Explanation of Personal Travel Increases in Australian Cities

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Abstract:

This paper examines whether land-use can explain urban travel patterns in the five largest Australian cities. Travel data were calculated for 1947 and 1986. For 1986, the higher density cities had the expected lower per capital travel, but in 1947, when public transport dominated urban travel, the denser cities of Sydney and Melbourne had much higher travel levels than the smaller, less dense, capitals. Further, over the period 1947–1986, increasing urbanisation probably shortened the average distances between residences and activities such as work and shopping, yet per capita travel increased greatly. Travel convenience was found to provide a better fit for the data than land-use differences. It can explain both the 1947 data in terms of better public transport provision in the larger cities, and the 1986 travel patterns in terms of the superior traffic service levels in the smaller cities.

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Introduction

In the context of the large Australian city, this paper questions the sometimes-assumed idea that low density settlement has been the major cause of increasing per capita vehicular travel. The complement of the common assumption is challenged also. This is the belief that the most appropriate policy to reduce the demand for vehicular travel is to increase urban settlement densities.

Several researchers (e.g., Moriarty and Beed, 1990; Hillsman and Southworth, 1990; May, 1991), have suggested reductions in travel demand as a means of tackling such problems as greenhouse warming, oil depletion, urban air pollution and traffic congestion. But if for any reason, vehicular travel reductions are advocated, it is important to know the main causes of the great increases in per capita travel that occurred in large Australian cities over recent decades.

Several lines of evidence suggest that changes in land-use, especially urban density, are a major factor in explaining increases in personal travel levels. Newman and Kenworthy (1989), for example, studied 32 cities in Australia, Europe, North America and Asia, and found that per capita petrol consumption and vehicular travel decreased exponentially as urban density increased. For several of these cities, it has been found also that per capita travel increases with distance from the city centre (Moriarty and Beed 1987; Newman and Kenworthy, 1989), whereas residential density itself tends to decrease with distance from the centre.

Further evidence for a link between urban density and travel levels is found by examining how travel and density in each city change over time. In their book, Newman and Kenworthy (1989) present relevant data for each city for 1960, 1970 and 1980. For nearly all cities (including Australia's five major cities), increased personal travel has accompanied decreases in urban density over the 1960-1980 period.

There is therefore a strong case *prima facie* for advancing land-use as a major factor in explaining travel differences, both between various cities at any given time, and over time in each city. It is assumed that increased density reduces the average separation between typical origins and destinations, such as residences and shops or work places. The implicit assumption is then made that such reductions in the need for travel will lead directly to reductions in actual travel.

The main task of this paper is to consider these claims by examining transport and land-use data for Australia's five major cities for the years 1947-1986. (The first post-war census was held in 1947, and was selected as the starting point because public transport still dominated urban vehicular travel. The year 1986 was chosen because it is the most recent census for which full data are available). Since land-use and density was found **not** to have an important **direct** impact on travel, a second task of this paper is to provide alternative explanations for the travel and land-use patterns found.

Historical patterns of transport and land-use

In this section, transport and land-use characteristics of Australia's five largest cities are given, for the years 1947 and 1986. The cities can be conveniently divided into two groups: the larger cities (Sydney and Melbourne), and the smaller ones (Brisbane, Adelaide and Perth). Table 1 presents the data for 1947. All figures are based on present Statistical Division boundaries. (Populations within the 1947 urban boundaries are for each city about 10% less than the values shown.) It is evident that per capita travel increased with city size, as did the proportion of the city population living in local government areas (LGAs) with the relatively high densities of 2500 residents per gross km^2, or above. Car ownership, and thus car travel, did not vary with city size.

Table 1 Transport and land-use data 1947

	Sydney	Melbourne	Brisbane	Adelaide	Perth
Population (000s)	1696	1341	445	413	304
Cars/1000 population	66	75	65	99	74
Per capita vehicular pass-km	4140	3630	2730	2560	2220
- public transport	3500	2900	2100	1600	1500
- car	640	730	630	960	720
Average household size	3.91	3.58	N.A.	3.81	4.08
Pop. % at LGA densities ≥ 2500/km^2	72.2	64.0	43.4	34.6	6.2
Av. distance of pop. from CBD(km).	11.9	9.8	8.1	7.2	9.5
Retail sales (%) in central LGA	50.3	44.3	N.A.	61.4	70.4

Sources Australian Bureau of Statistics (ABS) Commonwealth and State yearbooks (1948-52); ABS Census of Retail Establishments, 1947-48 (1949)

Most of the figures in Table 1 can be derived directly from the State and Commonwealth Yearbooks of the period, with the important exceptions of the travel data. Although public transport patronage figures were available, average trip lengths were usually not available for each public mode. Where unavailable, total revenue and fares per kilometre were used to calculate total passenger-km for each public mode. For private transport in 1947, there was still some rationing of petrol, but the ration enabled the average motorist still to travel about 6500 km/year which was 90% of prewar use (ABS, 1948-52). Assuming an occupancy rate of 1.5 persons per car and the given car ownership figures, per capita travel by car could be calculated. But because of information gaps, the travel data can only be regarded as approximate.

Table 2 Transport and land-use data, 1986

	Sydney	Melbourne	Brisbane	Adelaide	Perth
Statistical Division Area (km^2)	12,154	6129	4530	1924	5417
Population (000s)	3473	2942	1149	1004	1065
Cars/1000 population	447	514	489	519	530
Per capita vehicular pass-km	9120	9600	10260	9170	9780
- public transport	1500	800	880	550	490
- car	7620	8800	9380	8620	9290
Average household size	2.93	2.88	2.96	2.78	2.90
Pop. % at LGA densities ≥ 2500/km^2	31.6	25.7	8.3	5.0	0
Av. distance of pop. from CBD(km)	22.8	19.0	15.8	12.1	15.3
Retail sales (%) in central LGA	10.1	8.4	N.A.	19.6	24.5

Sources ABS Commonwealth and State Yearbooks (1988); ABS Survey of Motor Vehicle Use 1985 and 1988; INTSTAT (1988); ABS Census of Retail Establishments 1985-86 (1987).

Table 2 shows that by 1986, per capita vehicular travel in the smaller cities was, on average, slightly higher than in the larger cities. As in 1947, car ownership and household size varied little across the five cities. Once again, the share of the population living at gross LGA densities of 2500/km^2 or higher was greater in the two larger capitals

Comparison of Tables 1 and 2 shows that personal travel levels grew rapidly over the period 1947-1986 in all cities, with the greatest increase in the smaller capitals. In all cities, this per capita travel rise is associated with increasing car ownership and use, since public transport patronage has fallen, even in absolute terms. Population of the inner suburbs had fallen, as the ABS Yearbooks show, partly because of declining household size in all five cities. The average distance of the population from the CBD increased also with growth in city population over the period. Finally, Tables 1 and 2 show that the relative importance of the CBD for shopping declined greatly since 1947.

No overall density figures are presented in Tables 1 and 2, because of their ambiguity. Newman and Kenworthy (1989) base their definition of "urban density" on the exclusion of land used for agriculture, forest or large open space, as well as zoned urban land presently undeveloped. For the Australian cities, their relevant urban populations were those of the Statistical Divisions, as used in this paper, but their urban area for 1980 was only a small fraction (15% - 38%) of the Statistical Division areas given in Table 2. On Newman and Kenworthy's definition, the larger two capitals have experienced a density decrease of nearly 20% between 1960 and 1980, and the smaller three cities of 30% or more. Such a definition would give even greater decreases over the period 1947-1986, since this density figure depends mainly on household size and residential plot size.

Other density definitions give a very different picture. For example, if density calculations are based on the 1986 Statistical Division areas, density will show a several-fold increase over the period, corresponding to population growth. Even if the much more modest metropolitan areas (as defined at the 1947 census) are used - for example, about 800km^2 for Melbourne - population density still shows a 50% or more increase over the period for each city. But this definition of urban boundaries would exclude a large proportion of the 1986 Statistical Division population.

The problems evident in using constant boundaries over time are avoided by Newman and Kenworthy's approach. However, this definition brings its own problems, since a very dispersed city, for example one with much "ribbon development" along rail lines or main roads, can still give a high urban density. It is thus a poor measure of the compactness of a city, and its change through time. Clearly, to track land-use changes over time, measures other than density will be needed.

Can land-use help explain travel changes?

The data presented in the tables allow three ways of examining the relationship between vehicular travel and land-use; first, comparison of land-use and travel across the cities in 1947, second, the same thing for 1986, and, third, comparison of land-use and transport changes for each city over the period 1947-1986

The travel parameter used throughout this paper is vehicular passenger-km per capita. A variety of land-use parameters is available, either singularly or in combination. These include not only the density types already discussed, but also population and job densities of various zones of each city, and population (and job) density gradients. Other parameters, discussed later, attempt to measure the degree of intermixing of various land-uses such as residences, shops and workplaces. Density is found to be adequate for comparing cities at a given time, but for following changes in a given city over time, it is necessary to use parameters based on the degree of intermixing of different land uses.

Density and travel relationships

As we have seen, there are many definitions of density. Fortunately, however the various density measures given much the same results when used to compare the different cities at any one year. Thus for both 1947 and 1986, Newman and Kenworthy's urban density, gross urban density gradients, and population % living at LGA densities $\geq 2500/km^2$, all show that the order in terms of decreasing density is Sydney, Melbourne, Brisbane, Adelaide and Perth. This is the same ranking as population. It follows from Table 1 that in 1947, increased density of cities correlates positively with increased travel, not inversely! This is an important result, since travel and density differences between the two groups of cities was then quite clear

By 1986 , per capita travel and density were inversely related, although travel in the smaller capitals was only slightly higher than in the larger two cities. So, with the change in dominant travel mode from public to private transport, the effect of density on travel has been reversed. There have been large per capita travel increases, but as already discussed, density changes over the period 1947-1986 are ambiguous. We therefore turn to other land-use measures for the third test of the land-use transport relationship.

Minimum trip lengths and overall travel

What needs to be determined is whether the separation of residences and destinations such as workplaces or schools has, on average, increased or decreased over the period examined. Here we will attempt to measure minimum trip lengths for three important trip types: work, education and shopping.

Because the great majority of workers can be assigned a definite workplace, it is possible, using census data, to obtain a fairly precise measure of average home-workplace separation Using the transportation assignment method, the minimum airline commuter travel distance can be calculated for each city For Australian cities, with their job-surplus centres and generally workplace-deficient middle and outer suburbs, minimum work travel occurs when all workers who cannot be assigned a job in their own LGA travel to a job located on a ray joining their residence and the city centre (Hamilton 1982; Moriarty and Beed 1987). Dividing by the relevant workforce then allows comparison of the average minimum commuter distance for each city, and its change over time.

Unfortunately, the earliest workplace data is for the 1961 census, and is now available only for Sydney and Melbourne (Sydney Area Transport Study, 1974; O'Connor and Maher, 1979) From 1961 to 1986, minimum commutes actually decreased from 5.3km to 4.8km for Melbourne, and from 5.9km to 5.4 km for Sydney. (For comparison, the 1986 values for Adelaide and Perth were 3.9km and 5.0km respectively) A possible objection is that workplace specialisation has increased since 1961; allowing for such specialisation would increase the 1986 figures more than the 1961 ones. But job specialisation can have only a minor effect on minimum work trip distances (Moriarty and Beed, 1988) This conclusion is supported by actual work trip distances, which appear to have changed very little over the years; in Melbourne, for example, it has fluctuated between 10km and 11km since 1961.

For other home-based trips - and the great majority of urban passenger trips are home-based - the calculation of minimum separation is more difficult; hence we will only try to ascertain the direction of change There have been marked changes in educational training since 1947. Then, the equivalent of about 16.5% of the Australian population studied full-time, but by 1986, this figure had risen to 24% (ABS, 1948-52; ABS, 1988). All this increase occured at the secondary and tertiary levels. This rise, combined with a doubling or trebling of city populations, resulted in a greatly expanded number of secondary and tertiary educational centres in each city.

Overall, for the total student population in each city, the average distance to the nearest relevant educational institution has probably increased since 1947, because the catchment areas for secondary and tertiary centres are larger than those for primary schools. But especially for secondary and tertiary education, average minimum trip distances will have fallen, because of the increased number of new campuses in the middle and outer suburbs.

Patterns of shopping have also changed greatly Real retail expenditure per urban resident has doubled between the 1947/8 and 1985/6 surveys of retail establishments (ABS 1949, 1987) Further, in 1948, the Central municipality in each city (containing the CBD) averaged over half of each city's retail sales, but by 1986 central sales averaged only about one-eighth of the total But even in 1948, most food shopping was done in local shopping centres. Today, both central and local shopping centres have lost market share to the regional drive-in shopping centres.

In all cities, the trip length to the major shopping centre (still the CBD) has risen, since the average residential distance from the CBD has risen (Tables 1 and 2). The average distances to local shops may also be slightly greater. On the other hand, the average resident is now much closer to a larger retail centre. For example, in Melbourne in 1948, only one suburban LGA (Prahran) had a retail turnover exceeding $200 million in 1986 values; by 1986, there were 36. Most of these LGAs had individual shopping centres with sales exceeding $(1986) 100 million (ABS 1987). In summary, average residential separation from the traditional centres of shopping - central and local - has increased, but the average resident in all five cities is now much closer to a major shopping centre than she was in 1948.

Overall in this section, we have found density to have contradictory effects on personal travel levels, depending on which vehicular travel mode is dominant. Furthermore, over the period studied, we found no evidence that ongoing suburbanization has increased the average separation between residences and workplaces, shopping centres or educational institutions of a given level. The evidence suggests that the strong present-day relationship found by comparing density between and within cities (for a given year) with personal travel is the result of one or more other factors which correlate strongly with density.

Why have personal travel levels increased?

We have already shown that a reversal in the correlation of density and personal travel accompanied the change from public transport to car as the leading travel mode, and further suggested that we need to examine factors other than density - or other land-use parameters. Here, we defend the view that changes in vehicular travel convenience best explain the data we have presented. We first look at how travel, and its convenience, has changed since 1947.

Before the surge in car ownership which began in the late 1940s, most urban residents relied on non-motorised travel, especially walking, for accessing local shops and schools, or visiting friends, if such destinations were within a kilometre or so of their home. Typically, some 20% of work trips were made on foot or by bicycle. Vehicular travel was mainly used for travel to the city centre, where the majority of workplaces, retail sales, major sports centres and entertainment activities were concentrated. The central city was - and remains - the focus of the public transport system, although the adjacent suburbs were usually also well served. In surburbs further out, however, many short trips were either not possible by public transport, or could be made faster by non-motorised means.

The rise of mass car ownership changed all this. The continuously upgraded road network joined any origin to all possible destinations. Local trips, except for the very shortest, were now made by car rather than on foot. Longer non-radial trips, hitherto slow and difficult - if even possible - by public transport, could now be made directly by car Especially in the larger cities of Sydney and Melbourne, the city centre was now less, not more, accessible than other urban locations As suburbanisation proceeded, vehicular travel destinations were progressively shifted outwards from the centre, (as witnessed, for example, by the shift in shopping patterns, already discussed). Since work trip lengths, and work frequency per capita remained fairly constant, most of the travel increase occurred at off-peak times, including weekends. Car travel was now spread not only more evenly over the urban region, but also over the week

This enabled the growing cities to avoid the paralysing congestion that would have resulted if private travel had merely duplicated the public transport system, where travel is greatly concentrated in space and time Overall, the convenience of car travel was maintained and even improved, despite its more than 10-fold increase since 1947

Travel convenience

We now examine whether travel convenience provides a better explanation than land-use for observed travel As before, we can compare the five cities in 1947, again for 1986, and the change in each city 1947-1986. Since car travel was of minor importance in 1947, only public transport convenience will be considered For public transport, convenience depends upon the speed, frequency and coverage of the various services Convenience was higher in the two larger, high-travel cities in 1947; although all cities had bus and tram services, only Sydney and Melbourne had electric rail services And these rail services were more extensive, even on a per capita basis, with the two large cities averaging about 10.5 train-km per capita, 50% larger than in the smaller capitals.

By 1986, only car travel convenience was important, since public transport averaged only some 10% of urban travel. Car travel convenience can be considered as consisting of two parts. One part, including privacy, all-weather protection and ease of transporting young children or goods varies little from city to city The other part depends on such factors as average speeds, traffic service levels and ease of parking These do vary from city to city, as shown by the 1981 data in the NAASRA Roads Study (NAASRA, 1984) and the 1980 data in Newman and Kenworthy (1989). Such indicators of car travel convenience are higher for cities with higher personal travel levels. In fact, Newman and Kenworthy find high positive statistical correlations between both average traffic speed and ease of central city parking, and petrol use per capita.

From the discussion earlier in this section, it is evident that overall vehicular travel convenience has risen for all five cities This is especially true for the smaller three cities, since their smaller populations and more dispersed urban form changed from being a drawback in the public transport era to an asset in a car-based system It is not only that door to door travel speeds have increased; it is also that new trip types are possible This, combined with the advantages mentioned above, such as privacy, mean that evaluating changes in travel convenience over time, as the main travel mode varies, is inevitably subjective.

Travel convenience can thus provide reasonable explanations for all three sets of travel data. Land-use, on the other hand, is inadequate as an explanation of the 1947 travel data, and the changes since then. Moreover, we argue that the main reason why the high densities of Europe and Japan today have lower personal travel levels than Australian or U.S. cities is because they are much less convenient for car traffic. Similarly, inner city residents have lower travel levels than outer suburban residents because of the inferior traffic service levels closer to the CBD (NAASRA, 1984).

Policy implications

What are the policy implications of our argument? We are not denying that certain land-use changes can help reduce travel. Increasing the population and/or job density of the inner and middle suburbs will reduce travel - but mainly by reducing travel convenience. But increasing the density of outer suburbs will not of itself reduce travel; such density increases have occured since 1947, but travel by each outer suburban resident has also grown rapidly. Densities there are still too low to constrain car travel. Even high-density development (for example, around railway stations) will reduce travel minimally, if traffic is only constrained over this small area.

In Australian cities, at least, modifying land-use is thus really only an indirect way of increasing traffic constraint. It is better to practise such restraint directly, since policies such as speed limit reductions, parking restrictions or road closures are cheaper and faster to implement. Even if politically feasible, large density increases in the inner areas of our cities would take decades to accomplish. Nevertheless land-use policies are still necessary in Australian cities, to conserve agricultural and bush land, for example.

Travel levels are not solely determined by travel convenience. Generally, income levels and the costs of travel are also important, since rising incomes enable mass car ownership and the associated suburban life-style. In poor societies, income is the obvious constraint on vehicular travel. But for high-income countries, there is no relationship between income and travel; Japanese cities have higher incomes, but much lower personal travel levels than Australian cities today. Also, the rising personal costs of travel as the car replaced public transport did not prevent the huge growth in travel levels. (Even so, increasing car travel costs could complement traffic restraint as a travel reduction policy).

Finally, rising incomes are also linked with social changes such as declining household size, increased enrolment in secondary and tertiary education and greater numbers of women in the workforce. All these changes would increase per capita travel frequency; on the other hand, other social changes (e.g. declining church or cinema attendance) would decrease it.

Conclusions

The main aim of this paper has been to examine whether land-use can explain urban travel patterns in the five largest Australian cities. Travel data were calculated for 1947 and 1986. For 1986, the conventional inverse relationship between density and per capita travel was found, but in 1947, when public transport was dominant, the denser cities of Sydney and Melbourne had higher travel levels than the smaller, less dense capitals. Further, over the period 1947-86, suburbanisation probably shortened the average distances between residencies and activities such as work and shopping, yet per capita travel grew apace.

Travel convenience was then proposed as the major factor influencing travel. It was able to explain both the higher travel levels in the larger cities in 1947 in terms of better public transport provision, and the reverse result in 1986 in terms of the superior traffic service levels in the smaller capitals. Per capita travel growth over the period in all cities is matched by the evident increase in overall travel convenience accompanying the shift from public transport to cars.

The strong inverse correlation found between density and (car) travel per capita in Western cities is argued to result from the much higher levels of restraint on car travel provided by the more densely populated cities. Although increasing the density of cities can in some circumstances reduce travel, it is inferior to direct measures to increase travel restraint, as these can be introduced both more rapidly and more cheaply.

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