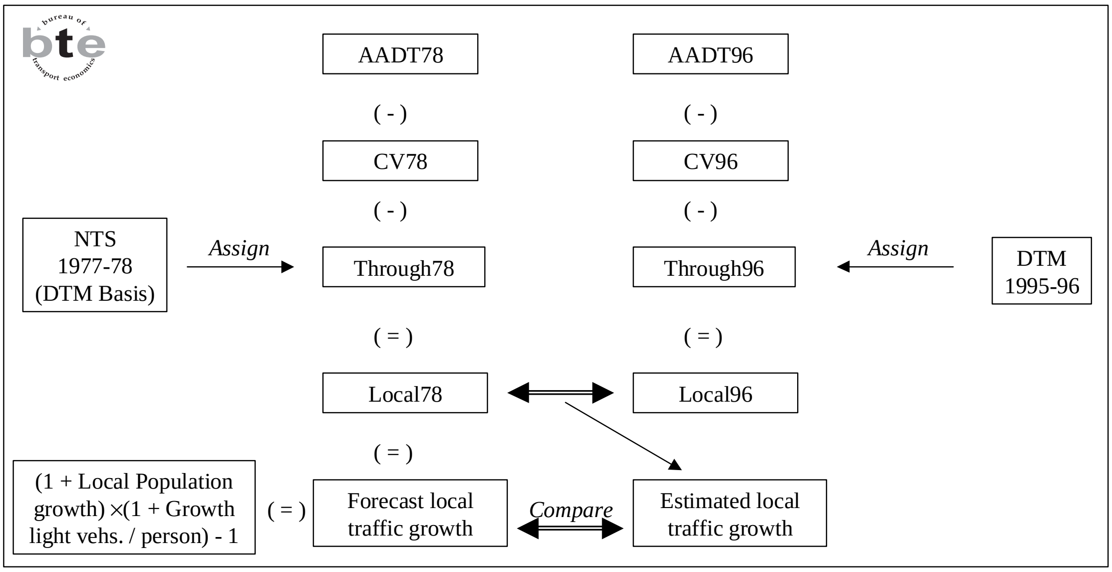
The BTE National Travel Survey (NTS) 1977-78 (BTE 1981), the BTR Domestic Tourism Monitor (DTM) survey (BTR 1997), and WA rural highway traffic data were the principal data sources used to validate the forecast methodology.

The NTS was used to estimate through traffic for 1978. The through traffic estimates were then assigned to the highway network, using *TransCAD*® (Caliper Corporation 1996), and subtracted from WA AADT counts in 1977-78 to isolate local traffic in that year. The BTR's Domestic Tourism Monitor 1995-96 passenger vehicle trip data were assigned to the highway network to estimate through (and thus local) light vehicle traffic in 1995-96. Forecasts of 1995-96 WA local traffic were derived from 1977-78 WA rural local traffic estimates, using the BTE forecasting methodology. Projected local traffic growth was then tested against estimated local traffic growth on WA rural highways. The test involved regressing estimated local traffic growth between 1978 and 1996 against predicted growth in local traffic. A regression coefficient of close to unity indicates that projected traffic growth agrees with estimated traffic growth.

Data from the WA rural highway network were chosen primarily because of easily accessible time series, with annual traffic count data for a number of permanent count sites covering all major rural highways throughout the state. WA offers the additional advantage of being a long way from the eastern states, with only two major routes available to interstate light vehicle traffic to enter and leave the state. This fact reduces the number of different inter-regional traffic pairs that need to be considered, and simplifies the validation of the forecasting methodology.

Finally, the availability of the NTS in 1977-78 permitted the testing of the forecasting methodology over the 18 year period 1978 to 1996.

FIGURE II.1 PROCEDURE FOR VALIDATING BTE HIGHWAY TRAFFIC FORECASTING METHODOLOGY



Source BTE.

Traffic Forecasting Methodology – A Recapitulation

The forecasting methodology used to project traffic growth on Australian highways (chapter 3) is based on models of passenger travel demand, mode share and highway traffic count data. Highway traffic forecasts are based on projections of three different types of traffic:

- commercial vehicles;
- through light vehicle traffic; and
- local light vehicle traffic.

Commercial vehicle traffic growth was assumed to grow at 3 per cent per annum on all road links, from actual (or estimated) 1996 commercial vehicle traffic levels (equation II.1). The 3 per cent annual growth rate was similar to that adopted by the National Transport Planning Taskforce (NTPT 1995, p.17). The BTE hopes to undertake an analysis of the interregional road freight transport task in the near future, in order to provide a better estimate of commercial vehicle traffic growth for different highways.

Through traffic on each road section was projected by using a simple gravity model formulation: through traffic growth between any two centres was taken to be proportional to the rate of population growth of the two centres and inversely proportional to the real cost of travel between those centres, adjusted for the underlying pattern of modal shift. Through traffic estimates for 1996 were used as the base for the forecasts.

Local traffic is the residual left after subtracting estimated commercial vehicle traffic and through traffic from total AADT. Forecast growth in local traffic is equal to SLA population growth and growth in the number of vehicles per person nationally (with average annual VKT per vehicle assumed constant).

$$CV_{t+k} = CV_t \times (1 + 0.03)^k \tag{II.1}$$

$$Through_{t+k} = Through_t \times \left(1 + \%\Delta Pop_{t,t+k}\right)^{0.5} \left(1 + \%\Delta AWE_{t,t+k}\right)^{-1.25} \times Dist\ \ factor \tag{II.2}$$

$$Local_{t+k} = Local_t \times \left(1 + \%\Delta Pop_{t,t+k}\right)\left(1 + \%\Delta Veh / Pers_{t,t+k}\right) \tag{II.3}$$

$$AADT_{t+k} = CV_{t+k} + Through_{t+k} + Local_{t+k} \tag{II.4}$$

where:

CV_t – denotes commercial vehicle traffic at time *t*.

$Through_t$ – through light vehicle traffic at time *t*.

$Local_t$ – local light vehicle traffic at time *t*.

$AADT_t$ – total AADT at time *t*.

$\%\Delta Pop_{t,t+k}$ – growth (percentage change) in population between time *t* and time *t+k*.

$\%\Delta AWE_{t,t+k}$ – growth rate (percentage change) in average weekly ordinary time earnings between time *t* and time *t+k*.

$\%\Delta Veh/Pers_{t,t+k}$ – growth rate (percentage change) in light vehicle ownership per person between time *t* and time *t+k*.

Data

The 1978 National Travel Survey (NTS) (BTE 1981) passenger travel forecasts were used to derive 'through' traffic on WA roads. To assign the NTS data to the highway system, to forecast through traffic consistent with the Domestic Tourism Monitor (DTM) data, the NTS data was first converted to a measurement base consistent to that used in the DTM. The NTS definition of a passenger trip was any return journey within Australia (i.e. starting and finishing at home) to a destination at least 100km from home, that is not part of a regular journey to work, nor made as a crew member. The NTS estimates include children in the measure of passenger trips. The DTM definition of a trip involves a return passenger trip within Australia travelling to a destination at least 40km from home and involving an overnight stay. The DTM does not count journeys undertaken by children under 14 years of age, or day trips.

To convert the NTS data to a DTM basis measure, the 1978-79 DTM was used as an indicator of the level of traffic that would have prevailed in the 1977-78 DTM. The 1977-78 NTS data also had to be converted to the DTM regional definition. The process involved calculation of adjustment factors to convert the 1977-78 NTS to the DTM basis. Adjustment factors were calculated for state of origin and DTM region of destination, and were applied to the interregional NTS traffic to derive NTS 1977-78 (DTM basis) traffic.

Inter-regional OD pair traffic for the NTS 1977-78 (DTM basis) and DTM 1995-96 was assigned to the Australian Highway network using the stochastic user equilibrium traffic assignment function in *TransCAD*® (Caliper Corporation 1996).

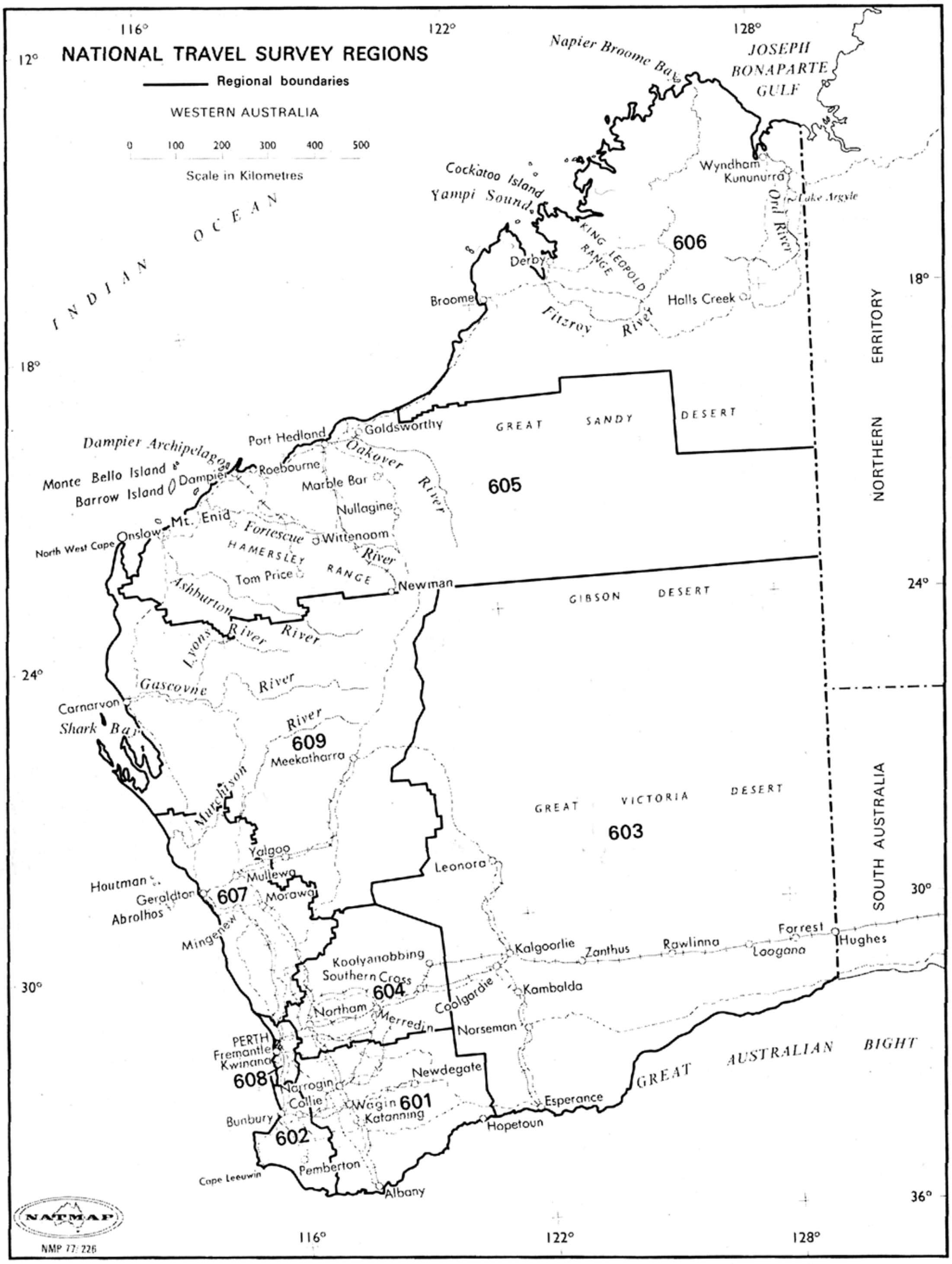
The assignment of inter-regional OD pair traffic was based on 64 OD regions Australia-wide (9 regions in WA) for the NTS and 84 OD regions Australia-wide (12 regions in WA) for the DTM. The WA geographic regions are illustrated in figures II.2 and II.3. The traffic assignment procedure required assigning node(s) for each OD region. Assignments based on a single node for each region produced poor estimates of local traffic, with all through traffic to a region being assigned to one path, and all alternative paths between regions being assigned zero through traffic. For example, Region 509, in the DTM survey, is called the Lower South West, and encompasses the South West corner of WA, taking in the Margaret River and Cape Leeuwin as well as the 'tall timber' country around Manjimup and Pemberton. Assigning only one node for this region meant that all through traffic was assigned to only one of these areas, depending on where the node is placed, and no through traffic travelled to the other area. Both areas are significant tourist attractions in their own right, and both will attract a share of the through traffic to the region. Multiple nodes can therefore be expected to give a better approximation of through traffic to this region.

Because of the poor through traffic assignment with single nodes for each WA region, regions that contain multiple major tourist destinations or population centres were assigned multiple nodes, one for each of those centres. Traffic to and from each region was split between alternative nodes using simple rules of thumb based on the distribution of traffic. The through traffic assignment using this procedure led to a better spread of through traffic estimates on most links. Tables II.1 and II.2 list the regional nodes used for the through traffic assignment.

Testing the forecasting method using local traffic growth

Testing forecasts of local traffic growth required the analysis of growth at specific sections of the WA rural highway network. Table II.3 lists the WA rural permanent count stations that were included in the analysis. Not all WA permanent count stations were included in the analysis, because traffic data do not exist back to 1978 for some stations, and data for other stations are sparse and would feature little tourism traffic. Figure II.4 shows Western Australia's rural road network and the count station locations.

FIGURE II.2 NATIONAL TRAVEL SURVEY REGIONS – WESTERN AUSTRALIA



Source BTE 1978.

FIGURE II.3 DTM SURVEY REGIONS – WESTERN AUSTRALIA

Source ABS 1998c.

Table II.4 lists the raw regression results for the comparison of estimated WA local traffic regressed against forecast WA local traffic. Figure II.5 plots the regression line versus a scatter plot of estimated versus predicted local traffic growth at selected rural WA count stations. The results suggest an approximate correlation between estimated local traffic growth and predicted local traffic growth of one. There are, however, a number of outlying observations that require further explanation.

TABLE II.1 NODE SET USED FOR ASSIGNING 1978 NTS TRAFFIC ESTIMATES

NTS Code	*NTS region name*	*Node code*	*Node location*	*Assumed traffic proportion*
601	Albany	601.1	Albany	$^1/_2$
		601.2	Narrogin	$^1/_3$
		601.3	Katanning	$^1/_6$
602	Bunbury	602.1	Margaret River	$^1/_4$
		602.2	Manjimup	$^1/_4$
		602.3	Bunbury	$^1/_2$
603	Kalgoorlie	603.1	Esperance	$^1/_4$
		603.2	Kalgoorlie	$^3/_4$
604	Northam	604.1	Northam	$^1/_2$
		604.2	Merridin	$^1/_4$
		604.3	York	$^1/_4$
605	Port Hedland	605.1	Port Hedland	$^1/_3$
		605.2	Newman	$^1/_3$
		605.3	Roeburne	$^1/_3$
606	Derby	606.1	Broome	$^2/_3$
		606.2	Wyndham	$^1/_3$
607	Geraldton	607.1	Geraldton	$^1/_2$
		607.2	Lancelin	$^1/_2$
608	Perth	608	Perth	1
609	Carnarvon	609.1	Carnarvon	$^1/_2$
		609.2	Meekatharra	$^1/_6$
		609.3	Exmouth	$^1/_3$

Source BTE estimates.

TABLE II.2 NODE SET USED FOR ASSIGNING 1996 DTM TRAFFIC ESTIMATES

NTS Code	*NTS region name*	*Node code*	*Node location*	*Assumed traffic proportion*
501	South East	501.1	Esperance	$^3/_4$
		501.2	Norseman	$^1/_4$
502	Goldfields	502	Kalgoorlie	1
503	Midwest	503.1	Geraldton	$^3/_4$
		503.2	Meekatharra	$^1/_4$
504	Gascoyne	504.1	Carnarvon	$^5/_6$
		504.2	Exmouth	$^1/_6$
505	Pilbara	505.1	Port Hedland	$^3/_4$
		505.2	Newman	$^1/_4$
506	Kimberley	506.1	Broome	$^4/_5$
		506.2	Wyndham	$^1/_5$
507	Perth	507	Perth	1
508	Upper South West	508.1	Bunbury	$^1/_2$
		508.2	Mandurah	$^1/_3$
		508.3	Pinjarra	$^1/_6$
509	Lower South West	509.1	Margaret River	$^1/_2$
		509.2	Manjimup	$^1/_2$
510	Great Southern	510.1	Albany	$^4/_5$
		510.2	Kojonup	$^1/_5$
511	Central South	511.1	Narrogin	$^1/_2$
		511.2	Brookton	$^1/_2$
512	Midlands	512.1	Lancelin	$^1/_2$
		512.2	Northam	$^1/_3$
		512.3	Merredin	$^1/_6$

Source BTE estimates.

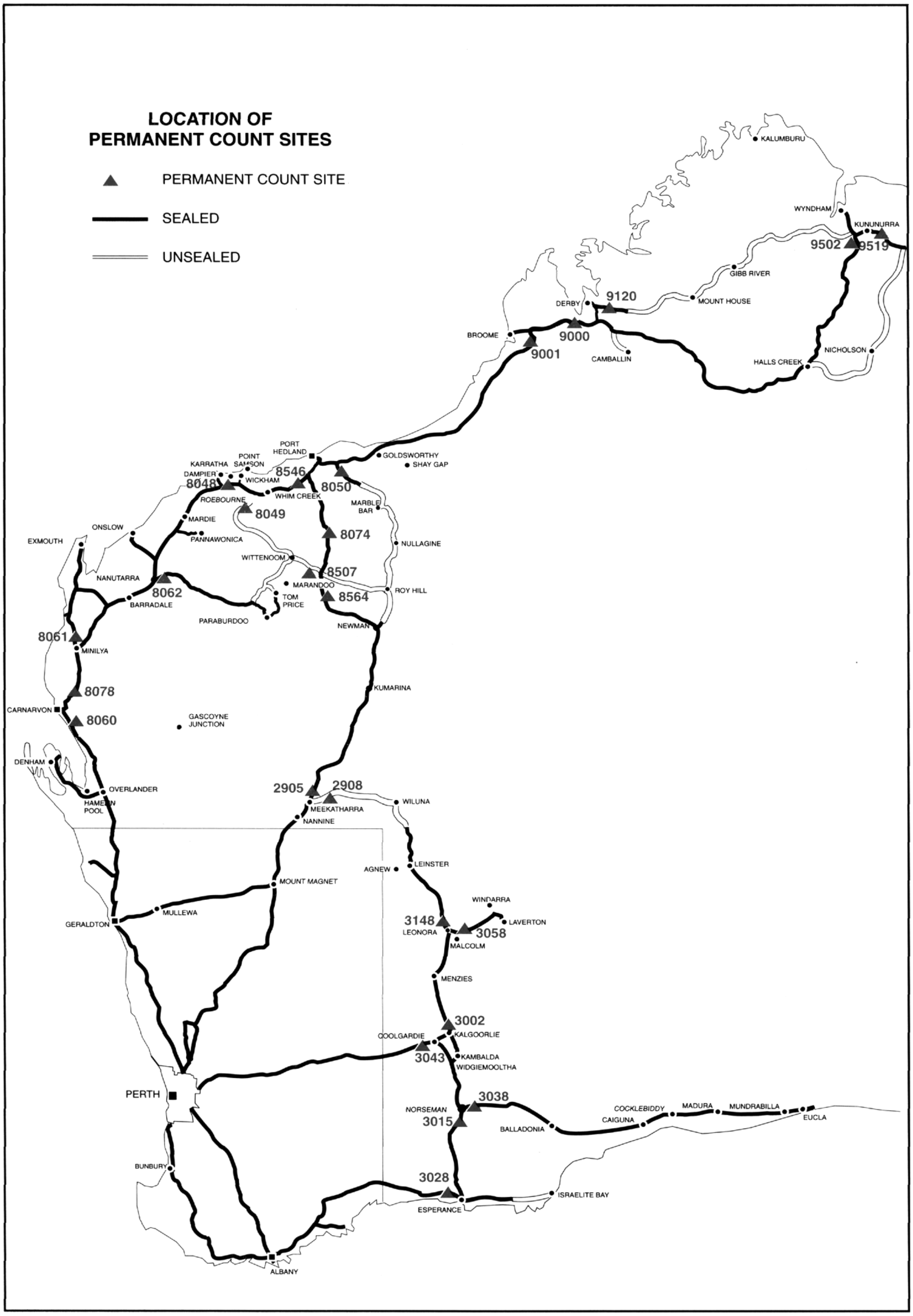
TABLE II.3 WESTERN AUSTRALIAN COUNT STATIONS INCLUDED IN REGRESSION ANALYSIS FOR TESTING FORECASTING METHOD

(Count station number)

120	1130	2900	3015	4014	5074	6037	7001	8048	9000
121	1131	2901	2028	4025	5096	6045	7023	8060	9001
123	1251	2902	3043	4084		6095	7089	8061	9502
124	1252	2903	3058	4841		6097	7113	8062	9519
125	1253	2904				6105	7123	8507	
126	1322	2905				6112	7136		
		2906				6169	7145		
						6326	7157		
							7182		

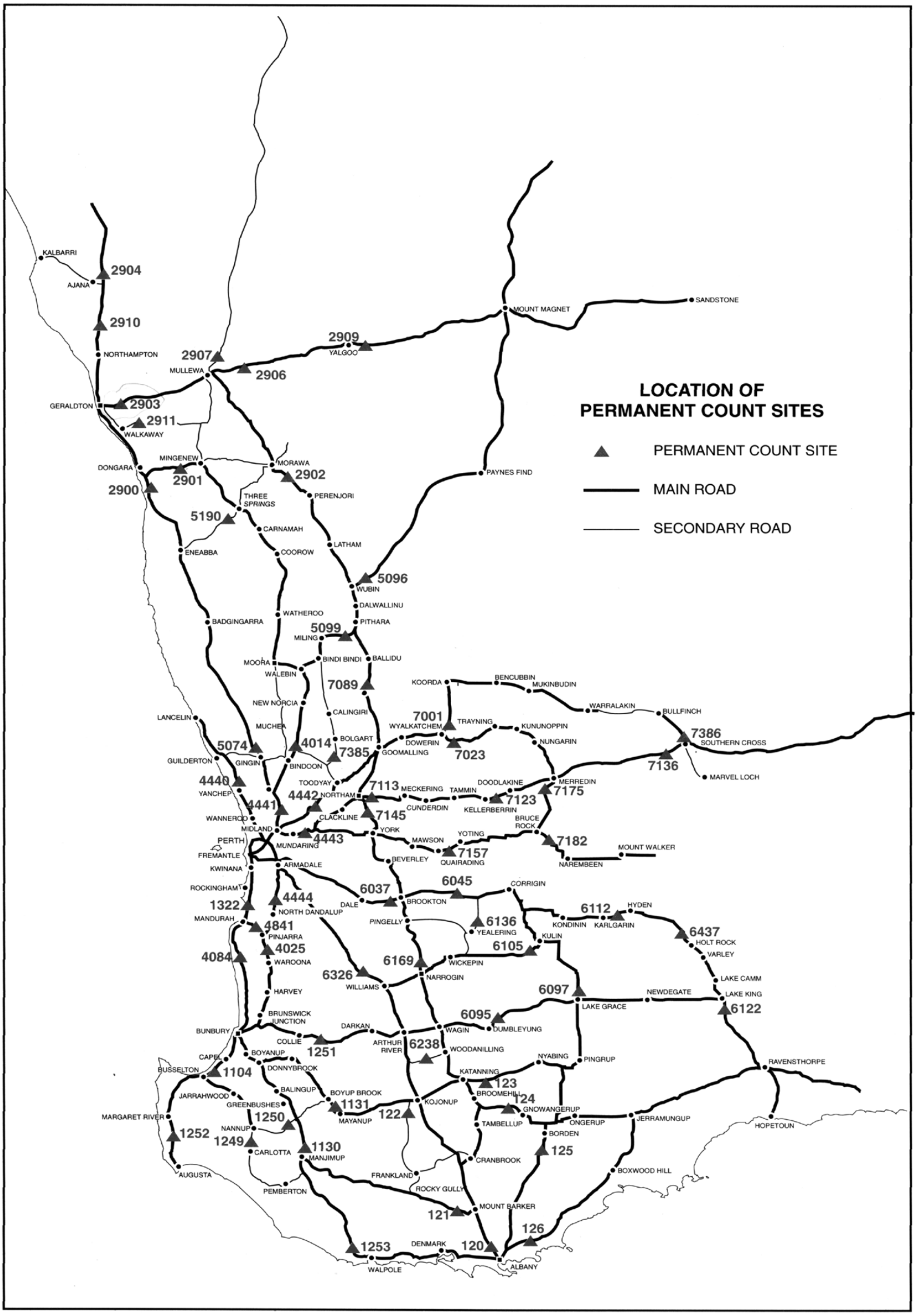
Source Main Roads WA 1996.

FIGURE II.4 LOCATION OF PERMANENT COUNT SITES – WESTERN AUSTRALIAN HIGHWAYS



Source Main Roads WA 1996.

FIGURE II.4 LOCATION OF PERMANENT COUNT SITES – WESTERN AUSTRALIAN HIGHWAYS (CONTINUED)



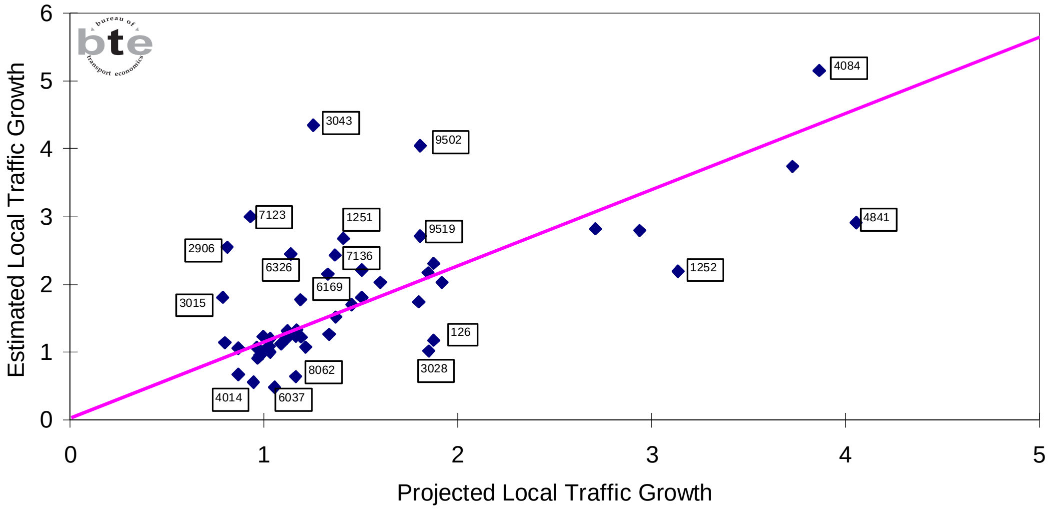
Source Main Roads WA 1996.

TABLE II.4 FORECAST VERSUS ESTIMATED LOCAL TRAFFIC GROWTH ON WA HIGHWAYS 1978 TO 1996: REGRESSION RESULTS

Dependent Variable:	Estimated Local Light Vehicle Traffic Growth 1978 to 1996		
Estimation Method:	OLS		
No. observations:	50		
Adjusted R squared:	0.2981		
Independent Variable	**Coefficient**	**Standard Error**	**t-Test (coeff=1)**
Intercept	No intercept		
Predicted Local Light Vehicle Traffic Growth 1978 to 1996	1.13	0.069	1.88

Source BTE estimates.

FIGURE II.5 ESTIMATED AND PROJECTED LOCAL LIGHT VEHICLE TRAFFIC GROWTH AT SELECTED COUNT SITES ON WA HIGHWAYS, 1978 TO 1996



Note Diamonds represent individual count stations (outliers labelled); line represents regression fit.

Sources BTE estimates, Main Roads WA 1996.

Note that count stations 2900, 2904, 2905, 5074, 8060, 8061 and 9001 were not included in the regression analysis, because of difficulties in assigning through traffic. At stations 8060 and 8061, there appears to be too much through traffic assigned to the coastal route in 1978, because after subtracting CV and through traffic from the total AADT count there is negative local traffic. For station 2905, too much through traffic appears to have been assigned for 1996.

Figure II.5 shows that the forecasting method under–estimated local traffic growth at sites 1251, 2906, 3015, 3043, 4084, 5074, 6169, 6326, 7123, 7136, 9502, and 9519. It overestimated local traffic growth at sites 126, 1252, 1322, 3028, 4014, 4841, 6037, 8062, and 9001. A brief investigation of the outlying count stations, table II.5, suggests that the discrepancy is more likely because of data problems rather than the method itself.

TABLE II.5 ANALYSIS OF PROJECTED LOCAL TRAFFIC GROWTH AT SELECTED WA COUNT STATIONS

WA count station no:	*Possible explanation of validation results*
126	The forecasting method over-estimated local traffic growth at this site. The travel survey data implied that there was very little through traffic on this section in both 1978 and 1996, and that local passenger traffic contributed most of the traffic growth. The projection method appeared to over-estimate local traffic growth because of high population growth in Albany (S) SLA. Examination of the Population Census data (ABS 1993a and 1982) suggested that much of the population growth was residential spillover around Albany (T). The traffic count site is located approximately 40km from Albany (T), and therefore it may be that the Albany (S) population growth rate overestimated the effect of population growth on local traffic levels at the count site.
1251	The projection method under-estimated local traffic growth at this site. This result may be attributable to differences in coverage between the two data sources used to estimate through traffic. The NTS data indicated a high level of through traffic in 1978 while the DTM data showed very little through traffic in 1996, resulting in the high estimated local traffic growth between 1978 and 1996.
1252	The projection method over-estimated local traffic growth at this site. Traffic estimates: 1978: 36 *(through)* 818 *(local)* 1996: 0 *(through)* 1795 *(local)* The projection method may over-estimate local traffic growth because of the location of the count site in relation to the main population centres within the SLA. The count site is approximately 10 km south of Margaret River town, the main population centre within the SLA. Much of the local traffic growth may be centred around Margaret River town, west to the coast and north to the growing population centres in the Busselton SLA. Estimated through traffic was a small proportion of total traffic at this site. The 1996 through traffic estimates suggest the survey coverage of the 1996 DTM may not adequately account for through traffic growth to this region, especially given the growth in tourist travel to the region.
2906	The projection method under-estimated local traffic growth at this site. There was practically no through traffic at this site, located on

TABLE II.5 ANALYSIS OF PROJECTED LOCAL TRAFFIC GROWTH AT SELECTED WA COUNT STATIONS (CONTINUED)

WA count station no:	*Possible explanation of validation results*
2906 (continued)	the road between Geraldton and Mount Magnet. It is difficult to explain the estimated local traffic growth without further investigation of other factors influencing traffic growth in the local area.
3015	The projection method under-estimated local traffic growth at this site. Estimated through traffic at this site grew by only a small amount between 1978 and 1996 – therefore, total traffic growth was attributed mainly to local traffic growth. It is possible that the 1996 DTM data under-estimated through traffic at this site, leading to over-estimated local traffic growth.
3028	The projection method over-estimated local traffic growth at this site. There was little growth in total car traffic and little change in the proportion of through to local traffic between 1978 and 1996. The count site is approximately 20km from Esperance. The distance of the count site from the main population centre and/or low through traffic estimates in 1996 may explain why the projection method over-estimated local traffic growth.
3043	The projection method under-estimated local traffic growth at this site. A decline in estimated through traffic and an increase in total light vehicle traffic, between 1978 and 1996, may have contributed to high growth in estimated local traffic at site 3043.
4014	The projection method over-estimated local traffic growth at this site. The NTS and DTM data imply high growth in through car traffic between 1978 and 1996 at this site. It is possible that some through traffic that was assigned to the Great Northern Highway (past site 4014) should have been assigned to the Brand Highway (these highways provide alternative routes between Geraldton and Perth), thereby inflating through traffic at this site. Additional data are necessary to verify this.
4084, 1322	Count station sites 4084 and 1322 are located on the Old Coast Road, which links Perth and Bunbury via the coast. The Old Coast Road is also one of two routes to the tourist region of south west WA. The region surrounding count sites 4084 and 1322 experienced very high population growth rates between 1978 and 1996. Given the very high population growth rate of this region, the projection method performs reasonably well. For these two sites, population growth was assumed to be equal to the weighted average population growth of three SLAs. For 4084 – Mandurah (very high growth), Waroona (median growth) and Harvey (high

TABLE II.5 ANALYSIS OF PROTECTED LOCAL TRAFFIC GROWTH AT SELECTED WA COUNT STATIONS (CONTINUED)

WA count station no:	*Possible explanation of validation results*
4084, 1322 (continued)	growth), and for 1322 – Mandurah, Murray and Rockingham.
4841	The projection method over-estimated local traffic growth at this site. Count station site 4841 is close to the boundaries of Mandurah and Murray SLAs. As in the case of count sites 4084 and 1322, population growth of the surrounding region and local traffic growth at site 4841 were quite high, and the projection method did not accurately predict local traffic growth. The population forecast used at this site was based on the weighted average population growth of Mandurah and Murray SLAs.
5074, 2900, 2904	At sites 5074, 2900 and 2904 local traffic growth was under-estimated. Through traffic was quite high in 1978 and quite low in 1996, resulting in high estimated local traffic growth between 1978 and 1996 and possibly contributing to the under-estimation of local traffic using the projection method. The large decline in through traffic between 1978 and 1996 may be due to: (i) inappropriate allocation of traffic to the North West Western Australian regional nodes; and / or (ii) the broader survey coverage, in regional WA, of the 1977-78 NTS compared to the 1996 DTM.
6037, 6326	The projection method over-estimated local traffic growth at site 6037 and under-estimated growth at site 6326. These two stations are on alternative routes from Perth to Narrogin. It is possible that too much through traffic was assigned via 6326, and insufficient through traffic via 6037 in 1996, giving rise to over-estimation of local traffic at 6037 using the projection method.
7123, 7136	The forecasting method under-estimated growth in local car traffic at sites 7123 and 7136. Both count sites are on the Great Eastern Highway, the main route between Perth and Kalgoorlie and the Eastern States. Through car traffic is a much higher proportion of total car traffic in 1978 than in 1996. Total car traffic grew appreciably over that period, resulting in high estimated local car traffic growth.
8062	The projection method under-estimated the decline in local traffic at this site. There was very little estimated through traffic at this site in 1978 and 1996. All estimated light vehicle traffic growth was, therefore, attributed as local traffic growth. The relevant geographic region (Ashburton SLA) shows a decline in population, but allowing for growth in national average car ownership suggests an increase in total local traffic. It may be, however, that

TABLE II.5 ANALYSIS OF PROTECTED LOCAL TRAFFIC GROWTH AT SELECTED WA COUNT STATIONS (CONTINUED)

WA count station no:	*Possible explanation of validation results*
8062 (continued)	growth in national average vehicle ownership was above growth in vehicle ownership in this region, contributing to the projection method's error. Additionally, the location of the count site in a sparsely populated region may also contribute to the projection method under-estimating the decline in local traffic. Further analysis is required to better explain this result.
9001	The projection method over-estimated local traffic growth at this site. There was very high growth in through traffic, between 1978 and 1996, resulting in a decline in estimated local traffic. Forecast traffic 1978: 19 *(through)* 84 *(local)* 103 *(total car)* 1996: 163 *(through)* 46 *(local)* 209 *(total car)* Further analysis is required to better explain this result.
9502	The projection method under-estimates local traffic growth at this site. Estimated through traffic levels did not change between 1978 and 1996. The completed sealing of the Great Northern Highway between Fitzroy Crossing and Halls Creek in 1988-89 may have contributed to increased through traffic at this site, and thus lower levels of local traffic in 1996 than estimated, but without additional data this is speculative.

Notes (S) denotes Shire, (T) denotes Town.

Source BTE estimates, Main Roads WA 1996 and 1984.

In general, the outlying observations in figure II.5 appear to be attributable, in part, to (i) misallocation of interregional traffic to interregional nodes and/or (ii) inadequate information on interregional car passenger traffic from the tourism survey data (especially for the 1995-96 DTM). Equally, the outlying observations may be due to other factors, uncorrelated with population growth, which the method does not explain.

Misallocation of interregional traffic to traffic nodes within regions could arise because the tourism survey data had to be expanded to account for traffic to important alternative geographical centres in WA. The 1995-96 DTM splits tourism travel data into 12 separate regional areas in WA. The BTE 1996 traffic assignment process used 24 regional nodes, with 10 of the regions being assigned multiple nodes. The NTS 1977-78 was based on nine separate regional areas for WA. The BTE 1978 traffic assignment procedure used 22 regional nodes, with all WA regions except Perth being assigned multiple nodes.

The 1995-96 DTM may under-estimate interregional passenger vehicle traffic in WA, particularly on roads furthest away from Perth. The 1995-96 DTM recorded only traffic from Perth and environs to the rest of WA (table II.8). By contrast, the NTS 1977-78 recorded traffic flows to and from a greater number of regional pairs in WA (table II.6). The discrepancy in geographic coverage between the two sources may have resulted in inaccurate estimates of through traffic growth on the WA rural road system.

Further work is required to resolve the problem of assigning tourism survey data. A richer regional coverage of transport used by domestic tourists, especially from regions other than the major capital cities, would improve the allocation in the model of through and local light vehicle highway traffic. The BTE understands that the BTR will include the SLA of the origin and destination regions for domestic tourism in future DTM surveys.

In the absence of richer tourism data, other methods exist for obtaining more detailed estimates of interregional traffic. Algorithms exist for estimating interregional OD traffic flows from count station traffic flow data (for example, Wills 1986) which have the potential to provide a much richer set of inter regional traffic data. Successful application of such methods may reduce the traffic assignment problems arising from the sparseness of the tourism data. These methods, however, do not provide a complete solution to the problem because they cannot differentiate between local and interregional traffic, but this can be overcome by defining finer geographical regions.

TABLE II.6 NTS 1977-78: TOTAL LIGHT VEHICLE PASSENGER TRIPS TO, FROM, AND WITHIN WESTERN AUSTRALIA

('000 passenger trips)

Origin	*Destination*										
	601	*602*	*603*	*604*	*605*	*606*	*607*	*608 (Perth)*	*609*	*Interstate*	*Total*
601	107	26	6	10	0	0	6	121	0	30	306
602	24	30	6	0	0	0	16	230	0	10	316
603	2	0	19	6	1	1	5	23	3	1	61
604	23	23	13	59	0	0	17	321	3	23	482
605	3	1	0	0	110	7	6	32	1	7	167
606	0	0	1	0	0	20	0	2	0	3	26
607	11	12	4	15	5	3	89	176	17	2	334
608 (Perth)	195	370	57	124	18	6	193	256	22	46	1287
609	3	3	0	0	8	0	18	36	32	1	101
Interstate	12	9	6	0	2	5	11	111	1	-	157
Total	380	474	112	214	144	42	361	1308	79	123	3237

Source BTE 1978.

TABLE II.7 DTM 1978-79: TOTAL LIGHT VEHICLE PASSENGER TRIPS TO, FROM, AND WITHIN WESTERN AUSTRALIA (NTS REGIONAL DEFINITION)

('000 passenger trips)

Origin	*Destination*										
	601	*602*	*603*	*604*	*605*	*606*	*607*	*608*	*609*	*Interstate*	*Total*
Perth	254.0	496.6	91.0	177.6	12.2	3.6	101.8	501.7	69.6	57.8	1765.8
Rest WA	202.6	220.0	86.2	97.2	14.4	1.0	44.4	464.3	31.5	11.8	1173.4
Interstate	0.0	7.1	11.9	0.0	13.9	0.0	5.4	36.3	2.7	-	77.2
Total	456.7	723.6	189.0	274.9	40.5	4.5	151.6	1002.2	103.8	69.7	3016.4

Source BTR 1997 and earlier issues.

TABLE II.8 NTS 1977-78 ADJUSTED BY DTM 1978-79 TO DERIVE DTM TYPE PASSENGER TRAFFIC ESTIMATES: TOTAL LIGHT VEHICLE PASSENGER TRIPS TO, FROM, AND WITHIN WESTERN AUSTRALIA

('000 passenger trips)

	Destination										
Origin	*601*	*602*	*603*	*604*	*605*	*606*	*607*	*608*	*609*	*Interstate*	*Total*
601	125.3	60.2	10.6	10.8	0.0	0.0	1.7	59.7	0.0	0.2	268.5
602	28.1	69.5	10.6	0.0	0.0	0.0	4.5	113.5	0.0	0.7	226.8
603	2.3	0.0	33.4	6.5	0.1	0.0	1.4	11.3	1.7	0.0	56.8
604	26.9	53.3	22.9	63.7	0.0	0.0	4.8	158.4	1.7	0.1	331.8
605	3.5	2.3	0.0	0.0	12.8	0.2	1.7	15.8	0.6	0.2	37.1
606	0.0	0.0	1.8	0.0	0.0	0.6	0.0	1.0	0.0	0.1	3.4
607	12.9	27.8	7.0	16.2	0.6	0.1	25.2	86.8	9.6	0.2	186.3
608	254.0	496.6	91.0	177.6	12.2	3.6	101.8	501.7	69.6	11.9	1719.8
609	3.5	6.9	0.0	0.0	0.9	0.0	5.1	17.8	18.0	0.0	52.3
Interstate	0.0	2.4	2.2	0.0	0.0	0.0	0.0	20.8	0.0	-	25.4
Total	456.7	719.0	179.3	274.9	26.6	4.5	146.2	986.7	101.1	13.3	2908.2

Sources BTE estimates, BTE 1978, BTR 1997 and earlier issues.

TABLE II.9 DTM 1995-96: TOTAL LIGHT VEHICLE PASSENGER TRIPS TO, FROM, AND WITHIN WESTERN AUSTRALIA

('000 passenger trips)

	Destination													
Origin	*501*	*502*	*503*	*504*	*505*	*506*	*507*	*508*	*509*	*510*	*511*	*512*	*Interstate*	*Total*
507	56.7	66.3	143.6	31.7	35.6	54.0	197.1	748.2	701.4	236.9	89.0	390.5	52.6	2803.7
512	0.0	2.4	5.9	0.0	0.0	0.0	28.1	8.8	0.0	0.0	0.0	0.0	0.0	45.2
Interstate	2.9	1.8	0.0	3.4	0.9	5.4	20.1	4.8	0.0	10.9	0.0	0.0	-	50.1
Total	59.5	70.4	149.5	35.1	36.5	59.4	245.3	761.8	701.4	247.8	89.0	390.5	52.6	2899.0

Source BTR 1997.

GLOSSARY

Australian Standard Geographical Classification (ASGC) A hierarchical classification system, consisting of six interrelated classification structures, designed for collecting and disseminating geographically classified statistics. The hierarchy of ASGC spatial units referred to in this Working Paper is: State, Statistical Division, Statistical Sub-Division (or Statistical District), Statistical Local Area, and Collection District.

AADT (Average Annual Daily Traffic) The average daily number of vehicles travelling past a particular point on the highway (sum of traffic in both directions).

Collection Districts (CD) A general purpose spatial unit. CDs are the smallest spatial unit and, designed for use in census years for the collection and dissemination of Population Census data. In non-census years, CDs are undefined. In aggregate, CDs cover the whole of Australia without gaps or overlap (ABS 1996a).

Diffusion processes The species of mathematical models for estimating the spread in space or the acceptance in a social environment, over time, of some specific technology or pattern.

Estimated resident population The official ABS estimate of the Australian population. It is based on results from the Population Census and, between censuses, is updated annually using demographic statistics. The census count is adjusted, for underenumeration and Australian residents temporarily overseas on census night, to obtain ERP figures.

Forward control vehicle Type of vehicle design in which the driver sits as far forward as possible, with the windscreen placed almost over the front bumper. The steering wheel in in the forward quarter of the vehicle's length. This is usually achieved by having the engine under the driver's seat, between the front seats or at the vehicle's rear (Davis 1986, p. 172).

Gravity model A model used to explain the amount of flow (e.g. trade, transport, etc), or interaction (e.g. political influence), between any two points on the basis of forces of attraction (such as population or GDP at each point) and impedance factors such as physical distance or cost of travel. The greater the population of the two centres, for example, the greater the interaction; the greater the distance, the less the interaction.

Growth rate In this Working Paper, refers to the annual percentage change of a variable between one year and the next. The formula for calculating the annual percentage change is:

$$\left(\frac{x_{t+1}-x_t}{x_t}\right)\times 100$$

where x_t is the value of the data point at year t, x_{t+1} is the value of the data point at year $t+1$.

Light commercial vehicles Vehicles constructed primarily for the carriage of goods and which are less than or equal to 3.5 tonnes gross vehicle mass. Included are utilities, panel vans, cab-chassis and forward control load carrying vehicles (ABS 1997c).

Light vehicle traffic Passenger car and small light commercial vehicle traffic.

Logistic substitution model A specific model of multitechnological diffusion processes.

National Highway System 18,400 km of road linking Australia's State capital cities and major provincial centres, fully funded by the Federal Government.

Origin–Destination passenger trip A measure of passenger trips between a specific geographic origin and destination pair.

Passenger kilometre A measure of the passenger transport task – defined as one passenger travelling one kilometre.

Passenger vehicle (car) Vehicles constructed primarily for the carriage of up to nine occupants, including the driver. Included are cars, station wagons, four-wheel drive passenger vehicles and forward control passenger vehicles (ABS 1997c).

Statistical Division (SD) A general purpose spatial unit and is the largest and most stable spatial unit within each state. SDs consist of one or more Statistical Subdivisions. In aggregate, SDs cover Australia without gaps or overlap (ABS 1996a).

Statistical Local Area (SLA) A general purpose spatial unit. It is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Census. SLAs are based on the boundaries of incorporated bodies of local government, where these exist. In aggregate, SLAs cover the whole of Australia without gaps or overlap (ABS 1996a).

Statistical Subdivision (SSD) A general purpose spatial unit or intermediate size between the Statistical Local Area (smaller) and Statistical Division (larger). SSDs consist of one or more Statistical Local Areas. In aggregate, SSDs cover the whole of Australia without gaps or overlap (ABS 1996a).

Through light vehicle traffic Interregional passenger car and light commercial vehicle traffic passing a point on the highway (measured in AADT).

Tonne–kilometre A measure of freight transport task - defined as one tonne carried one kilometre.

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ABBREVIATIONS

AADT	Average annual daily traffic
ABS	Australian Bureau of Statistics
AGPS	Australian Government Publishing Service
AN	Australian National Railways Commission
AUSLIG	Australian Surveying and Land Information Group
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics (forerunner and successor to BTCE)
BTR	Bureau of Tourism Research
CBCS	Commonwealth Bureau of Census and Statistics (forerunner to ABS)
CBR	Commonwealth Bureau of Roads (forerunner to BTE)
CPI	consumer price index
DoT	(Commonwealth) Department of Transport
DoTRD	(Commonwealth) Department of Transport and Regional Development
DTM	Domestic Tourism Monitor
FORS	Federal Office of Road Safety
HORSCCTMR	House of Representatives Standing Committee on Communications, Transport and Microeconomic Reform
LCV	light commercial vehicle
NRMA	National Roads and Motorists Association
NTPT	National Transport Planning Taskforce
NTS	National Travel Survey, 1977-78, a BTE home-interview travel survey
OD	Origin-Destination
OLS	Ordinary Least Squares
PKM	passenger kilometres
QR	Queensland Rail
RIAM	Road Infrastructure Assessment Model (BTCE)
SLA	Statistical Local Area
SMEC	Snowy Mountains Engineering Corporation
SMVU	Survey of Motor Vehicle Use (ABS survey)
SRA	State Rail Authority of New South Wales
TKM	tonne-kilometres
TVS	Tasmanian Visitors Survey

UPT	urban public transport
US	United States
VicRail	Victorian Railways Commission
VKT	vehicle kilometres travelled
WA	Western Australia(n)
WestRail	West Australian Government Railways Commission