The Australian Domestic Transport Task

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Abstract:

This paper presents time series estimates detailing the Australian domestic transport task during the period 1970–71 to 1990–91. No such presentation of aggregate transport activity (across all modes) over time seems to exist in the current literature.

The size of Australia's freight task is examined, for both urban and non-urban areas. For each mode, the task in tonnes and tonne-kilometres is estimated and, where appropriate, split by vehicle type. The Australian passenger task is also split by vehicle type into urban and non-urban sectors, and estimates of passenger numbers and passenger-kilometres are presented.

The implications and possible uses of the time series are canvassed. Examples of policy debates which require fundamental knowledge of transport task magnitudes include those relating to vehicle emissions (both noxious and greenhouse), road funding, fuel efficiency concerns, and urban planning issues.

The views expressed in this paper are those of the authors, and do not necessarily represent those of the Bureau of Transport and Communications Economics.

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Introduction

The Australian transport task consists of a diverse range of services and activities, with greatly differing scales of operation and levels of patronage. Any line of inquiry involving the national transport sector or its societal influences usually requires knowledge of the levels of aggregate transport tasks. In particular, concern over the impact of transport activities on the environment (especially from greenhouse gas and noxious emissions) focuses attention on transport efficiency issues Proper assessment of such issues is founded on measurement of the utilisation levels for the different modes. One of the imperatives for national debate on the management of the transport task is an adequate understanding of the task components and their trend rates of growth.

There are various theoretical difficulties with deriving national transport aggregates One example, for freight transport, would be accounting for the use of private cars to transport goods (such as groceries). This is generally counted as only a passenger movement in transport activity surveys. Yet were the consumer to order the goods delivered, their carriage would be recorded as freight movement However, such theoretical impediments to calculating task estimates are minor compared to the practical difficulties resulting from the fragmented nature of data collection on the extent of Australian passenger and freight movement

There have been few past attempts at presenting national estimates of all major transport activities in Australia. Detailed transport statistics by mode were once presented annually by the Australian Bureau of Statistics (ABS) in the bulletin *Transport and Communication*, but this was discontinued in 1972. A consultancy report for the Energy Research and Development Corporation (Apelbaum, 1991) has probably been the most complete recent effort It updates a previous consultancy report by Nelson English, Loxton and Andrews Pty. Ltd (NELA, 1988) and gives modal estimates for three separate years; 1975-76, 1984-85 and 1987-88. Newman and Kenworthy (1989) obtained a significant amount of modal data for 1960, 1970 and 1980 - but dealt only with urban passenger movement.

The Bureau of Transport and Communications Economics (BTCE) has also recently presented task estimates by mode, for the years 1984-85 and 1987-88 (BTCE, 1991a). The then Bureau of Transport Economics (BTE) had previously published estimates of national transport levels in two Occasional Papers, for 1970-71 (BTE, 1975) and 1975-76 (BTE, 1980).

Also, transport surveys at the national level are relatively infrequent. For example, the main data source for road vehicle utilisation and trucking activity, the ABS Survey of Motor Vehicle Use (SMVU), is only done once every three years. Over the last decade there has been only one national survey of day-to-day travel across all passenger modes - by the Federal Office of Road Safety for 1985-86 (Adena and Montesin, 1988).

Trend analysis based on these past estimates is hampered by there generally being a shortage of comparisons between years, deficient coverage of some modes, often conflicting estimates derived, and a lack of adequate discussion of the estimation methods. This paper strives to draw together the disparate estimates from existing sources: the above-mentioned studies, regularly collected transport statistics (mainly by the ABS, the Department of Transport and Communications, and the BTCE) and detailed localised surveys (for example, *Trends in Morning Peak Travel in Sydney 1971-1981* by the State Transport Study Group).

By reconciling inconsistent sources and developing appropriate measurement methodologies, we have derived estimates of the Australian domestic freight and passenger transport tasks over the years 1970-71 to 1990-91. Proper discussion of transport issues requires that the different components of the complete transport task be considered separately. This paper divides both passenger and freight movement by sector (urban and non-urban), mode (road, rail, air and sea) and vehicle type. The urban sector consists of all districts with a population of greater than 40 thousand.

Appendices to the paper outline the major areas of difficulty in making these estimates of modal transport activity - specifically, conflicting evidence on average car occupancies, a paucity of data on bus activity (which necessitates a method of indirect estimation), and a lack of estimates of the road task for years between the ABS Survey of Motor Vehicle Use (conducted triennially).

Although subject to inevitable measurement error (especially in those areas affected by scarce or conflicting data), the resulting time series on modal composition should prove to have applications to a variety of studies. These would include research on vehicle emission levels, the transport intensity of economic growth, road funding, and urban planning.

The freight task

The total Australian freight task in 1990-91 is estimated to have amounted to 281.4 billion (10^9) tonne-kilometres. The movement of freight within Australia comprises a collection of activities as diverse in character as in geographical location; including the long-haul movement of domestic raw materials for secondary industry (primarily iron ore, oil and coal) by coastal sea freight, the carriage of primary products from inland mines and farms to coastal city markets and export ports by railway, and the urban and intercity distribution of non-bulk goods for consumption by road transport.

Table 1 presents the modal composition of the Australian freight task over the last two decades (1970-71 to 1990-91). The urban freight task (detailed in table 2) is accomplished almost exclusively by road transport, so the other modes are assumed to involve non-urban freight movement only. Due to the wide variance in the average length of haul across the different modes, tasks that appear equivalent in tonne-kilometre terms may involve greatly differing amounts of freight. So for comparison purposes, table 3 gives estimates of tonnes consigned by mode over the period. Figure 1 illustrates the current modal split of Australian tonne-kilometres performed; around 33.8 per cent by road, 31.6 per cent by rail, 34.5 by coastal shipping and 0.1 per cent by air.

Over the years, the freight task transported by road in Australia has increased substantially, almost doubling in tonne-kilometres within the last decade (see table 1). Of this, nearly 80 per cent is due to non-bulk commodities (ABS 1990). The growing demand for door-to-door delivery has helped the road freight industry capture an increasing share of the non-bulk freight task from rail, and road now performs around 70 per cent. Interstate trucking accounts for around 30 per cent of the road task, with over 95 per cent of long distance road freight being hauled on articulated trucks. The most common configuration of these trucks, consisting of a 3-axle prime mover with a triaxle trailer, accomplishes almost half of Australia's total road freight movement (ABS 1990). In terms of tonnes consigned (table 3), road has by far the dominant modal share of Australian freight.

The government operated rail systems account for a similar proportion of the overall non-urban task as the road freight industry. However, since most of the rail tonnage is bulk commodities (around 85 per cent), rail currently handles only a fifth of the total intercity non-bulk freight task

Table 1 The Australian domestic freight task by sector and mode; estimates of tonne-kilometres performed, 1970-71 to 1990-91

(thousand million tonne-kilometres)

Year ending June	Road		Railway				
	Urban	Non-urban	Government	Private	Sea	Air	Total
1971	9.14	18.05	25.0	13.8	72.0	0.09	138.1
1972	9.68	18.97	25.4	16.6	83.2	0.09	154.0
1973	10.26	19.75	26.6	20.0	89.5	0.09	166.2
1974	11.04	20.70	28.3	26.5	96.1	0.11	182.7
1975	11.95	21.93	29.8	30.2	101.2	0.11	195.2
1976	13.10	23.60	30.8	26.3	104.6	0.11	198.5
1977	13.95	25.74	32.0	27.3	102.3	0.11	201.4
1978	14.81	27.71	31.8	28.4	105.1	0.12	207.9
1979	16.36	31.78	32.1	25.6	104.7	0.12	210.6
1980	17.93	34.64	36.4	27.8	105.1	0.13	222.0
1981	18.78	35.90	36.5	28.9	110.3	0.13	230.5
1982	20.61	38.76	37.3	27.4	97.8	0.13	222.0
1983	20.69	39.47	34.5	25.0	80.9	0.14	200.7
1984	22.64	43.65	39.4	23.3	94.3	0.15	223.2
1985	25.12	49.18	44.8	28.4	96.3	0.15	244.0
1986	26.54	50.27	48.4	29.2	101.8	0.12	256.3
1987	28.41	51.74	48.9	30.3	95.2	0.12	254.7
1988	31.00	54.53	50.2	31.0	93.6	0.14	260.4
1989	33.05	58.55	50.7	28.4	90.7	0.14	261.5
1990	34.25	61.33	52.0	32.0	94.2	0.10	273.9
1991	34.06	61.15	52.0	37.0	97.0	0.15	281.4

Sources: ABS (1991b, 1990, 1986, 1983, 1981a, 1981b, 1978, 1973), BTCE (1991a, 1991b, 1989), BTE (1980, 1975), DTC (1991a, 1991b), BTCE estimates

Around 42 per cent of the rail freight task is undertaken by privately operated railways. These non-government railways are used almost entirely for the transfer of bulk materials (iron ore, sugar, coal and various minerals), often over short distances.

Most of the Australian domestic sea task consists of long-haul movements of iron ore, petroleum and bauxite, with coastal shipping carrying close to 90 per cent of the tonne-kilometres due to bulk interstate freight.

Air freight is a very small segment of the national total, carrying less than 1 per cent of interstate non-bulk freight in terms of both tonne-kilometres and tonnes consigned (ABS 1991a). Of course, neither of these definitions of task takes into account the value added in the industries involved. If such elements were considered, the air freight industry would be a significant contributor to the freight task.

Table 2 The Australian road freight task by sector and vehicle type[a]; estimates of tonne-kilometres performed, 1970-71 to 1990-91

(thousand million tonne-kilometres)

Year ending June	Urban			Non-urban			
	LCV	Rigid	Articulated	LCV	Rigid	Articulated	Total
1971	0.54	5.60	3.00	0.45	5.40	12.20	27.19
1972	0.60	5.64	3.45	0.47	5.35	13.16	28.65
1973	0.67	5.72	3.88	0.49	5.34	13.92	30.00
1974	0.77	5.93	4.35	0.53	5.46	14.72	31.74
1975	0.88	6.13	4.95	0.57	5.55	15.81	33.88
1976	0.98	6.38	5.74	0.60	5.70	17.30	36.70
1977	1.14	6.53	6.28	0.68	6.09	18.97	39.69
1978	1.30	6.75	6.76	0.74	6.49	20.47	42.51
1979	1.43	7.03	7.90	0.80	6.98	24.00	48.14
1980	1.40	7.62	8.91	0.86	7.45	26.33	52.47
1981	1.39	8.00	9.39	0.93	7.83	27.13	54.68
1982	1.40	8.72	10.49	1.02	7.98	29.76	59.37
1983	1.47	8.55	10.68	1.07	7.69	30.71	60.16
1984	1.62	9.18	11.85	1.20	8.11	34.34	66.29
1985	1.75	9.93	13.43	1.31	8.64	39.23	74.30
1986	2.04	10.77	13.73	1.41	8.53	40.34	76.81
1987	2.32	11.75	14.34	1.49	8.41	41.85	80.15
1988	2.69	13.10	15.21	1.59	8.42	44.52	85.53
1989	2.92	14.11	16.03	1.69	8.70	48.16	91.60
1990	3.06	14.72	16.47	1.79	8.88	50.66	95.57
1991	3.09	14.69	16.30	1.83	8.71	50.61	95.20

a. Comprises the freight vehicle types of LCV (for light commercial vehicle; that is, a utility or panel van), rigid truck and articulated truck.

Sources: ABS (1990, 1986, 1983, 1981b, 1978, 1973), BTCE (1991a, 1991b), BIE (1980, 1975), BICE estimates.

Table 3 Australian domestic freight by mode; estimates of tonnes consigned, 1970-71 to 1990-91

(million tonnes)

Year ending June	Road	Railway			Sea	Air	Total
		Government	Private	Total			
1971	618	87	73	160	36.0	0.10	814
1972	641	89	79	168	39.0	0.10	848
1973	660	92	95	187	43.3	0.10	890
1974	683	97	115	212	46.3	0.12	941
1975	712	103	128	231	46.4	0.12	989
1976	757	104	117	221	47.5	0.12	1025
1977	795	110	124	234	47.2	0.12	1077
1978	829	107	121	228	48.0	0.13	1105
1979	913	111	114	225	47.4	0.14	1185
1980	935	122	123	245	48.1	0.14	1229
1981	930	123	124	247	47.3	0.14	1224
1982	950	122	121	243	44.0	0.15	1237
1983	926	120	110	230	39.0	0.16	1195
1984	961	137	108	245	42.8	0.17	1249
1985	1032	159	129	288	42.7	0.17	1363
1986	1000	172	126	298	44.7	0.17	1343
1987	982	176	132	308	44.4	0.15	1335
1988	990	176	136	312	43.2	0.16	1346
1989	1013	179	135	314	43.0	0.17	1370
1990	1034	187	148	335	44.5	0.10	1414
1991	1019	189	154	343	46.0	0.14	1409

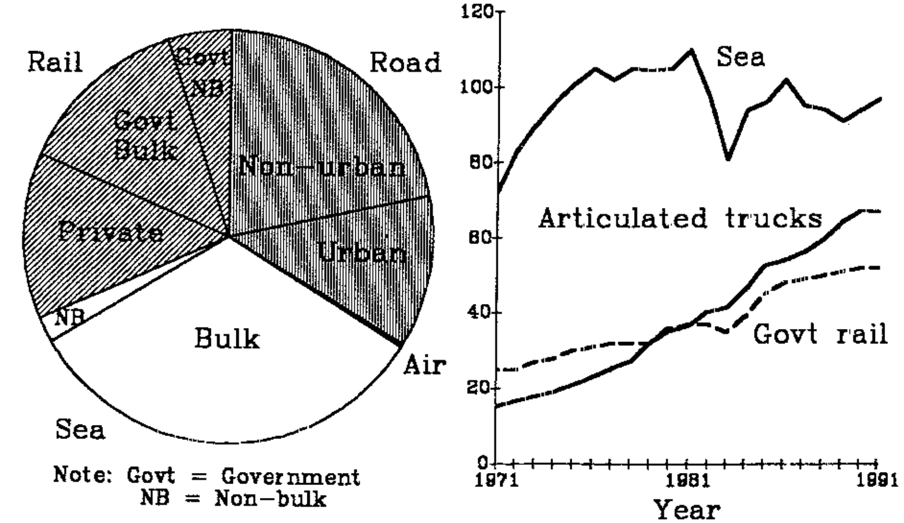
Sources: ABS (1991b, 1990, 1986, 1983, 1981a, 1981b, 1978, 1972), BTCE (1991b, 1989), BTE (1982, 1980, 1975), DTC (1991a, 1991b), BTCE estimates.

The trends in modal freight activity are quite varied. Post 1974-75, the average per annum rates of growth (in terms of tonne-kilometres) have been: urban road, 6.7 per cent; non-urban road, 6.6 per cent; government rail, 3.5 per cent; private rail, 1.3 per cent; and air, about 2 per cent. Sea freight has exhibited a decline, on average, of 0.3 per cent per year. Clearly, the road freight industry has had the highest level of responsiveness to the economic growth over the past two decades.

The non-urban passenger task

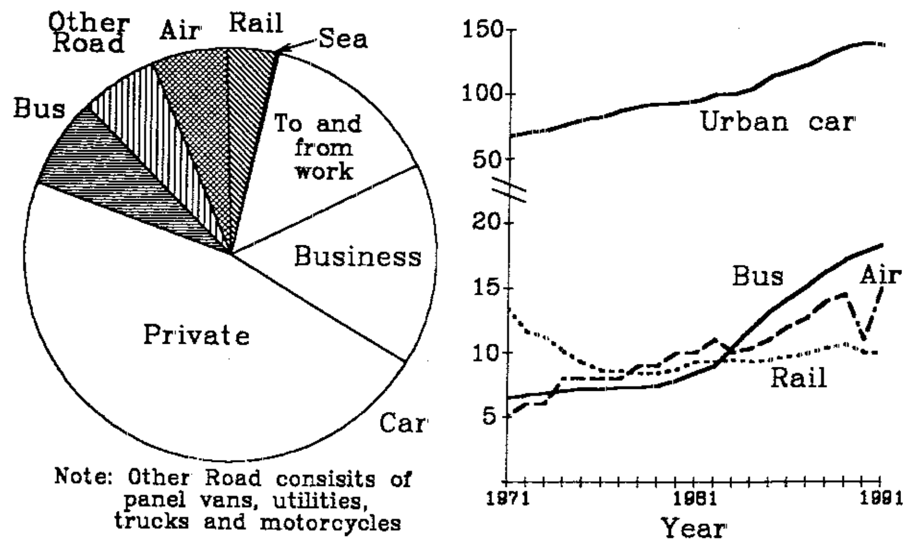
Estimates of the Australian non-urban passenger task are presented by vehicle type in table 4. The dominance of private car travel is marked, with 61 per cent of total (1990-91) non-urban passenger-kilometres being performed by cars. As shown in figure 2, car travel far surpasses all other modes of Australian passenger movement.

Figure 1 Modal split, 1990-91; and major trends, 1970-71 to 1990-91; of Australian domestic freight task in billions of tonne-kilometres



Sources: Table 1, table 2, BTCE (1991a, 1991b), BIE (1981)

Figure 2 Modal split, 1990-91; and major trends, 1970-71 to 1990-91; of Australian passenger task in billions of passenger-kilometres



Sources: Table 4, table 5, ABS (1990)

After cars, the largest segments of the 1990-91 non-urban passenger task were due to the bus or coach (14 per cent) and airline (15 per cent) industries. These were followed by other road vehicles with 6.8 per cent, trains with 2.6 per cent, and sea travel (mainly Bass Strait ferries) with 0.1 per cent. Since 1974-75, the fastest growth in passenger kilometres has occurred in bus travel (which was deregulated during the 1980s) and in air travel (even before the 1990-91 deregulation).

Table 4 The Australian non-urban passenger task by vehicle type; estimates of passenger-kilometres performed, 1970-71 to 1990-91

(thousand million passenger-kilometres)

Year ending June	Road			Rail	Air[b]	Sea[c]	Total
	Car	Bus	Other[a]				
1971	41.9	3.08	3.51	6.08	5.20	0.13	59.9
1972	42.0	3.21	3.86	5.04	5.83	0.13	60.1
1973	43.0	3.22	4.28	4.98	6.40	0.13	62.0
1974	45.7	3.17	4.82	3.77	7.60	0.13	65.2
1975	48.2	3.25	5.25	3.18	8.19	0.13	68.1
1976	49.4	3.27	5.70	2.61	8.00	0.13	69.1
1977	49.4	3.27	6.05	2.73	7.78	0.13	69.4
1978	51.1	3.30	6.15	2.72	8.64	0.13	72.1
1979	52.0	3.34	6.21	2.65	9.14	0.12	73.5
1980	52.9	3.66	6.27	2.61	10.08	0.12	75.6
1981	53.7	4.21	6.54	2.97	10.35	0.12	77.8
1982	56.7	4.70	6.77	2.88	10.78	0.12	82.0
1983	56.8	6.11	6.82	2.96	9.91	0.12	82.7
1984	59.2	7.59	7.22	2.88	10.29	0.12	87.2
1985	57.3	8.97	7.49	2.96	11.03	0.13	87.9
1986	59.5	9.91	7.00	2.71	11.95	0.15	91.2
1987	57.6	10.88	6.57	2.71	12.73	0.13	90.6
1988	55.8	11.79	6.32	2.93	14.03	0.12	91.0
1989	58.3	12.46	6.56	2.89	14.54	0.14	94.9
1990	59.7	13.03	6.70	2.51	10.86	0.15	93.0
1991	59.2	13.50	6.63	2.48	15.16	0.14	97.1

a Motor cycles and non-business use of light commercial vehicles and trucks.
b. Domestic airlines, commuter airlines, and general aviation (business and charter)
c. Bass strait ferries and coastal cruises

Note: The decline in 1989-90 air travel was due to the airline pilots' dispute.
Sources: Apelbaum (1991), ABS (1991b, 1990, 1989, 1986, 1983, 1981a, 1981b, 1978, 1973, 1972), BTCE (1991a, 1991b), BTE (1980, 1975), DTC (1991b), NELA (1988), Transport Tasmania, BTCE estimates.

Train and sea travel have remained essentially static for over a decade. Non-urban private car travel exhibited slower growth during the 1980s (1.2 per cent per annum) than in the 1970s (2.6 per cent per annum), perhaps experiencing competition from the bus industry.

The urban passenger task

Table 5 The Australian urban passenger task by vehicle type; estimates of passenger-kilometres performed, 1970-71 to 1990-91

(thousand million passenger-kilometres)

Year ending June	Road			Rail		Ferry	Total
	Car	Bus	Other[a]	Train	Tram		
1971	66.5	3.50	3.27	6.82	0.50	0.16	80.8
1972	69.9	3.51	3.70	6.14	0.47	0.16	83.9
1973	71.8	3.66	4.22	5.74	0.49	0.15	86.0
1974	76.3	3.80	4.90	5.79	0.51	0.15	91.4
1975	80.4	3.89	5.51	5.49	0.53	0.18	96.0
1976	82.5	3.91	6.22	5.45	0.51	0.19	98.8
1977	87.9	3.97	6.74	5.35	0.50	0.18	104.6
1978	90.9	4.00	7.14	5.20	0.50	0.15	107.9
1979	92.5	4.06	7.57	5.16	0.51	0.14	109.9
1980	93.1	4.19	7.39	5.61	0.52	0.13	111.0
1981	94.5	4.16	7.42	5.76	0.53	0.15	112.5
1982	99.9	4.19	7.43	5.92	0.54	0.17	118.2
1983	100.1	4.17	7.44	5.75	0.55	0.18	118.1
1984	104.2	4.15	7.92	5.80	0.56	0.19	122.8
1985	113.9	4.26	8.22	5.84	0.60	0.20	133.0
1986	117.8	4.34	8.27	6.35	0.62	0.20	137.5
1987	123.3	4.43	8.29	6.56	0.63	0.23	143.5
1988	131.3	4.51	8.48	6.83	0.64	0.26	152.0
1989	137.2	4.76	8.97	7.00	0.67	0.26	158.8
1990	140.5	4.75	9.13	6.85	0.62	0.27	162.1
1991	139.1	4.87	9.03	6.88	0.64	0.27	160.8

a. Motor cycles and non-business use of light commercial vehicles and trucks.

Sources: Apelbaum (1991), Adena and Montesin (1988), ABS (1991b, 1990, 1989, 1986, 1983, 1981a, 1981b, 1978, 1973, 1972), BTCE (1991a, 1991b), BTE (1980, 1975), NELA (1988), Newman and Kenworthy (1989), RIC (1990), BTCE estimates.

Australia is one of the most urbanised countries in the world, with ten urban localities accounting for about 70 per cent of the population (ABS 1991b) The larger Australian cities are generally decentralised, typically evolving by the gradual extension of outer residential areas. This type of development, which frequently places large distances between residential and work locations, has resulted in considerable dependence being placed on private cars for urban commuting tasks and limited reliance on public transit systems.

Public transport performs the majority of trips to work to the Central Business Districts (CBDs) of the major cities; around 76 per cent for Sydney, for example (STSG, 1985). However, work trips to the CBD are now a minor proportion of total urban travel (between 3 to 6 per cent, based on total Sydney travel estimates from Adena and Montesin 1988 and CBD travel estimates from STSG 1985) During the 1970s, Sydney work trips to the outer suburbs grew by 38 per cent, while trips to inner city areas slightly declined. High vehicle availability coupled with relative ease of parking in suburban centres allowed practically all this extra travel to be done by private cars (STSG, 1985).

The total Australian urban passenger task for 1990-91 is estimated at 161 billion passenger-kilometres. Table 5 presents modal estimates for urban travel over the previous two decades. Again, the dominance of the private automobile is evident. In 1990-91, the car accounted for 87 per cent of urban passenger-kilometres; while the public transport share of the task was below 8 per cent (with bus at 3.0 per cent, rail at 4.7 per cent and ferry at 0.2 per cent).

Newman and Kenworthy (1989) have noted that Australian cities have a high degree of 'automobile dependence' compared with many other major cities around the world. Post 1974-75, urban car travel has grown at an average rate of 3.5 per cent per year, compared to 1.4 per cent per year for both bus and rail transport.

Motor vehicle ownership in Australia has grown steadily over the years; from 0.39 vehicles per person in 1971, to 0.59 vehicles per person by 1990 (ABS 1991c). Table 6 highlights the automobile dependence of Australian passenger transport, with private car travel presently accounting for around 85 per cent of all passenger journeys.

General observations

Estimates of the Australian transport task (its magnitude, modal shares and trends by mode) have many direct applications in current analyses of transport policy issues. Four topical areas which come to mind are vehicle emissions, fuel efficiency concerns, urban planning and road funding

Consider first, the derivation of an average rate of carbon dioxide emission by Australian transport as a simple example of a use of these task statistics. The emission intensity of passenger and freight transport activities can be defined in terms of grams of carbon dioxide emitted per passenger-kilometre (gCO_2/pkm) and grams of carbon dioxide emitted per tonne-kilometre (gCO_2/tkm) respectively. Emission levels may be estimated using energy statistics (such as ABARE, 1991) and appropriate conversion factors (such as those given in Wilkenfeld, 1991).

Table 6 Australian domestic passengers by vehicle type; estimates of passenger volumes, 1970-71 to 1990-91

(million passengers)

Year ending June	Road Car	Bus	Other[a]	Rail	Air[b]	Sea[c]	Total
1971	8912	763	519	565	6.4	16.1	10782
1972	9217	756	584	508	6.9	15.7	11087
1973	9456	772	663	484	7.7	15.1	11397
1974	10049	788	765	484	9.2	15.0	12111
1975	10594	793	854	464	9.8	17.7	12731
1976	10863	784	950	453	9.8	19.0	13078
1977	11340	784	1028	443	9.9	17.9	13622
1978	11729	779	1073	430	10.8	15.2	14037
1979	11935	777	1119	427	11.3	13.7	14282
1980	12057	791	1100	447	12.2	13.2	14421
1981	12232	791	1118	457	12.2	15.2	14625
1982	12936	800	1130	465	12.4	16.2	15359
1983	12953	810	1138	454	11.3	17.2	15384
1984	13483	821	1218	455	11.6	18.2	16008
1985	14198	851	1270	463	12.3	18.9	16814
1986	14703	873	1241	493	13.2	19.0	17342
1987	15053	896	1212	505	13.7	21.4	17701
1988	15621	926	1211	524	14.9	24.1	18321
1989	16318	963	1272	537	15.3	24.3	19130
1990	16712	966	1299	519	11.3	25.3	19533
1991	16553	993	1288	523	15.5	25.3	19397

a. Motor cycles and non-business use of light commercial vehicles and trucks.
b. Domestic airlines, commuter airlines, and general aviation (business and charter).
c. Bass strait ferries, major city ferries and coastal cruises.

Note: The anomalously low figure for 1989-90 air travel was due to the airline pilots' dispute.

Sources: Apelbaum (1991), Adena and Montesin (1988), ABS (1991b, 1990, 1989, 1986, 1983, 1981a, 1981b, 1978, 1973, 1972), BTCE (1991a, 1991b), BTE (1980, 1975), DTC (1991b), NELA (1988), Newman and Kenworthy (1989), RIC (1990), Transport Tasmania, BTCE estimates.

Using energy and emission data given in the BICE (1991a) and BIE (1975) reports, along with task estimates from tables 1 to 5 from this paper, implies average intensities of 180 gCO_2/pkm and 91 gCO_2/tkm for 1971, and of 185 gCO_2/pkm and 85 gCO_2/tkm for 1988. Though these figures are very approximate, they suggest that, regarding the output of carbon dioxide, there has been little or no improvement in the efficiency of the Australian transport sector over the last two decades.

Even though technological innovations would have been improving the energy efficiency of the vehicles that comprise Australian transport fleets, factors such as mode switching (e.g. public transit passengers moving to the private car or rail freight to road), trading power for efficiency (e.g. exchanging small cars with large cars), and decreasing vehicle occupancy levels have balanced these improvements.

This lack of a decrease in energy intensity per unit task (in spite of technological progress) has distinct implications in a situation where the transport task is growing rapidly and the government has signalled its desire that greenhouse gas emissions be reduced. One such issue highlighted (and which may be examined also by reference to the task tables) is the transport intensity of economic growth.

The transport intensity of economic growth can be measured by the growth relative to national income (Gross Domestic Product) of various transport aggregates. Measures of the physical transport task have been presented in this paper in units of passenger and tonne kilometres. Two other measures of transport activity are employment and gross product for the transport and storage sector. Employment should, in theory, grow less quickly than the physical task, due to technical progress. Theoretically, gross product in the transport sector should also grow less quickly than the physical task measures. This is because gross product as defined by the ABS is the sum of labour, profit and depreciation (the last two representing returns to capital items). So one would expect growth in both labour and capital productivity, giving physical task measures faster growth rates than measures of gross product.

However, there are several reasons why the transport gross product could be the faster growing figure. Firstly, since it is a value added index, it more heavily weights the high value, fast growing areas of transport (such as road freight and airlines). Secondly, while private motoring is a major part of the physical task estimates, it is excluded from transport and storage gross product in the national accounts, since it is a consumption activity. Over the last twenty years, private car travel has exhibited considerably slower per annum growth than the trucking industry. Thirdly, there is an increasing trend to substitute transport company activity for the in-house transport activity of other industries (which is not included in transport gross product). Finally, gross product growth does not fully reflect the slow growth in urban public transport (UPT), since UPT is not fully cost recovered.

Empirically, the growth rate ratio, relative to national income, of transport gross product turns out to be higher than those of employment or the physical task levels. The ratios of activity growth to GDP growth, calculated over the period 1974-75 to 1990-91, are: transport employment, 0.50; tonne-kilometres, 0.76; passenger kilometres, 0.98; and transport gross product, 1.20. The physical task measures thus give growth intensities which are intermediate between the employment and value added series.

The task data suggest a preponderance of travel by car, especially for urban passenger movement, with the modal share of private cars rising steadily over the last two decades. This emphasis on private automobile travel is derived from such factors as the greater freedom cars provide, the increasing complexity of travel patterns in urban areas, and (symbiotically) the very design of Australian cities. The estimates of transport growth patterns over the past decades are valuable input into analyses of alternative urban planning strategies.

As a final example of the policy issues highlighted by the transport task data presented, consider the question of road funding. Heavy trucks do proportionally more damage to roads than private automobiles (BTCE 1988, ISC 1990, NRTC 1992). The increasing market share of the road freight industry, and its use of heavier trucks, will clearly impact on road maintenance budgets in the 1990s Private automobiles, on the other hand, are the chief contributor to traffic congestion (which can lead to a requirement for upgraded road systems, should alternatives to travel not be introduced). Data on task levels and trends are crucial when designing funding options for road user charging.

Conclusion

Consistent time series estimates for all major transport sectors can be derived using the methodologies and data sources detailed in this paper and its appendices. The total Australian transport task for 1990-91 has been calculated to be around 281 billion tonne-kilometres and 258 billion passenger-kilometres This is up from an estimated 138 billion tonne-kilometres and 141 billion passenger-kilometres in 1970-71, per annum growth of 3.6 per cent in freight movement and 3.1 per cent in passenger movement

The series can be readily updated each year, especially if the ABS Motor Vehicle Census (currently triennial) is done in future on an annual basis (as is apparently being considered by the ABS). These activity statistics are useful for transport policy purposes that require knowledge of aggregate transport activity levels and the movement or trends over time in those levels. The results highlight the growing reliance of Australian passenger and freight movement on road transport.

Appendix I: Passenger vehicle occupancies

In evaluating the passenger task of urban and non-urban transport, one of the primary data items is the average occupancy of private motor vehicles. Estimates of passenger tasks, such as those of NELA (1988) and Newman and Kenworthy (1989), have generally been derived from vehicle occupancy data collected by the Australian Bureau of Statistics (ABS) in their Survey of Motor Vehicle Use (SMVU). Due to a paucity of published data on average vehicle occupancies, SMVU values have been widely accepted, despite misgivings as to their accuracy.

However, the BTE (1980) did not rely on SMVU occupancies after concluding that they were unreliable, particularly for urban car usage. The validity of the SMVU values has been further questioned by much lower figures presented by Anderson and Hodgkin (1990), and by a SMVU user forum (in September 1990) during which ABS officers said that they felt survey respondents had considerably overestimated the actual operating occupancies of their vehicles.

Due to the lack of confidence in existing estimates of average car occupancy, the BTCE compiled a set of occupancy values from a large variety of studies, and attempted to extract consistent figures. These studies involved years ranging from 1960 to 1990. Two conclusions were drawn from observation of this collection of occupancy results.

Firstly, the type of survey performed severely influenced the results obtained. As shown in figure 3 (where occupancies obtained for the capital cities are plotted over time), three sets of results seem to separate out: high values of around 1.8 persons per vehicle, due to recall surveys (such as the SMVU); low values of around 1.2, due to observation surveys (such as roadside traffic counts); and the middle values of around 1.5 from more complete travel surveys (involving diary or interview techniques).

Secondly, average vehicle occupancies are decreasing over time. Any of the surveys which covered several years (including the SMVU) exhibited a gradually declining average car occupancy over time. The implied average decrease is between 0.2 and 0.4 per cent per annum, over the previous three decades.

Two of the studies examined had very controlled methodologies and were considered to be the most accurate recent measurements of actual vehicle occupancies. Occupancy data were collected during extensive surveys on seatbelt use conducted by VicRoads, the Victorian road authority, in 1988 (data provided by S. Eriksson); and the Federal Office of Road Safety (FORS) sponsored, in 1986, the national *Survey of Day-to-Day Travel*. The latter study collected information for each day of the year on all modes of transport. Trips for all purposes were included, with the sample size being considerable, at over 145 thousand trips. The survey covered all capital cities, many other major population centres, several rural towns, and some sparsely settled areas. The results are reported in FORS Report CR69 (Adena and Montesin, 1988).

The FORS report gives estimates of total kilometres travelled (in thousands per day) by car drivers (D_i) and car passengers (P_i). This enables the calculation of the average car occupancy for a sector i (O_i) by,

$$O_i = (D_i + P_i) / D_i.$$

Both these studies fall in the middle band of figure 3, and being of the diary or interview type of survey would be expected to record travel behaviour generally better than recall surveys (which may reflect respondents' subjective self-estimation rather than actual operation), or observation surveys (which are normally only conducted during peak traffic periods).

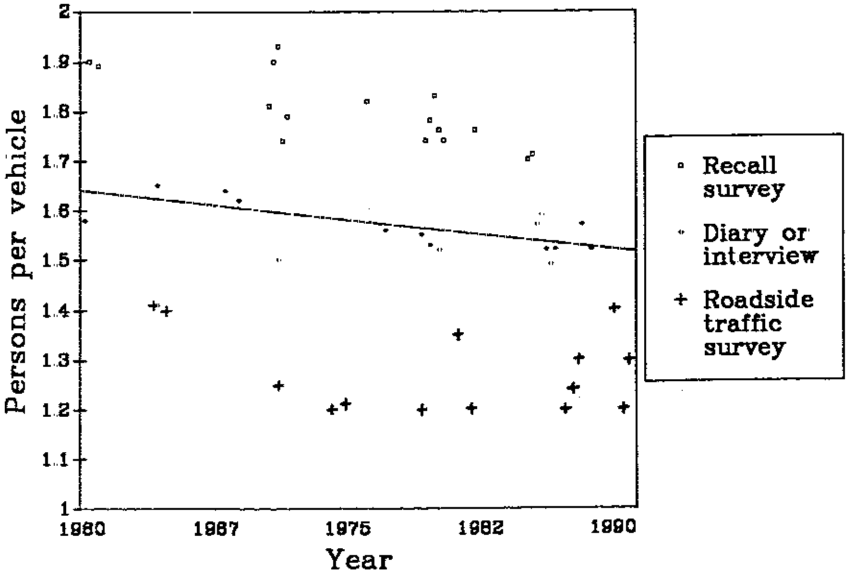
Assuming the FORS survey gives an accurate picture of sectoral vehicle occupancies the following values are suggested (using SMVU categories) for 1986: 1.53 (persons per vehicle) for capital cities, 1.69 for provincial cities, 1.70 for travel within the rest of the state, and 2.01 for interstate travel.

Using the SMVU vehicle utilisation data (ABS, 1990) to weight these figures between urban and non-urban travel, and assuming the average trend is a 0.3 per cent decrease per year, gives the following average occupancies for car trips by sector: 1971 - 1.63 for urban travel, 1.82 for non-urban travel, and 1.70 national average; 1986 - 1.56 for urban travel, 1.75 for non-urban travel, and 1.61 national average; 1988 - 1.55 for urban travel, 1.74 for non-urban travel, and 1.60 national average.

Averaging over those studies that provide data on car occupancies by travel purpose allows the derivation of the following estimates by trip type. For 1971 we have; 1.3 (persons per vehicle) during trips to and from work, 1.2 during business trips, and 2.0 during private travel. For 1988 we have; 1.2 during trips to and from work, 1.3 during business trips, and 1.9 during private travel.

Trend lines fitted to these figures gives the vehicle occupancy values used to calculate the car passenger task estimates of this paper. It is stressed that this procedure is fairly approximate, with the inherent variability in many of the occupancy estimates possibly of the order of 10 per cent.

Figure 3 Average car occupancies for Australian capital cities, 1960 to 1990



Sources: Apelbaum (1991), Adena & Montesin (1988), ABS (1986, 1983, 1978), BTE (1975), NELA (1988), Newman & Kenworthy (1989), BTCE estimates.

Appendix II: General estimation methodologies

This appendix gives a summary of the methods devised to resolve two major data problems: the paucity of statistics on bus activity (which necessitated a method of indirect estimation) and the lack of estimates on road vehicle utilisation for years not covered by the ABS Survey of Motor Vehicle Use (SMVU).

Estimation of bus and coach task

Statistics on the bus industry in Australia are very scarce. There is decent data collection for capital city government bus services, but little on all other sectors. The scope of the private bus industry has only been estimated fairly recently (see Hensher, 1989). Construction of a time series of the total bus task was thus hampered by severe data deficiencies.

The solution adopted was to isolate a series on 'commercial' buses on register. Commercial buses were defined as those greater than 1.8 tonnes tare weight. Statistics from the ABS Motor Vehicle Census (ABS, 1989) were used to calculate a weight distribution by make of vehicle, since each manufacturer's fleet tends to comprise a fairly constant mix of bus sizes. For example, 100 per cent of Volvo buses on register in 1988 were large (over 1.8 tonnes tare), while only 28 per cent of Toyota made buses were. Applying this distribution to numbers of buses on register for past years (and updated using data from the ABS, 1991c), allows the construction of a time series of numbers of commercial buses on register.

A series of annual kilometres travelled per vehicle by commercial buses was then interpolated from values for 1971, 1976, 1979 and 1988; extracted from data collected by the triennial ABS Survey of Motor Vehicle Use. Multiplying these travel estimates by the respective number of vehicles furnished a time series on total vehicle kilometres travelled (VKT) by commercial buses.

A times series of urban transit bus passengers for the capital cities was compiled from the BTCE Transport Indicators Database (and statistics from the ABS, 1981a). Passenger-kilometre estimates were derived from these passenger numbers using a time series of average bus trip length (assembled from a variety of sources including Newman and Kenworthy 1989, Wilkenfeld 1991, and NELA 1988). Urban transit VKT was then estimated by dividing the passenger-kilometre series by average bus occupancies (again derived from a variety of sources including Newman and Kenworthy 1989, Wilkenfeld 1991, and NELA 1988). These series were scaled to give estimates of total urban bus travel using ABS data (1990, 1981a) on the relative contributions due to provincial cities and private bus operators.

The urban bus VKT series was subtracted from the total VKT series to obtain a series for non-urban bus travel. The non-urban vehicle kilometres travelled were converted into passenger-kilometres using appropriate average bus occupancies (from Apelbaum 1991 and NELA 1988).

Estimation of road vehicle utilisation

The ABS Survey of Motor Vehicle Use is the primary source of data on the road task. However, it is only done once every three years, and over the last two decades the years (ending June) covered by the survey have been 1971, 1976, 1979, 1982, 1985 and 1988 (ABS 1973, 1978, 1981b, 1983, 1986, 1990). In order to generate time series for road vehicle utilisation, a method of linking annually available data to the 6 SMVU task estimates had to be developed. The approach adopted was to use regression techniques to translate annual fuel sales into annual vehicle kilometres travelled (VKT).

Fuel sales for road vehicle use consist of automotive gasoline (petrol), automotive diesel oil (ADO), and liquified petroleum gas (LPG). Time series for the consumption of these three fuels can be obtained from ABARE (1991). The motor vehicle types covered by this exercise are cars, light commercial vehicles (LCVs), rigid trucks and articulated trucks.

For cars, total petrol sales (ABARE, 1991) were multiplied by the proportion of total road petrol consumption due to car use (where the level and variation over time of this proportion was estimated from the 6 SMVU data points). A regression of SMVU car petrol consumption (P_S) against these proportional estimates (P_A) yields:

$$P_S = 0.9809 \, P_A$$

(with an adjusted R^2 of 0.95). Car use of ADO and LPG comprise a small proportion of total car fuel consumption, and time series for these fuels were created by direct interpolation between the SMVU values. Adding these to the petrol consumption series generated by the equation above, gives total annual fuel consumption for cars. Dividing this fuel series (in litres) by the average rates of car fuel consumption (in litres per kilometre, with the variation over the years again estimated from SMVU data), provides a time series of automobile VKT.

For LCVs and trucks, annual ADO consumption has to be estimated. A fairly complete series for ADO consumption by road vehicles within the last two decades can be derived from biennial ABARE (1991, 1989) fuel surveys and the triennial SMVU values. Any year missing from this series may be approximated by interpolation based on the percentage change in total ADO sales for that year. Annual road ADO consumption was then split by vehicle type (into LCV, rigid and articulated) using proportions calculated from the SMVU. Annual VKT by diesel commercial vehicles was then estimated by dividing the fuel series by the appropriate vehicle fuel economies (in litres of ADO per kilometre).

Petrol consumption by commercial vehicles (P_c) was evaluated using total petrol sales (P_t) by the regression equation (with fuel use given in megalitres),

$$P_c = 0.876 \, (P_t - P_S) - 37.915$$

which, over the 6 SMVU observations, has an adjusted R^2 of 0.98 and where P_S is given by the previous equation. Then VKT by vehicle type were calculated for petrol fuelled trucks (in the same manner as for ADO). Consumption of LPG was treated similarly. Adding the three fuel types thus gives estimates of annual road freight vehicle utilisation.

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ABS	Australian Bureau of Statistics
ABARE	Australian Bureau of Agricultural and Resource Economics
AGPS	Australian Government Publishing Service
BTCE	Bureau of Transport and Communications Economics
BTE	Bureau of Transport Economics
DTC	Department of Transport and Communications
ERDC	Energy Research and Development Corporation
FORS	Federal Office of Road Safety
ISC	Interstate Commission
NELA	Nelson English, Loxton and Andrews Pty Ltd
NRTC	National Road Transport Commission
RIC	Railway Industry Council
STSG	State Transport Study Group

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