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Travel expenditure of Melbourne households – spatial variation by purpose

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Abstract

Transport costs make up about 15 per cent of a Melbourne household's total weekly expenditure: only food and housing costs are greater. It is increasingly being recognised that transport costs should be included when examining spatial variation in housing affordability: that is, both housing and transport contribute to the residential affordability of a location.

Determining the transport costs inherent to a particular area, however, is complicated, not least because of the difference between actual expenditure and the expenditure that one might deem "necessary". For example, how much travel for leisure activities is considered to be "necessary", and how expensive does a car need to be?

We present a simple model, relying mainly on geocoded data from the Victorian Integrated Survey of Travel Activity (VISTA) 2007, to define and estimate "necessary" travel expenditure and how this is split by mode of transport and by purpose of travel.

We then apply the model to demographically comparable households in three study areas in Melbourne, and discuss implications for residential affordability.

1. Introduction

Since the 1980s the cost of transport in Australian capital cities has been the second- or third-greatest category of average household expenditure. The most recent data, from 2003–04, shows that transport costs make up about 15 per cent of a Melbourne household's total weekly expenditure.[1] Not only does this make transport costs worth examining in themselves, but it is increasingly being recognised that transport costs should be included when examining spatial variation in housing affordability. That is, both housing and transport contribute to the *residential affordability* of a location.

Determining the transport costs inherent to a particular area, however, is complicated by the difference between actual expenditure and the expenditure that one might deem "necessary". For example, how much travel for leisure activities is "necessary" and how expensive does a car need to be?

This paper uses a simple model to investigate spatial variation in household transport expenditure within Melbourne, and teases apart the components of household transport expenditure not only into car and public transport costs, but into different *purposes* of travel. This will throw light on questions such as how, if at all, households in Melbourne's fringes are economising on transport spending.

[1] Australian Bureau of Statistics (2005)

2. Context and literature

While there do not appear to have been travel survey studies of households' financial travel costs split by trip purpose, there is an abundance of literature addressing a wide variety of questions related to household travel expenditure and travel costs more broadly. For example, some authors, such as Glazebrook (2009), have sought to develop estimates of the full costs of different modes of transport, including not only financial costs to households but financial costs to governments and external costs such as pollution and congestion.

More immediately related to this paper is the increasing acceptance that spatial variation in housing affordability cannot be considered in isolation from that of transport costs, as addressed, for example, in the Brookings Institution paper[2] on their *Affordability Index*. This index aims to remove the dependence of transport costs on household size and income and takes the ratio [housing cost plus 'location-intrinsic' transport cost] / [average household income] as its measure of the residential affordability of an area.

This is particularly relevant in large Australian capital cities where, over the last decade or two, house prices (which have increased even more dramatically near the city centre than in the outer suburbs) have encouraged people to buy housing in 'growth areas' on the urban fringe, where the cost of housing — and also the level of public transport service — is lower. Transport costs are expected to be higher on the city outskirts, both because jobs and services are farther away, and because the higher reliance on car travel compared to the inner suburbs means higher costs in fuel and car ownership. Work by researchers who constructed the Brookings Affordability Index claims that transport costs in American cities increase faster with journey-to-work distance than housing costs decrease, for journey-to-work distances between 19 and 24 kilometres.[3]

This claim should be interpreted with caution in the Australian context. Not only may it not be true of Australian cities, where spatial patterns of employment and housing costs may be different, but jobs are not always as distant for residents of Melbourne's growth areas as inner-city residents and workers might think from looking at a map. More than half of employed residents in Melbourne's growth local government areas (growth LGAs) work in the same LGA in which they live or in a neighbouring LGA (see Table 1 and DOT, 2008).

Table 1. Proportion of people working in their home & neighbouring LGAs
Source: Department of Transport and Australian Bureau of Statistics

Location of workers	2006
Casey	56 per cent
Cardinia	51 per cent
Hume	53 per cent
Melton	46 per cent
Whittlesea	55 per cent
Wyndham	52 per cent

It is also important to put the "explosion" in urban-fringe living into perspective. It is true that the growth LGAs have had greater absolute and relative population increases than most other Melbourne LGAs[4]; the number of residential sales in the urban fringe has nearly doubled during the period 1996–2006; and the proportion of sales that are in the fringe has increased by 10 percentage points from 16 per cent to almost 26 per cent, as shown in Table 2. While such statistics cannot be ignored, the great majority of residential sales are still in

[2] Center for Transit Oriented Development and Center for Neighborhood Technology (2006)
[3] Center for Housing Policy (2006)
[4] Department of Planning and Community Development (2010)

Melbourne's established areas. In other words, a large majority of households[5] that are moving are moving to established areas.

Table 2. Number of sales in Melbourne – Inner & Established areas vs Growth Area councils
Source: Valuer-General (2008) A Guide to Property Values

Sales activity	1996	2006
Metropolitan Melbourne Sales (excluding Growth Area LGAs)	66,350	75,622
Sales in Growth Area LGAs	12,730	25,932
Total sales in Metropolitan Melbourne	79,080	101,554

The exposure of the urban-fringe mortgage belt to increasing transport costs is the subject of a paper by Dodson and Sipe (2006), in which they defined an *ad-hoc* measure of the average "vulnerability" of households in a given area to increasing fuel prices and interest rates based on median household income, proportion of households with mortgages or with more than one car, and car mode share for journeys to work.

The cost of the journey to work — and its relationship to income, mode and geographical location — is also the subject of an ongoing collaboration between the Victorian Department of Transport and the Australian Bureau of Statistics to estimate journey-to-work costs using individual Census records.[6]

The journey to work, however, is only one component of household travel expenditure. Apart from the standing costs of car ownership, households also incur variable transport costs for journeys to education, for household tasks such as shopping, and travel to recreational activities. To get a more complete picture of residential affordability, we need to know on *what* households' transport budgets are being spent, including the variable cost of travel for different purposes.

3. Methodology

This paper compares "necessary" transport expenditure of households in three Melbourne study areas based on car ownership and travel as measured in a survey.

The difficulty is that it is impossible to define *necessary transport expenditure* with any degree of precision. Something like 'the cost of all reasonably required trips by the cheapest practical mode and route' begs the question of when a trip is reasonably required and what qualifies a mode as practical. This paper does not define which trips are necessary, but instead classifies them according to trip purpose and counts *all* trips towards "necessary" transport costs. But car costs, which constitute the bulk of households' transport expenditure, are based on a "necessary", no-frills car, as detailed in Section 3.3.

Note that this study does not add to the extensive and active field of research that seeks to apportion *causality* of travel behaviour to location, urban form, demographics, or to subjective elements such as attitudes or "lifestyles".[7] What it does do is to answer the question, 'How much do households in a given area *need to spend* to maintain their current travel patterns?'

[5] The exact figure is not known because some sales are to property investors.
[6] For related research, examining the relationship between location, income, and mode of journey to work, but not cost, see Shin et al. (2009).
[7] See e.g. Stead and Marshall (2001) for a review of the literature about the relationship between urban form and travel patterns, Scheiner (2009) for a recent study of the relationship between trip distances and subjective elements such as attitudes, and X. Cao et al (2009) for a review of the literature about residential self-selection and the true influence of urban form on travel patterns.

3.1 The travel survey

VISTA 07 (the Victorian Integrated Survey of Travel and Activity, 2007) is a one-day travel-diary survey that records how, where, and for what purposes people travel. Households were asked to fill in a travel diary for every person in the household for one specified day of the year, reporting all travel including short walking trips. Diaries for 11,400 randomly selected households in Melbourne were collected between May 2007 and June 2008. Results presented in this paper are weighted to give a proportionate sample of weekday and weekend travel.

3.2 The study sample

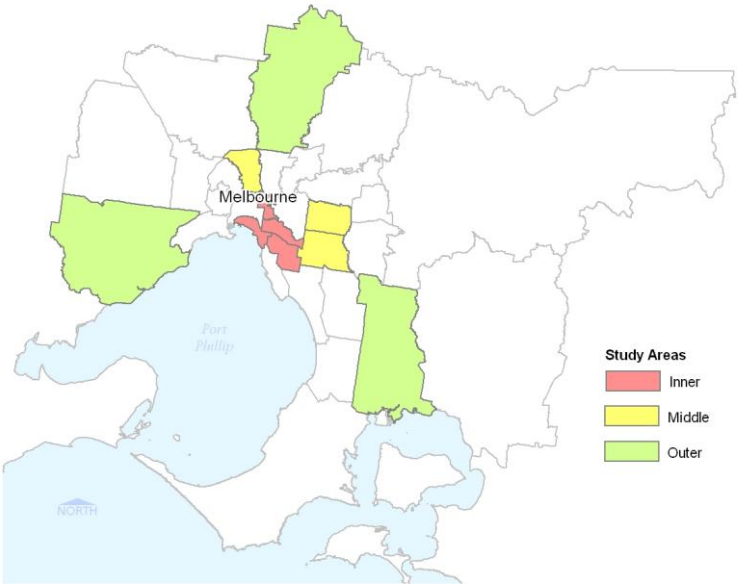
The sample is narrowed to households of a particular composition because transport expenditure depends on composition, and the mix of household compositions varies spatially. While any household composition could have been chosen, this study is based on working couples with two children under eighteen because this composition is common.[8]

It is well known that household travel spending is also correlated with household income. No attempt has been made to remove this dependence, but the differences in median income are reported in section 4 to give context.[9]

Three study areas were chosen: a set of LGAs that are illustrative of Melbourne's inner area, a second set for the middle area, and a final set from the 'growth areas' on the urban fringe. They are:

- Inner – Port Phillip, Stonnington, Yarra, and Glen Eira (77 households)
- Middle – Whitehorse, Monash, and Moreland (106 households)
- Outer – Casey, Whittlesea, and Wyndham (105 households)

Figure 1. The LGAs that form the three study areas



[8] Couples with children made up almost half of all households in the Melbourne Statistical Division at the 2006 Census, and most of these households were couples with children under *fifteen* only.
[9] There is a large body of literature on the correlation between characteristics such as household income and transport expenditure. For a recent model that attempts to disentangle these factors, see e.g. P.M. Haas et al (2008), which uses data from the USA's National Household Travel Survey.

LGAs were chosen as a convenient geographical unit, and three or four LGAs per study area balanced the aim of developing "case study" profiles for spatial areas with the need for sufficient sample size. This study consciously avoids grouping *all* of Melbourne's LGAs into 'inner', 'middle' and 'outer' groups: this would have masked differences *within* the groups and may have been misconstrued as simplistic attempt to study the whole city. The aim is to give an illustrative example of how necessary household travel expenditure varies spatially.

The study excludes households with lorries, vans, or pickup trucks, because these vehicles are likely to be used for business purposes.[10] The small number of households with motorcycles are also excluded.

3.3 Costing travel

This paper uses a common, medium-sized car (the Toyota Camry, which is henceforth called the *standard car*) as the yardstick for car costs, since anything more expensive is clearly not necessary for couple households with two children. The splitting of trip costs by purposes will also throw light on how households are spending their transport budgets.

We define *necessary transport costs* (sometimes 'transport costs' or 'transport expenditure' in this paper) as

$$\text{Necessary transport costs} = x_{pt} + x_s + x_r + \text{taxi fares},$$ where

1. x_{pt} is the cost of public transport tickets;
2. x_s is standing car costs (car ownership and associated costs): registration fees, insurance, driving licence, and capital cost of the car (which is explained in more detail later); in this paper, $x_s = nF$, where the household has n cars and F is the standing cost of one standard car; and
3. x_r is car running costs: such as those of fuel, tyres, servicing, and repairs. It is assumed that cost of running a car is proportional to the distance it is driven, i.e. for the jth car, $x_r^j = C\, d_j$, where d_j is the distance it is driven and C is a constant per-kilometre cost.[11]

Costs other than standing car costs are called *variable costs* in this paper[12]. We derive x_{pt}, n, and d_j directly from the VISTA data, and C and F from the vehicle operating costs estimated by the Royal Automobile Club of Victoria (RACV). Details of the individual components are provided below. All costs are in July 2008 dollars.

Public transport fares

In this analysis, the origins and destinations of public transport trips were geocoded. For simplicity, the pay-as-you-go fare that survey participants would have paid with Victoria's new smart-card ticketing system was imputed.

Value of C (the per-kilometre running cost of the standard car)

[10] It would be difficult to distinguish private and business travel and, since many of these households would run their own small businesses, impossible to disentangle costs incurred by a household in a private capacity from those incurred by a company.

[11] It is not worthwhile to allow C to be a function of variables such vehicle speed because such adjustments would be insignificant alongside the inaccuracy in C due to the varying price of fuel and the assumptions that need to be made about F to calculate standing costs.

[12] These *variable* transport costs are so called to contrast with the standing cost of cars, a *fixed* cost. They are per-trip or per-unit-distance costs (public transport fares, car fuel, etc.) and are the *marginal* cost of travel. If, for example, a recreational trip is by car and not public transport, then the true total cost of the trip is the marginal cost (of running the car) plus whatever fraction of standing car costs should be attributed to the trip. For short, this paper will refer to 'the cost of recreation trips' or 'the cost of travel for recreation'.

The per-kilometre running cost for the standard car (a Toyota Camry with a 4-cylinder petrol engine and automatic transmission) is 18.92 c/km, of which fuel accounts for 13.45 c/km.

Value of F (the standing cost of the standard car)

The standing costs of the standard car are

- registration, insurance, and licensing: $20.25 per week;
- depreciation — see below;
- cost of capital or interest foregone — see below.

Depreciation

Two different treatments of depreciation of cars are used. (It should also be remembered that a different cost of depreciation can easily be 'plugged into' the model.) In the first, a household buys a new car and sells it after five years: the car is depreciated linearly over this time. In the second, a second-hand car is depreciated to zero value over five years.[13]

The following prices for the standard car have been used:

New car: $29,990
Trade-in value after 5 years: $10,347
Cost to buy 5-year-old second-hand car: $13,000.

Cost of capital / interest foregone

This is calculated as the interest (net of inflation) that would have been earned in the financial year 2007–08 (which is more or less when the VISTA 07 survey was conducted) if capital had not been tied up in car ownership. The interest rates used are the policy cash rate of the Reserve Bank of Australia, and the inflation rate is the change in CPI excluding volatile items. This gives a cost of capital of 2.85 per cent for 2007–08.

These calculations give the values of F used in the model: $15.99 per day for new cars and $11.02 per day for second-hand cars. Note, however, that a standing car cost of zero would sometimes be more appropriate, e.g for "free" cars provided by an employer or very old cars (which would incur only registration costs: about $11 per week).

3.4 Mode and purpose of trip chains

Variable transport costs are broken down by mode of transport and the purpose of travel, as shown in Table 3. Note that since our focus is on transport expenditure and not modes *per se*, zero-cost modes are grouped together.

VISTA 07 records travel stop by stop. So the travel in Table 4, for example, is recorded as three trips (or 'trip stages' or 'stops'). Both the mode of transport and the purpose of travel are recorded for each stage. Variable costs are calculated for individual stops and therefore easy to split by mode, but splitting costs by purpose is more complicated.

[13] It is not unusual for a 10-year-old Toyota Camry to cost more than $5,000, but the trade-in value of a 10-year-old Camry is typically no more than $1,000 – $2,000.

Table 3. Modes of transport imputed for each trip stage, and the categories of purposes assigned to each trip chain

Mode of transport	Purpose of travel
1. Car (as driver)	1. Work
2. Public transport	2. Education
3. Zero cost (walking, cycling, passenger in car)[14]	3. Household tasks
4. Taxi[15]	4. Recreation
5. Other (assigned zero cost)[16]	5. Chauffeuring (e.g. driving children to school)
	6. Other[17]

Table 4. Example of three stops of travel

Origin	Destination	Distance	Mode	Purpose
Home	Train station 1	2 km	Car - driver	To get on/off public transport
Train station 1	Train station 2	15 km	Train	To get on/off public transport
Train station 2	Workplace	0.5 km	Walking	Destination is place of work

It is clear that, for this analysis, the cost of all three trip stages should be counted in the 'work' purpose category. Assigning purposes, distances, and costs is often a more complicated problem, as in the example in Table 5, where the person who went to work as in Table 4 stops at a supermarket on his way home.

Table 5. Example of four stops of travel: a person returns home from work *via* a supermarket

Origin	Destination	Distance	Mode	Purpose
Workplace	Train station 2	0.5 km	Walking	To get on/off public transport
Train station 2	Train station 1	15 km	Train	To get on/off public transport
Train station 1	Supermarket	1.5 km	Car - driver	To buy something
Supermarket	Home	1 km	Car - driver	Destination is home

For simplicity, home-to-home trip chains were extracted and assigned an 'overall' purpose to the entire chain. So, for example, the home-to-home chain in Tables 4 and 5 is classified as 'for work'. It seems reasonable to cost this chain as travel for work and consider the person to have gone to the supermarket "for free".[18]

In general, one of the six purposes in Table 3 is assigned to a trip chain as follows. The 39 detailed travel purposes recorded in VISTA were refined based on what each stop destination was[19] and put into a hierarchy. For each trip chain, the highest-ranked of the detailed stop purposes was identified, classified into one of the six categories of purposes listed in Table 3, and this category assigned to the chain.

[14] Car running costs are allocated only to the driver, to avoid double counting.
[15] The small number of taxi journeys are costed using flagfall and per-kilometre rates (neglecting per-minute rates); taxi costs are included in total variable travel costs but not in 'public transport' costs.
[16] The 'other' mode includes cases where the mode of transport was not recorded on the survey (examination of unit records suggests that many of these trips are walking trips) and air travel (which is included in VISTA but excluded from our analysis).
[17] This includes trips where the purpose was not recorded, or travel to return home that was in progress at 4am, when each survey day begins. It also includes trip chains for religious and volunteer activities and to stay overnight at somebody else's home.
[18] It is clear in this particular example that there should be 0.5 km of car running costs assigned to 'travel household tasks', with everything else assigned to 'travel for work', but not only is it difficult to do this algorithmically, it may be impossible to deduce how costs should be split, as, for example, in the following trip chain by a car driver: Home → Child's school → Workplace → Supermarket → Home.
[19] For example, 'buying something' at a supermarket is distinguished from 'buying something' at a hobby shop.

4. Results

Before analysing the results from the survey data it is useful to note that public-transport service levels differ substantially between the study areas, being highest in the Inner and lowest in the Outer study area (see Appendix). Some of the findings reported in Section 4.3 are a reflection of differing public transport availability. For example, Outer households spend much less on public transport than Inner households, and Inner households have lower car running costs not only because of shorter distances but because more of their travel is by public transport.

Because household transport spending is correlated with income, it is also important to note that household incomes decrease from Inner to Outer. The median income of households in our study is $2,600 per week in the Inner area, $2,050 per week in the Middle area, and $1,850 in the Outer area.

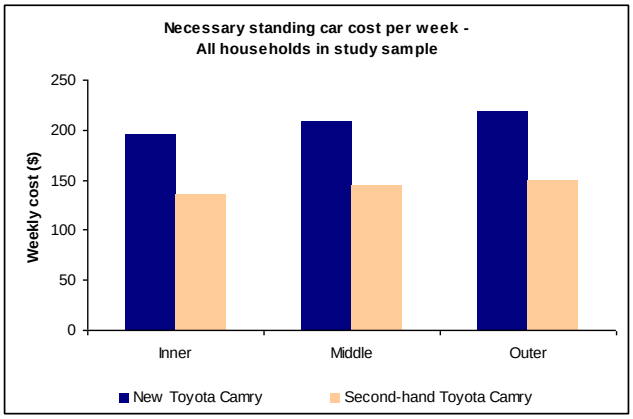
4.1 Weekly standing car costs

Necessary car standing costs (x_s) are about twice variable transport costs (x_r , x_{pt} , and taxi fares) in all three study areas. Standing costs (which, in this model, are directly proportional to the number of cars per household) are slightly greater in the Middle study area than in Inner, and greater again in Outer, where they are 11 per cent greater than in Inner (see Figure 2). This spatial difference is slightly greater (15 per cent) if we consider only those households where at least one child is under five.

This reflects the fact that the difference in car ownership rates in Inner and Outer parts of Melbourne is significant but still small when one considers only households with the same composition: the Outer study areas had 1.94 cars per household, the Middle 1.86, and the Inner households 1.75. The well known spatial variations in car ownership rates are more a result of spatially varying household composition than a reflection of differing household choices.

Note that households' *actual* expenditure on car ownership is likely to vary much more between Inner, Middle, and Outer study areas. It will depend on whether households have "free" cars and, of course, on the makes, models, and ages of cars.

Figure 2. Necessary standing car costs (x_s) per week, according to the definitions of §3.3



4.2 Weekly number of trip chains – by purpose

The most dramatic difference between the three study areas is in the number of **recreational** trip chains, as seen in Figure 3. Inner households make more than double the number of recreational trip chains as Outer households.

The number of chains for **household tasks** also decreases as we move from Inner to Middle to Outer. There is not much variation in the number of **education** and **chauffeuring** trip chains, but it is interesting to note that the number of chauffeuring chains is lowest in Outer. The counting of trip chains is discussed further below.

There are significantly more trip chains for **work** in the Outer study area than both Middle and Inner areas. Given that the study sample consists of households with two working parents, this most likely reflects differences between the study areas in the balance of full-time and part-time work, since working from home, though more common in the Inner study area than in Outer, is still comparatively rare.[20]

Chaining of trips

The apparently counter-intuitive result that the number of chauffeuring trip chains is lowest in the Outer study area, where children have the poorest access to public transport, is partly the result of more efficient trip-chaining by these households.[21]

Indeed, it is clear from these results that households in the different areas have different patterns of combining multiple purposes into trip chains. For example, the weekly number of individual *stops* (or legs of trip chains) for chauffeuring is *higher* in Outer than Inner (13.3 per week in Outer, 12.8 in Inner), even though the number of *chains* that are primarily for chauffeuring is *lower* in Outer than Inner.

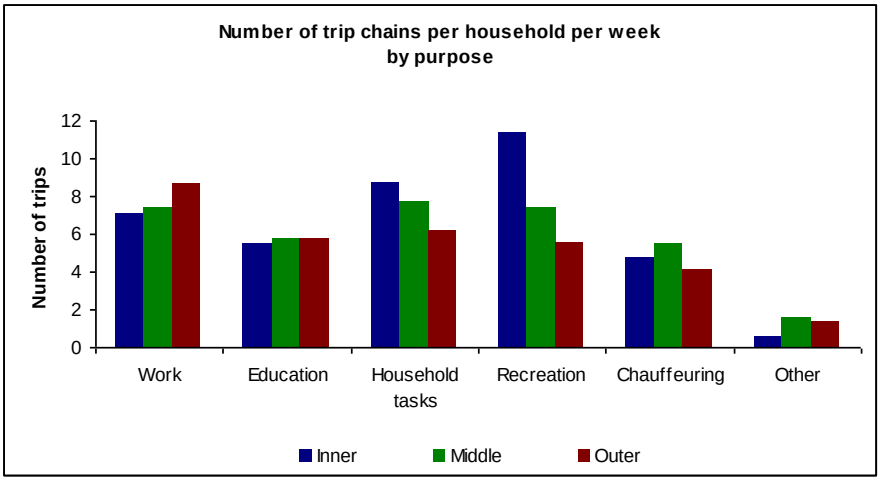
Detailed study of trip-chaining patterns, and in particular of differences in children's travel patterns between the study areas, would be of interest but is outside the scope of this paper.

The key differences between the study areas are real and not artefacts of how trips are counted, although more efficient trip-chaining by households in Outer Melbourne does mean that the "true" differences may be smaller than indicated by counting trip chains. Consider travel for recreation: Inner households make 18.5 recreational stops per week in 11.39 trip chains, while Outer households make 10.7 stops in 5.5 chains.

[20] 3.7 per cent of employed residents of the Melbourne Statistical Division worked at home on Census Day 2006. 2.5 per cent did so in the Outer study area (Casey, Wyndham, Whittlesea), and 4.6 per cent in the Inner area (Port Phillip, Stonnington, Yarra, and Glen Eira).

[21] Recall from Section 3.4 that a trip chain is assigned its highest-ranked stop purpose. If a parent drops off a child at school on the way to work, the parent's trip chain is still 'for work' and the child's 'for education'.

Figure 3. The number of trip chains that households make for different purposes



4.3 Weekly variable costs – by purpose & mode

Having examined how the number of trip chains varies between the three study areas, we now examine the variable cost of this travel (that is, x_{pt} , x_r , and taxi fares — see footnote 12). Expenditure increases from Inner to Outer study areas: $77 per week in Inner, $88 in Middle, and $116 in Outer. Most of this variable cost is in car running costs, not public-transport fares, as shown in Table 6.

Table 6. Variable costs by study area: expenditure on running cars and public-transport fares)

Weekly car running cost, x_r ($)	***Study area***		
Purpose of trip chain	Inner	Middle	Outer
Work	28.85	41.98	71.24
Education	0.00	1.52	0.05
Household tasks	11.35	9.23	15.87
Recreation	14.89	10.71	10.85
Chauffering	3.56	5.48	5.84
Other	1.76	3.21	4.09
Total	*60.41*	*72.13*	*107.95*
Weekly public transport fares, x_{pt} ($)	***Study area***		
Purpose of trip chain	Inner	Middle	Outer
Work	9.43	7.08	3.09
Education	3.19	3.62	1.63
Household tasks	0.49	1.28	0.00
Recreation	1.38	0.42	0.00
Chauffering	0.00	0.00	0.00
Other	0.00	0.13	0.00
Total	*14.49*	*12.53*	*4.72*

A large part of the difference in variable costs between study areas is accounted for by the cost of work-related journeys, the average weekly cost of which increases greatly from Inner to Outer. Expenditure on travel for work is easily greater than expenditure on travel for any other purpose, as shown in Figure 4.

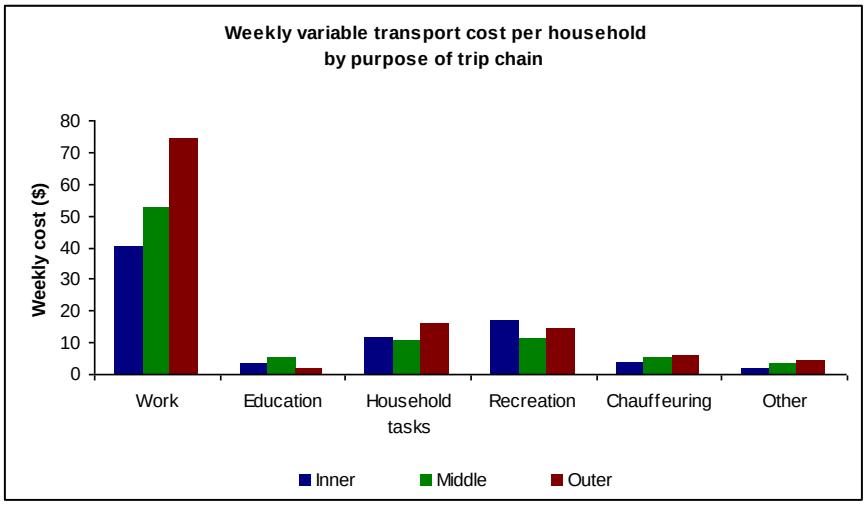
The expenditure on car running costs (x_r) also increases, while expenditure on public transport decreases, from Inner to Outer. This, given that public-transport journeys by inner-city residents are usually cheaper because of the structure of Melbourne's public transport

network and fares, reflects still greater differences in public-transport mode share between the study areas. This is not surprising: public-transport service levels are higher in Melbourne's inner parts (see map in Appendix), and most journeys to work on the primarily radial public-transport system are to Inner Melbourne, whereas more than half the working population of Melbourne's six 'growth' local government areas on the urban fringe work in the same LGA in which the live or in a neighbouring LGA (see Table 2).

Education journeys, after work journeys, are the main category of public transport spending, as expected, and again expenditure decreases from Inner to Outer.

The expenditure on recreational trip chains is particularly interesting to note. Although spending on recreational chains is highest in the Inner area, as expected from the number of recreational trip chains, the spending *per* recreational trip chain is substantially greater in the Outer area than in Middle and Inner (between which there is little difference).[22]

Figure 4. The cost of trip chains for different purposes (x_r + x_{pt} + taxi fares)



5. Discussion

The standing cost of cars

Car standing costs are the greatest of the necessary transport costs incurred by households. Using a standard car to define necessary car costs, household expenditure on standing car costs is greater, in all three study areas, than variable transport costs (car running costs and public transport fares). This is true for both the new-car and second-hand-car estimates.

Car running costs make up the great majority of variable transport costs, with public-transport fares accounting for about 19 per cent of variable costs in the Inner, 14 per cent in the Middle, and only 4 per cent in the Outer study area.

Household expenditure on car running costs is greater in the Middle study area than the Inner area, and much greater still in the Outer area. Moreover, running costs make up a greater *proportion* of necessary transport expenditure in Outer than Inner or Middle, because the number of cars per household, and hence car standing costs, increases far less dramatically than car running costs as one moves from Inner to Outer. This suggests that

[22] The figure for Outer is distorted by one long taxi journey, which brings it up to $14.27/week from $10.85/week, but the observation on the cost per recreational chain remains true even if the taxi journey is excluded.

although the number of cars per household varies with location in Melbourne, much of this variation is due to variation in household composition.

Travel expenditure by purpose of trip chain

The trip chains from which households incur the greatest variable cost are work-related ones. Work-related trip chains account for a little over half of households' variable transport expenditure in the Inner study area, and almost two-thirds in the Outer area. This is because work-related trip chains cover greater *distances* than journeys for other purposes: the *number* of trip chains that are for work is comparable to the number of trip chains for each of the other four main purposes (education, household tasks, recreation and chauffeuring).

Trip chains for recreation and household tasks are the next greatest contributors to variable costs. Each recreational or household-task trip chain costs substantially more in the Outer study area than in Middle or Inner. The number of recreational trip chains decreases from Inner to Middle to Outer, with Outer households making less than half the number of trip chains for recreation as Inner households do. Inner households also make substantially more trip chains for recreation than for any other purpose.

Total transport expenditure

The estimated total necessary transport expenditure for households in each of the three study areas household is listed in Table 7. The total necessary household expenditure on transport is 22–25 per cent greater in Outer than Inner. Although the variable cost of transport is 50 per cent greater in Outer than Inner, the difference in total transport costs is smaller because the number of cars per household only increases from 1.75 in Inner to 1.94 in Outer and, given the assumptions of Section 3.3, the standing cost of cars (even if they are costed as second hand) accounts for more than half of total necessary transport expenditure in all study areas.

Table 7. Total necessary transport expenditure per household

	Inner	Middle	Outer
Necessary *weekly* expenditure (new standard car)	$ 273	$ 296	$ 334
Necessary *weekly* expenditure (second-hand standard car)	$ 212	$ 231	$ 266
Necessary *annual* expenditure (new standard car)	$ 14,260	$ 15,450	$ 17,410
Necessary *annual* expenditure (second-hand standard car)	$11,080	$12,080	$13,880

In absolute terms, this study estimates that a couple with two children under eighteen in the Outer study area "needs" to spend around $3,000 more on transport each year than a household of the same composition in the Inner area, and $2,000 more than one in the Middle area.

6. Conclusion & Further research

This paper has presented a simple model for estimating necessary household expenditure on transport in Melbourne. It can easily be adapted for different cities with travel survey data, and changing the assumptions made for the costs of owning and running cars only requires changing two of the model's plug-in parameters. It could also be used for any other geography and population samples for which travel survey data is available.

In this case, the model was applied to households in three study areas — in Inner, Middle and Outer parts of Melbourne — that were composed of working couples with two children under eighteen.

The analysis shows that the greatest spatial variation in variable transport costs is in trip chains for work. This cost is substantially higher in the Outer study area, where households made both more and longer trip chains for work. The greatest spatial variation in the *number* of trip chains, however, was in travel for recreation. Households in the Outer area made fewer than half the number of recreational trip chains as households in Inner, but households in the Middle area spent even less on recreational chains because *each* recreational chain by an Outer household cost 70 per cent more than one by an Inner or Middle household.

The study also shows that the progressive increase in the level of car ownership from Inner to Middle to Outer areas is significant but not enormous when households of the same composition are compared. Given that the principal transport cost that households face is the standing cost of car ownership (unless, for example, they keep very old cars or are provided with free cars by employers), this means that the total necessary cost of transport faced by households does not increase dramatically from Inner to Outer study areas.

In the context of residential affordability, the difference between necessary transport expenditure in the three study areas may be too small to make a substantial difference to households' choice of location (especially if the household is buying, not renting, and therefore faces much larger up-front costs in the more expensive inner parts of the city). But it is worth noting, firstly, that the $3,000 difference between necessary transport costs in the Inner and Outer areas would service an extra $40,000 of mortgage debt at an interest rate of 7.5 per cent; and, secondly, that the true difference in "necessary" transport expenditure is underestimated in this study because it is based on "observed" travel: the higher median income of households in the Inner area means that they spend more on travel for recreation (which is arguably less necessary than travel for work), and households in the Outer area may already be economising by chaining trips more efficiently.

The VISTA travel survey is being run again in 2009–10. Repeating the analysis described in this paper and comparing the results to the 2007–08 survey would identify emerging trends in Melbourne households' travel behaviour and the cost of transport, especially in light of intervening events such as the Global Financial Crisis and the sharp decrease in fuel prices. It also provides a further opportunity to investigate topics such as how the spatial variation of travel patterns is different for adults and children, or how trip-chaining patterns vary both spatially and by household characteristics such as composition, employment, income, and car ownership.

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Appendix

Figure A. Indicative public transport service level by Census Collection Districts. The level is based on a raw count of the number of public-transport services per weekday, defining service radii of 400m for bus stops and 800m for train stations. This indicator has been used in internal research at the Department of Transport, such as that on household vulnerability to increased oil prices (see DOT, 2009).
Source: Department of Transport and Metlink