# An Exploration of Mode Choice in Sydney Using Journey to Work Data

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## 1 Introduction

Journey to work information from the Census is used widely in transport planning in Sydney. In addition to forming an important input to transport modelling, journey to work information provides a yardstick to assist setting mode share targets for proposed large-scale developments.

This paper explores journey to work information for Sydney to understand the degree of variability of mode choice. Partly this is to provide a context in which to undertake further analysis, but also to suggest that, from a policy perspective, if higher non-car mode share is a good thing and if particular levels of non-car mode choice are already achieved in some parts of Sydney, then increasing non-car mode share in other parts of Sydney is not inherently impossible.

A number of simple locational attributes are compared with mode shares of journey to work trips from zones in an attempt to identify some rules of thumb that might be useful in future planning work. While a more rigorous approach would be to develop a very detailed and complex model for each new development, the richness of the journey to work dataset might provide the basis for such rules of thumb.

## 2 Purpose of analysis

The transport planning of large-scale development sites in Sydney is increasingly embracing more than just traffic impacts. Transport management and accessibility plans (TMAPs) or similar analyses have been prepared for a number of sites. These seek to achieve higher non-car mode shares for the transport demands generated by the development. This is partly to reduce traffic generation and the associated costs of trying to mitigate traffic impacts, as well as to assist to meet ambitious prevailing State Government targets for vehicle travel. Relationships between mode share and locational factors would assist to develop and justify mode share targets.

Mode share targets in a number of TMAPs and similar analyses typically relate to journey to work mode shares for the particular area. For example, planning for the development of the ADI site at St Marys sought to reduce the car mode share for the journey to work by around 10 percentage points from the mode share of the surrounding local government area of Blacktown. A TMAP for the redevelopment of the Sydney Fishmarket at Pyrmont, used a formula that scaled mode share targets for specific travel markets to future journey to work mode shares. In this way it sought to link site accessibility to that of the surrounding area to ensure that, if other government decisions in the area improved non-car accessibility, then targets would be similarly tightened.

This paper is seeking to find which locational factors have a relationship with mode share for journey to work trips originating from an area and are readily available at the planning stage and can be identified within the limitations of the data structure of the journey to work dataset's Table 2. During the early stage of site planning and development, the precise characteristics of future residents are unknown. Information such as household structure, car ownership, job locations are all uncertain. This makes the forecasting of transportrelated behaviour difficult, especially mode share, due to the complexity of this aspect of travel behaviour.

This paper is not suggesting that several rules of thumb, if they can be found, can ever hope to explain the complexities of mode choice. Rather, the use of a rich dataset, such as journey to work Table 2, in combination with planning variables, might potentially underpin estimates of small percentage point shifts in mode share as a result of measures included as part of site design. An illustration of the types of rule of thumb envisaged is the statement '*reducing the distance from the site to the nearest rail station from 2 km to 1.5 km can be expected to increase rail mode share for journeys to work from the site by between x and y percentage points*'.

If relationships could be established then it would provide greater confidence in likely transport outcomes.

The use of "simple" relationships to support various aspects of transport planning is well established. Traffic generation rates based on planning variables, such as floorspace, are well accepted. Yet traffic generation is the result of complex economic, geographic and social factors, rather than floorspace per se.

For a thorough-going analysis of explanations for mode share, the reader is referred to standard transport planning texts, such as de Dios Ortuzar and Willumsen (2001 p 200), and then to the very rich literature on mode choice.

The contextual analysis presented in this paper seeks to identify how much mode shares vary within Sydney and within smaller geographic units of Sydney. This is partly to identify what a mode share target might mean in terms of its plausibility. It is also an attempt to address the common refrain, heard from many quarters, that people in Sydney (and other places) will not leave their cars behind and use alternative forms of transport. If mode shares do vary, then it might be reasonable to assume that, under particular circumstances, a proportion of people *will* leave their cars behind and use alternative modes. Hence, mode share targets may be more than a vain hope. Journey to work data may assist to provide an insight into what these circumstances might be.

The variability of Sydney's geography, urban form, landuse and transport system is considerable. Therefore, it is considered to be a reasonable expectation that mode share would also vary between places.

The analysis in this paper provides an initial exploration of some of these potential relationships. Necessarily, from a planning perspective, when only limited information about a development and its population is known, one must use readily available (and generally simple) locational factors used to test for a relationship with mode choice.

## 3 Data and definitions

This paper considers mode shares for the journey to work only. This is because journey to work information provides the most comprehensive mode choice information, at a geographically disaggregate level, that is currently available in Sydney. It is commonly used for planning purposes because journey to work travel dominates the morning peak period, when demands on the transport system are at their greatest.

The journey to work dataset used in this paper is Table 2 of the 2001 Census Journey to Work. This is supplied in electronic form by Transport Data Centre and described formally in Transport Data Centre (2003). In outline, Table 2 provides origin by destination by mode for journey to work trips collected in the 2001 Census. Trip ends are coded to travel zone level. The modes used for the trips are coded to six classifications using a hierarchy of modes. If a person nominated more than one mode on their census form, then the trip is coded as being made by the highest mode in the modal hierarchy. The six modes used are train, bus, car driver, car passenger, other and not travelled. “Other” includes modes such as: bicycle, walking, ferry, tram; it also includes not stated.

This paper also uses the terms transit mode share and car mode share. Transit mode share combines train and bus; car mode share combines car driver and car passenger.

Mode shares are calculated by dividing the mode’s trips from an area by the sum of the trips from that area. This removes the “not travelled” trips from the particular area’s origins.

The focus of this paper is on travel from home locations in Sydney, which comprises the statistical district of Sydney less Blue Mountains, Gosford and Wyong. These were excluded because of their distance from the contiguous conurbation of Sydney. Destinations were coded as either in this area of Sydney or outside it. For the bulk of the analysis, trips with destinations outside this area are excluded due to their relatively small number, and the factors that underlie their mode choice are unlikely, although this was not tested, to be explained by the same factors relevant to the rest of Sydney.

Origin zones were excluded from the analysis if they had less than 10 trips by all modes.

Statistical local areas (SLA) are units that generally correspond to local government areas, although several local government areas contain a number of SLAs. For example, Blacktown comprises three SLAs.

Travel zones are smaller geographic units. These aggregate to SLAs. There are nearly 850 travel zones in the part of Sydney analysed in this paper. Travel zones are the smallest geographic unit in Table 2 of the journey to work dataset.

A further geographic unit used in landuse and transport planning in Sydney are three rings, Inner, Middle and Outer. They are useful because of their simplicity, reducing Sydney to three numbers for comparison purposes. There is also, to a point, some consistency of landuse and transport patterns within the rings.

## 4 Mode shares

Mode shares are used frequently when comparing cities’ transport performance and outcomes. For example, Newman and Kenworthy (1999) use mode shares, along with other measures, to compare car dependence in a large sample of international cities.

### 4.1 Australian capital cities

Mode shares for the journey to work in Australia’s capital cities vary considerably, as the data in Table 1 demonstrates. A feature of this comparison is the substantially higher transit mode share in Sydney, nearly twice that of the city with the next highest transit mode share. Car mode share in Sydney is lower than the other cities.

**Table 1 Transit mode shares for journey to work for Australian capital cities (source: ABS (2005))**

| City | Transit | Car | Other | Total |
|---|---|---|---|---|
| Adelaide | 9% | 82% | 9% | 100% |
| Brisbane | 12% | 77% | 11% | 100% |
| Canberra | 7% | 82% | 12% | 100% |
| Darwin | 4% | 79% | 17% | 100% |
| Hobart | 6% | 80% | 14% | 100% |
| Melbourne | 10% | 78% | 12% | 100% |
| Perth | 9% | 82% | 9% | 100% |
| Sydney | 22% | 67% | 11% | 100% |

## 4.2 Mode shares within Sydney

### 4.2.1 By ring

The mode share of each travel zone within the three rings was calculated to produce statistics that provide a sense of the variability of mode choice at the zone level. In addition, an overall average mode share for the ring was calculated for comparison with the average of zones' mode shares. Only trips starting and ending within the defined Sydney area were included.

The degree of variation of mode share (refer to Table 2 below) within each ring is substantial. There are also differences between rings, with car driver average mode share, for example, ranging from 40.5 per cent in the Inner Ring to 70.2 per cent in the Outer Ring.

**Table 2 Mode shares for journey to work for zones within Inner, Middle and Outer Rings (source: JTW Table 02, processing described in the text)**

| | Train | Bus | Car Driver | Car Passenger | Other |
|---|---|---|---|---|---|
| *Inner Ring* | | | | | |
| Minimum | 0.0% | 0.0% | 0.0% | 0.0% | 4.8% |
| Maximum | 55.5% | 44.4% | 72.1% | 10.6% | 93.2% |
| Average | 15.7% | 15.9% | 40.5% | 4.7% | 23.3% |
| Wgt average | 15.4% | 17.6% | 45.5% | 5.2% | 16.4% |
| Median | 11.1% | 15.5% | 41.2% | 4.8% | 15.5% |
| Std dev | 12.6% | 9.1% | 15.8% | 2.1% | 19.5% |
| | | | | | |
| Zone Count | 219 | | | | |
| | | | | | |
| *Middle Ring* | | | | | |
| Minimum | 0.8% | 0.0% | 32.3% | 2.1% | 2.6% |
| Maximum | 49.7% | 26.2% | 74.8% | 12.3% | 37.2% |
| Average | 21.3% | 4.9% | 58.8% | 6.5% | 8.5% |
| Wgt average | 21.0% | 5.0% | 59.4% | 6.4% | 8.1% |
| Median | 21.3% | 2.4% | 59.9% | 6.5% | 7.3% |
| Std dev | 23.7% | 7.7% | 59.5% | 6.7% | 9.8% |
| | | | | | |
| Zone Count | 217 | | | | |
| | | | | | |
| *Outer Ring* | | | | | |
| Minimum | 0.0% | 0.0% | 20.1% | 0.0% | 0.0% |
| Maximum | 44.2% | 21.5% | 91.7% | 33.3% | 71.0% |
| Average | 11.6% | 2.5% | 70.2% | 6.6% | 9.0% |
| Wgt average | 14.0% | 3.1% | 69.0% | 7.1% | 6.9% |
| Median | 10.2% | 1.1% | 71.9% | 6.5% | 7.6% |
| Std dev | 9.0% | 4.2% | 9.5% | 3.0% | 6.4% |
| | | | | | |
| Zone Count | 375 | | | | |

### 4.2.2 By SLA

A similar analysis to that described above was conducted for trips originating from each of the zones within each SLA. A series of figures show the minimum, average and maximum mode shares of zones within each SLA for each mode. The SLAs are sorted by ascending average mode share of the particular mode under consideration in the relevant figure, therefore they appear in different locations along the horizontal axis in different figures.

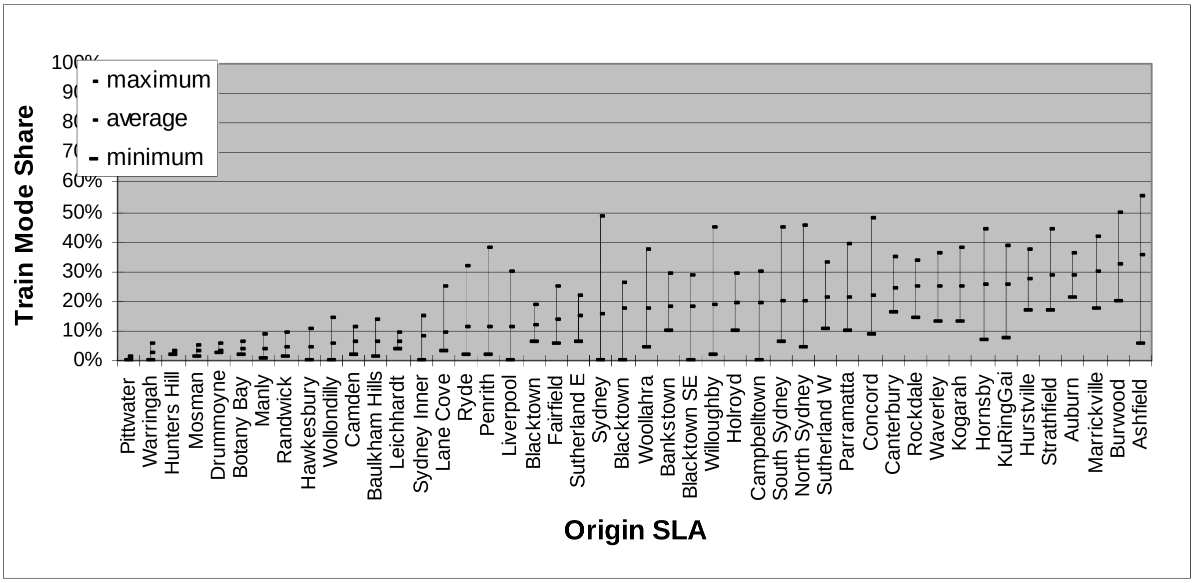


**Figure 1 Train mode shares journey to work origins – maximum, minimum and average for zones within each SLA (source: JTW Table 02, processing described in the text)**

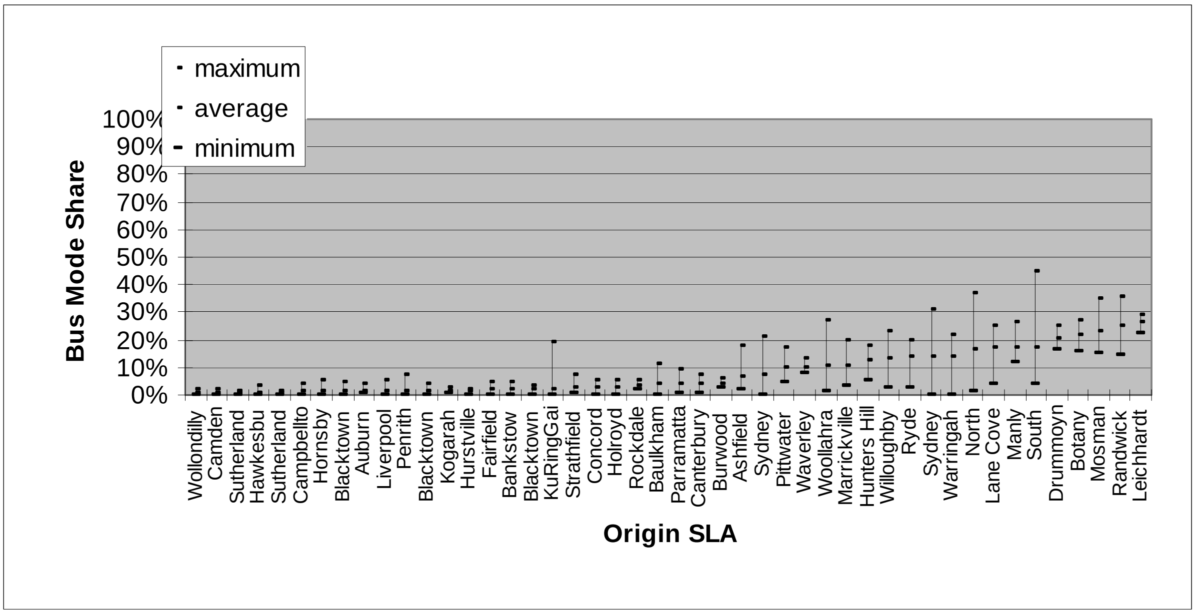


**Figure 2 Bus mode shares journey to work origins – maximum, minimum and average for zones within each SLA (source: JTW Table 02, processing described in the text)**

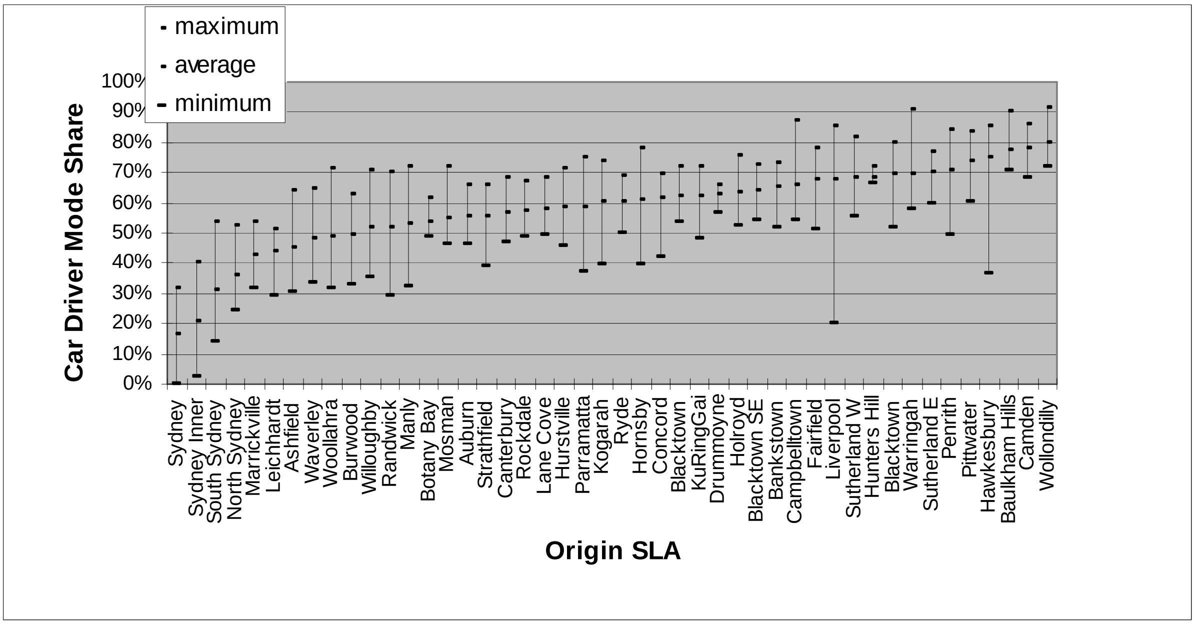


**Figure 3 Car driver mode shares journey to work origins – maximum, minimum and average for zones within each SLA (source: JTW Table 02, processing described in the text)**

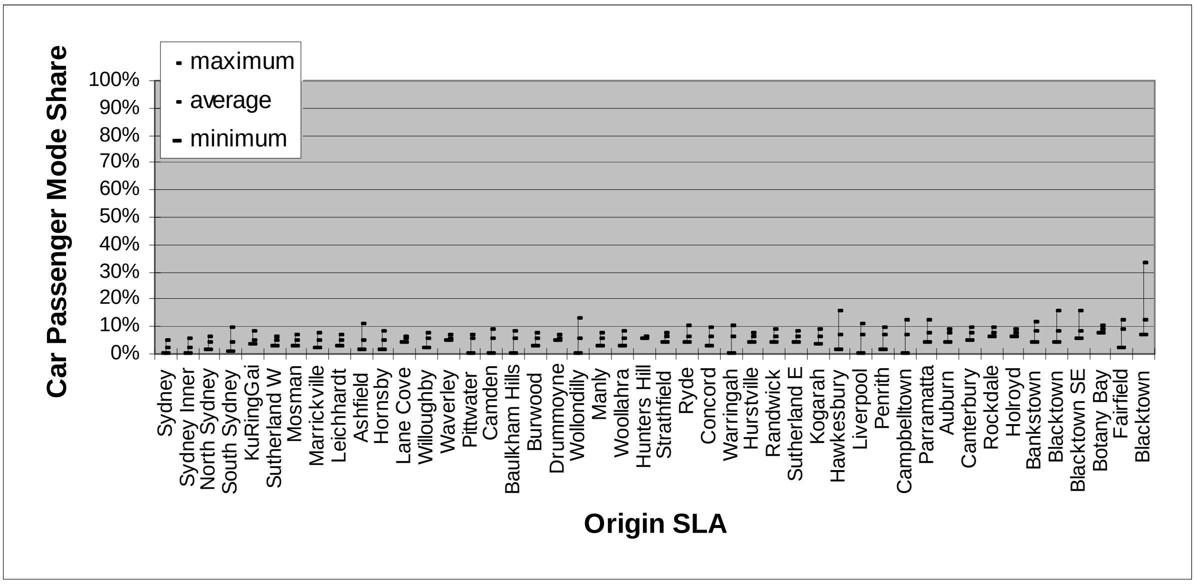


**Figure 4 Car passenger mode shares journey to work origins – maximum, minimum and average for zones within each SLA (source: JTW Table 02, processing described in the text)**

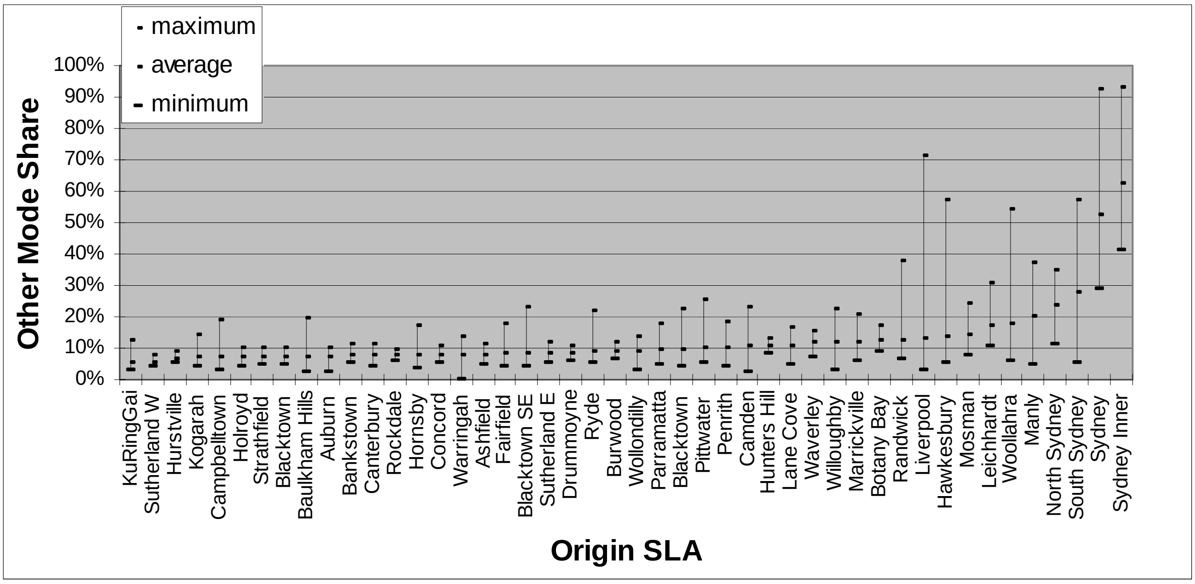


**Figure 5 Other mode shares journey to work origins – maximum, minimum and average for zones within each SLA (source: JTW Table 02, processing described in the text)**

4.2.3 Summary

The above analysis demonstrates that journey to work mode share varies substantially within the Sydney area. Very large differences are observed within rings, and even within SLAs there is considerable difference between individual zones' mode shares.

This indicates that mode choice for the journey to work can and does vary considerably across the whole of Sydney.

## 4.3 Market structure

The cumulative frequency distribution of mode shares from zones within Sydney provides a further indicator of market structure to provide a context within which to consider measures to alter mode choice. Figure 6 shows that 50 per cent of zones have less than 17 per cent transit mode share and 90 per cent have less than 35 per cent transit mode share.

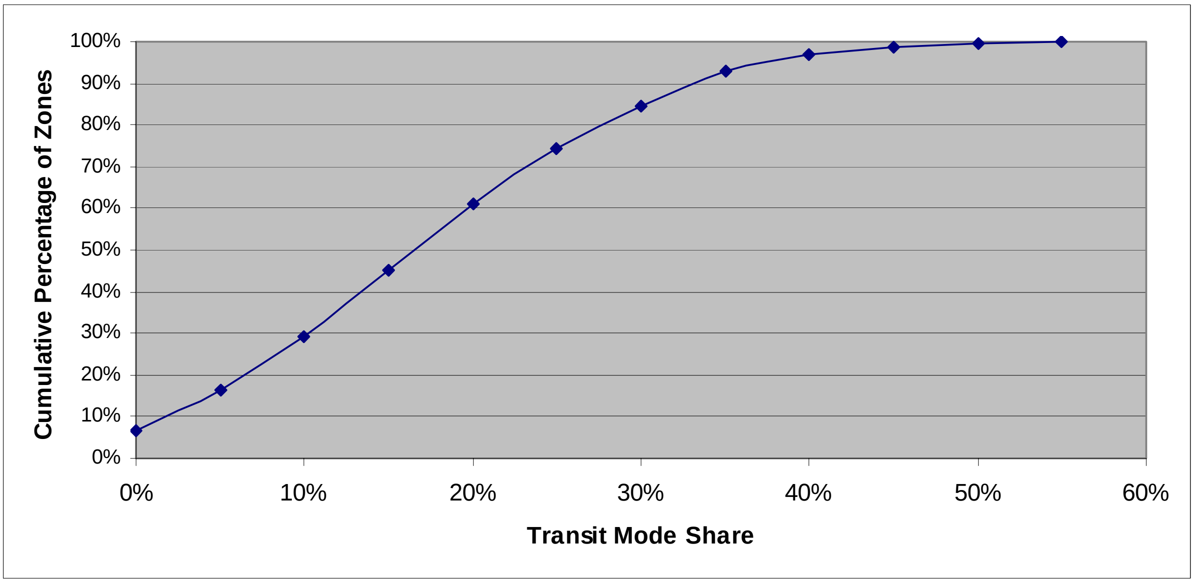


**Figure 6 Cumulative frequency distribution of origin zones by transit mode share (source: JTW Table 02, processing described in the text)**

The curve above presents a challenge for transport planning – to move a zone's transit mode share from 10 per cent to 20 per cent means, in broad terms, that the area in question needs to jump from the bottom 30 per cent of zones to the top 40 per cent of zones.

Car's higher market share is evident from Figure 7, with 50 per cent of zones having a car mode share of 68 per cent or more and only 10 per cent with 35 per cent car mode share or less. Figure 8 disaggregates cars' cumulative frequency distribution by ring.

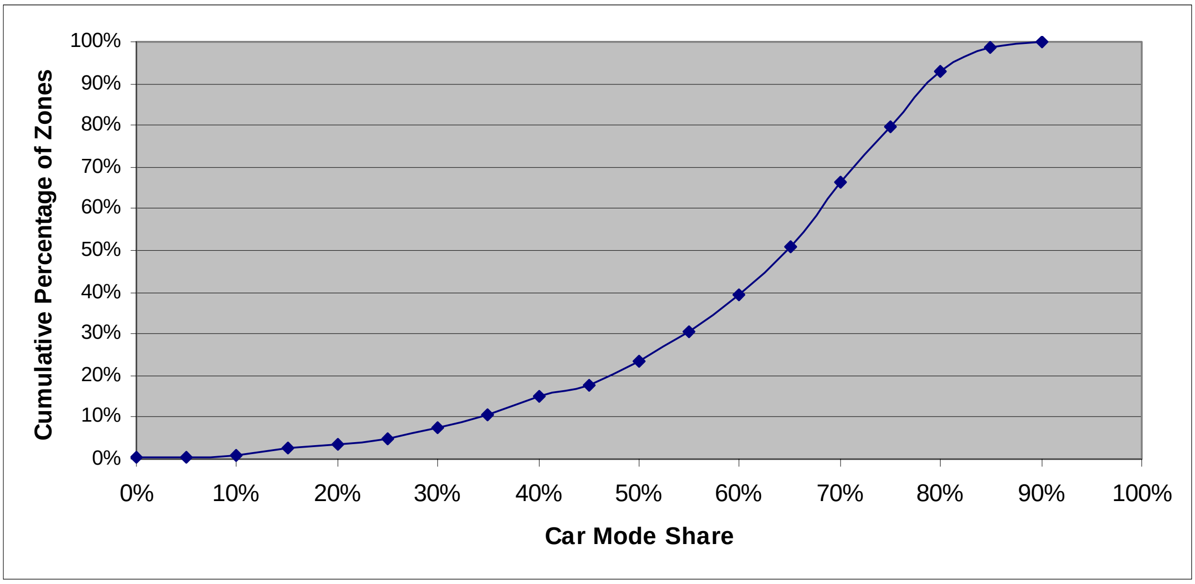


**Figure 7 Cumulative frequency distribution of origin zones by car mode share (source: JTW Table 02, processing described in the text)**

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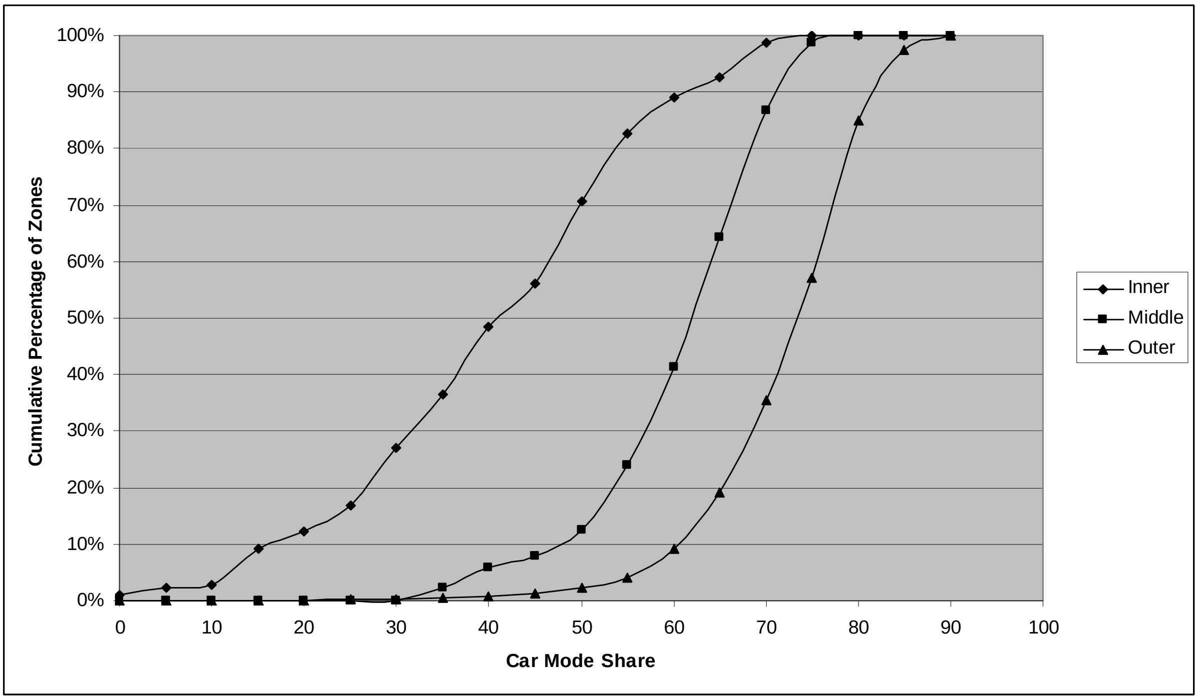


**Figure 8 Cumulative frequency distribution of origin zones by car mode share for each of Inner, Middle and Outer Rings (source: JTW Table 02, processing described in the text)**

The flatter gradient of the Inner Ring's curve in Figure 8 indicates that car mode share is more evenly distributed for zones within the Inner Ring, than in the Middle and Outer Rings. For Middle Ring zones, roughly 60 per cent of zones have mode shares between 55 and 70 per cent, that is, a relatively small change in mode share reflects a move from the highest15 per cent of zones to the lowest 25 per cent of zones. How this can be achieved in practice is a matter for further investigation. This compression is more marked for zones in the Outer Ring.

## 5 Exploration of relationships between mode share and site attributes of zones

As noted above in Section 2, this paper is seeking to identify simple relationships between mode choice and factors that would be known during the planning phase of a development. It is considering mode choice of journey to work trips originating from an area, rather than considering individual trips or sub-markets to specific destinations.

The attributes used in the analysis were: resident workforce density; proximity to rail network; proportion of CBD workers; proximity to the CBD; proximity to regional centres; and, selected rail corridors combined with distance to CBD and nearest station. Factors associated with the CBD were included because of the CBD's role as Sydney's prime employment centre and as the primary focal point of Sydney's transit system.

The utility of the proportion of CBD workers as a planning variable is somewhat limited, although conceivably there may be cases where a residential development might somehow specifically target CBD workers. In which case, this variable might assist to estimate mode share effects of such an approach to site development.

The process adopted was to produce scatter diagrams and, where a relationship was suggested from inspection, to fit a curve to provide a measure of the goodness of fit. Some relationships were explored further through segmentation of data into the three rings, with CBD origin zones excluded from some of the relationships.

## 5.1 Resident workforce density

The density of the resident workforce was estimated using the total number of origins from a zone and dividing it by the area of the zone. It was anticipated that the higher the density, the higher the use of non-car modes.

Analysis shows that workforce density correlates positively with transit mode share. For all zones, the correlation was weak with an $R^2$ value of 0.36. When the relationship was segmented by ring, the Inner and Middle Rings had weaker correlation coefficients, with the Inner Ring having $R^2$ value of 0.10. This did not improve when the CBD origin zones were removed. The Outer Ring had a slightly better, but still poor, correlation at $R^2$ value of 0.38.

## 5.2 Proximity to the rail network

A potential source of variability in mode choice is accessibility to the CityRail network. The distance between a zone and its nearest station, as the crow flies, was taken as a measure of access to the rail network.

As distance from stations increased, rail mode share declined, as would be expected. However, the scatter in the data is large. For Inner Ring zones, the correlation between log of distance and rail mode share was weak with an $R^2$ value of 0.37. For Middle Ring zones, the distance to the nearest station had a better fit with an $R^2$ value of 0.45 for a linear relationship and an $R^2$ value of 0.57 for a log distance relationship.

An analysis of zones within 2 km of the nearest station showed a definite decline in train mode share as the distance from the station increased. The weakness of the correlation, with an $R^2$ value of 0.20, was somewhat surprising. This relationship is shown on Figure 9.

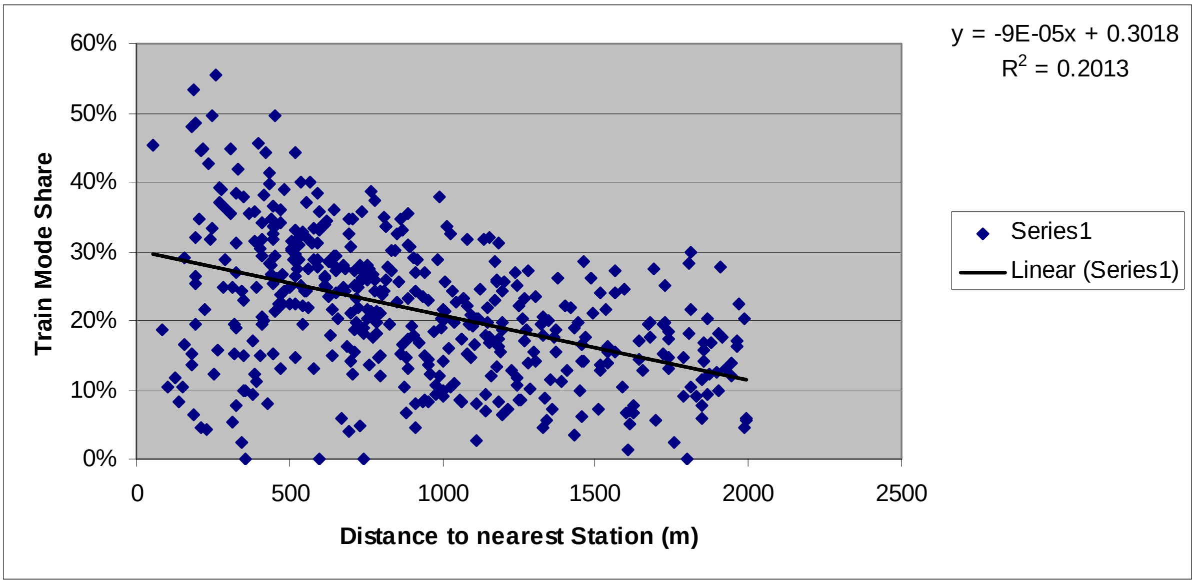


**Figure 9 Distance to nearest station versus train mode share of origins – zones within 2 km of stations (source: JTW Table 02, processing described in the text)**

Bus mode share tends to increase as distance to the nearest station increases, before declining again. This is especially marked for Inner Ring zones, for which a quadratic form produced a Kuznet-style curve, although it yields an $R^2$ value of just 0.32. Using this curve, the bus mode share peaks when zones are between 3.5 km and 4 km from the nearest station, with a bus mode share of just under 25 percent.

Car driver mode share tends to increase as distance from the nearest rail station increases. For zones in the Inner Ring, fitting a linear curve yields an $R^2$ value of 0.43, while a log curve yields an $R^2$ value of 0.49, due to that form's ability to capture the steep decline in car mode share that is evident for zones within 1 km of the nearest station.

## 5.3 Proportion of CBD workers

Given the important role of the CBD in the public transport system and market in Sydney, it had been anticipated that rail mode share would closely correlate with the proportion of CBD workers. However, this produced an $R^2$ value of 0.03. The issue seems to be that there are a number of zones with a high proportion of their resident workforce employed in the CBD, but not served by rail.

Therefore the relationship between the proportion of CBD workers and transit mode share was examined. By limiting the analysis to zones with no more than 50 per cent of their workers employed in the CBD, a linear correlation, with an $R^2$ value of 0.63 was produced. Many of these excluded zones, with high proportions of CBD workers, are close to the CBD, with good pedestrian access, hence their resident workforce has lower transit use and higher other mode share.

The linear relationship with car driver mode share was negative with an $R^2$ value of 0.69.

The relationship between the proportion of CBD workforce and other mode share appeared to be positive and non-linear. A quadratic form was fitted and produced an $R^2$ value of 0.69. This neatly fits the zones (refer to Figure 10) with very high proportions of CBD workers, who presumably walk to work.

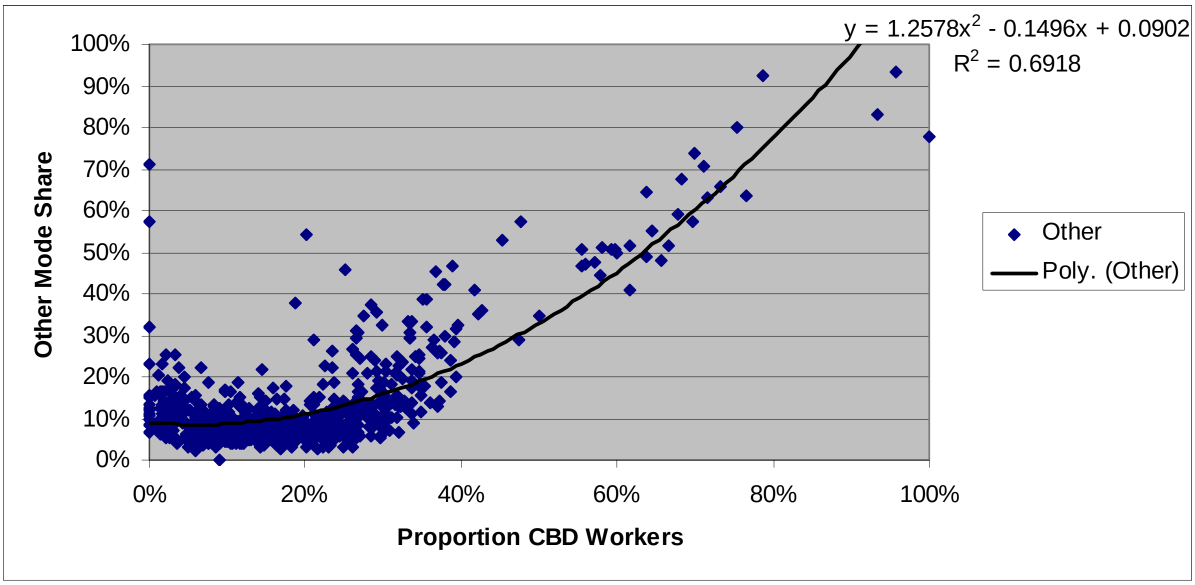


**Figure 10 Proportion of CBD workers versus other mode share from zones (source: JTW Table 02, processing described in the text)**

## 5.4 Proximity to CBD

Proximity to the CBD was based on the distance to travel zone 14 at Martin Pace, as the crow flies.

The scatter plot of distance to CBD and train mode share shows little overall pattern, apart from initially increasing and then declining as the distance to the CBD increase. For zones within 3 km of the nearest station, a quadratic form was fitted, but produced an $R^2$ value of 0.08.

Bus mode share, again with much scatter, increases with distance to the CBD, before declining beyond about 6 km.

Car driver mode share increases as the distance to the CBD increases. A linear form yields an $R^2$ value of 0.45.

Other mode share for zones within 4 km of the CBD provides a negative linear relationship with an $R^2$ value of 0.74. This is shown on Figure 11.

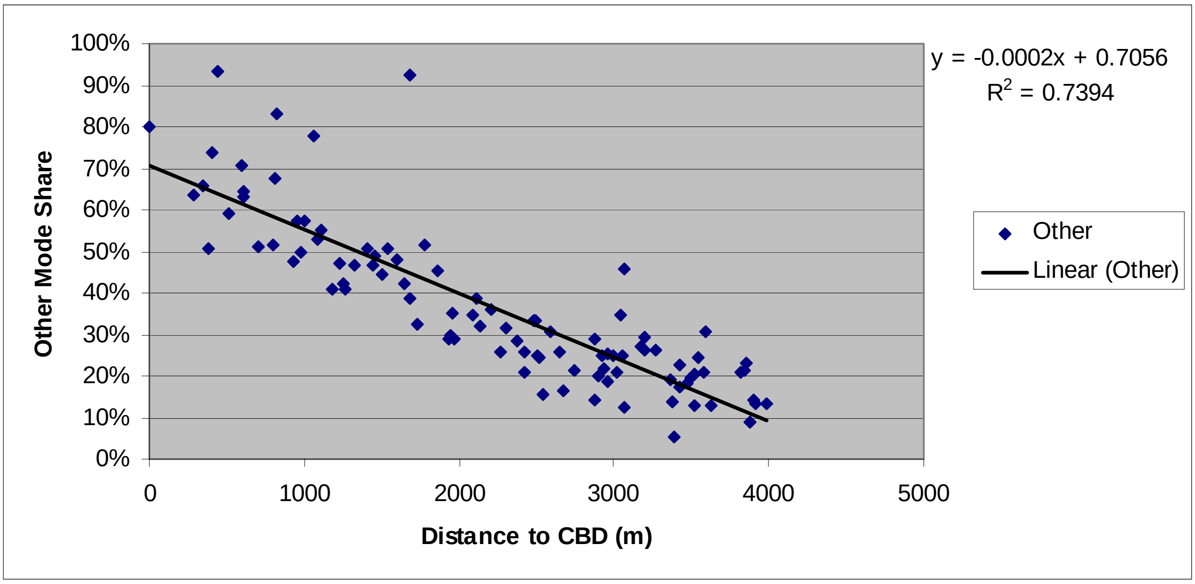


**Figure 11 Distance to CBD versus other mode share from zones (source: JTW Table 02, processing described in the text)**

## 5.5 Proximity to regional centres

Regional centres in Sydney tend to be nodes for local and regional public transport, as well as accommodating employment concentrations. Therefore, it was thought that mode share for the journey to work might be influenced by distance to the closest regional centre.

There is debate about what centre is, and what centre isn't, a regional centre within Sydney. For the purposes of this analysis Bondi Junction, Burwood, Hurstville, Dee Why, Liverpool, Bankstown, Macquarie Centre, Campbelltown, Penrith, Parramatta, Blacktown, Chatswood, Hornsby, Miranda and North Sydney were treated as regional centres.

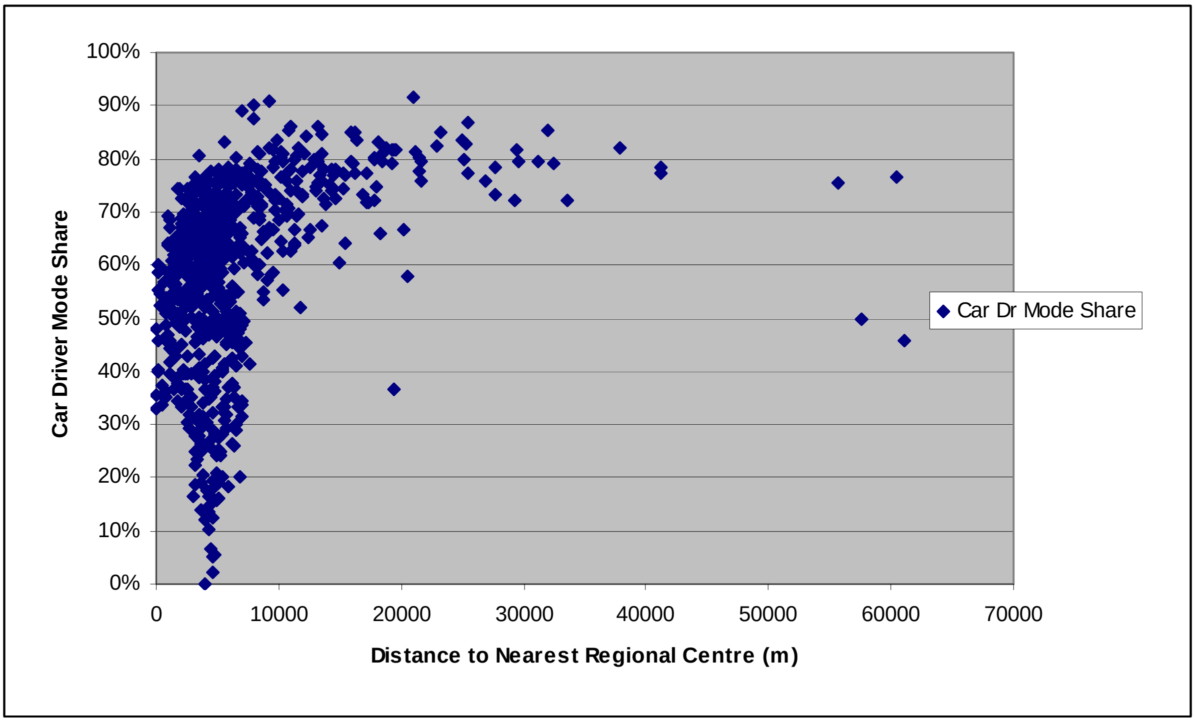


**Figure 12 Distance to nearest regional centre versus car driver mode share from zones (source: JTW Table 02, processing described in the text)**

Relationships between distance (as the crow flies) to the nearest regional centre and transit mode share were weak. Transit and other mode shares tended to fall with distance from regional centres, although the plots show considerable scatter. Bus mode share does show a slight rise as distance increases from the closest regional centre and then it declines.

Car driver mode share increases as distance from the nearest regional centre increases. This relationship is subject of scatter as shown on Figure 12.

## 5.6 Selected rail corridors

Three rail corridors were selected and their origin trips were analysed to identify how important being on a rail corridor was to mode choice. The Main Western Line corridor between Strathfield and Penrith; the Main Northern Line between North Strathfield and Hornsby and the North Shore Line between North Sydney and Hornsby were selected. Travel zones were included in the corridor if they were either touching the line or within a few hundred metres of touching it.

The mode shares for these selected corridors are summarised in Table 3. This shows that there is considerable variation in mode shares for journey to work trips from zones along the rail corridors. Also, train mode share along the corridors is higher than the average values for the Middle and Outer Rings (21 per cent and 11 per cent train mode share), in which these corridors' zones are primarily located.

**Table 3 Mode shares for journey to work origins for selected rail corridors (source: JTW Table 02, processing described in the text)**

| | Train | Bus | Car Driver | Car Passenger | Other |
|---|---|---|---|---|---|
| *Main Western* | | | | | |
| Minimum | 10.5% | 0.0% | 37.3% | 2.9% | 5.0% |
| Maximum | 48.1% | 5.5% | 72.3% | 11.1% | 18.5% |
| Average | 25.9% | 1.6% | 55.9% | 7.3% | 9.3% |
| Wgt average | 24.4% | 1.6% | 57.7% | 7.6% | 8.7% |
| Median | 24.7% | 1.3% | 56.0% | 7.2% | 8.5% |
| Count | 45 | | | | |
| *Main North* | | | | | |
| Minimum | 11.5% | 0.2% | 39.8% | 2.0% | 4.4% |
| Maximum | 44.2% | 14.6% | 67.7% | 9.3% | 11.3% |
| Average | 26.9% | 3.1% | 57.7% | 5.4% | 7.0% |
| Wgt average | 24.8% | 3.3% | 59.8% | 5.3% | 6.7% |
| Median | 24.4% | 2.3% | 60.7% | 5.2% | 6.6% |
| Count | 23 | | | | |
| *North Shore Line* | | | | | |
| Minimum | 7.0% | 0.0% | 24.3% | 1.3% | 3.2% |
| Maximum | 45.2% | 22.6% | 66.7% | 7.6% | 34.9% |
| Average | 30.2% | 4.7% | 47.6% | 4.3% | 13.1% |
| Wgt average | 29.8% | 4.6% | 49.6% | 4.4% | 11.6% |
| Median | 30.5% | 2.3% | 49.3% | 4.4% | 10.3% |
| Count | 40 | | | | |

Along the Main Western Line, train mode share *declines* with distance from the CBD. A linear curve yields an $R^2$ value of 0.43. Increasing distance from the nearest station is associated with declining rail mode share, even for zones within close proximity of the nearest station. Within the corridor, no zone has a mode share to rail greater than 25 per cent if it is more than 1.8 km from the nearest station.

Along the Main Northern Line, train mode share *increases* with distance from the CBD, with a linear curve having an $R^2$ value of 0.28. As the distance from the zone to the nearest station declines, train mode share also declines. A linear form has an $R^2$ value of 0.28.

Zones along the North Shore Line corridor exhibit a great deal of scatter. There is a very slight trend of increased train mode share as distance to the CBD increases, however the $R^2$ value is 0.02. As distance to the nearest station increases, rail mode share declines, although the relationship is also weak.

## 5.7 Summary

The above analysis shows very poor simple correlations between planning variables and mode choice of origin zones for the journey to work. With segmentation of the data, several correlation coefficients were achieved of between 0.60 and 0.80, however, many of the correlation coefficients were well below 0.50. While this exploration of the dataset does not rule out the existence of potentially useful simple relationships, it does suggest a number of potentially obvious ones appear to be fruitless.

Several alternatives are available to try to improve this position, including:

- Fine-grain the analysis using a lower level of geographic aggregation, such as is provided in Table 04 of the journey to work dataset. However, an objective of this paper was to use the more commonly used Table 02.
- Further segmentation of the data. An example of this is above in Section 5.4 when other mode share and proximity to the CBD was explored.
- Apply more information to the relationships.

The next section applies the last two ideas to the rail corridor analysis undertaken in Section 5.6.

# 6 More Detailed Exploration of Journey to Work Mode Choice along Selected Rail Corridors

Two additional planning variables were tested against rail mode share in the selected rail corridors described in Section 5.6. These were the number of trains to the CBD during the 7am to 9am period from each corridor zone's closest station, and the timetabled travel time from that closest station to Town Hall station in the CBD. While it is acknowledged that not all rail commuters are going to the CBD, these two measures provide an indication of the usefulness of rail services at zone's nearest rail station, to rail's major market.

Four multivariate linear models were tested for each of the three selected corridors. In all cases, the additional information improved the correlation coefficient, and identified statistically significant coefficients. The results are presented in Table 4 with each variable's coefficient and each model's correlation coefficient for the analyses based on distance to CBD alone for comparison purposes.

**Table 4 Coefficients of linear models for rail mode share, from origin zones selected corridors**

| | Variables | | | | $R^2$ |
|---|---|---|---|---|---|
| | Dist to CBD | Dist to Station | Peak Trains | TT to CBD | |
| *Main Western* | | | | | |
| Rail Mode Share | 0.121 | na | na | na | 0.16 |
| Model 1 | -3.52E-6* | -9.61E-5* | na | na | 0.57 |
| Model 2 | -3.14E-6* | -7.58E-5* | 0.0019* | na | 0.64 |
| Model 3 | na | -0.00011* | 0.0024* | na | 0.49 |
| Model 4 | na | -7.08E-5* | 0.00084* | -0.0038* | 0.62 |
| *Main North* | | | | | |
| Rail Mode Share | 1.0E-5 | na | na | na | 0.28 |
| Model 1 | 1.37E-5* | -9.67E-5* | na | na | 0.60 |
| Model 2 | 9.51E-6* | -8.17E-5* | 0.0061* | na | 0.69 |
| Model 3 | na | -7.00E-5* | 0.0093* | na | 0.58 |
| Model 4 | na | -7.75E-5* | 0.0028* | 0.0037 | 0.63 |
| *North Shore Line* | | | | | |
| Rail Mode Share | 2E-6 | na | na | na | 0.02 |
| Model 1 | 5.37E-6* | -0.00017* | na | na | 0.42 |
| Model 2 | 6.02E-6* | -0.00016* | 0.0017 | na | 0.43 |
| Model 3 | na | -0.00014* | -0.0016 | na | 0.31 |
| Model 4 | na | -0.00017* | 0.0025 | 0.0036* | 0.43 |

*Note – coefficients significantly different from zero, using the t-statistics, are denoted with **

The models for the Main Western Line have coefficients for distance to station and peak trains with signs as expected. The coefficient for the distance to CBD variable is negative, which was not entirely expected. However, given the distance from the western end of the corridor to major rail-served employment centres, it seems plausible. The distance to the CBD is a slightly more powerful variable than travel time to the CBD.

The Main North Line also has signs on coefficients as would be expected for distance to station and numbers of peak trains. However, as distance to CBD increases, so does rail mode share. This is probably the result of a decline in competing bus services as distance from the CBD increases and a possible relative travel time advantage over the car for longer trips. However, travel time to the CBD's coefficient is not significant, whereas distance to the CBD is.

The North Shore Line's models have coefficients with the same signs as the Main North Line. In this case the coefficient of the number of peak trains is not statistically significant, whereas travel time to the CBD is.

Each of the models' correlation coefficients are still poor, suggesting that further or different information is required to provide robust relationships. Of considerable note is that there is inconsistency between the three corridors for the sign of the coefficient for distance from the CBD, and that the number of peak trains does not have a significant coefficient for one of the corridors and that travel time to the CBD is not significant for another corridor.

This suggests that simple relationships or rules of thumb are going to be difficult to find without adding considerable complexity to data collection and analysis.

# 7 Conclusion

Sydney has a relatively high transit mode share for the journey to work of 22 per cent, when compared with other Australian capital cities, the next highest of which is Brisbane with a transit mode share of 12 per cent. Within Sydney, mode shares vary considerably, within and between the Inner, Middle and Outer Rings, as well as within and between SLAs. This substantial variation of mode shares suggests that there are opportunities to identify factors that might explain these differences.

The cumulative distribution frequency for car mode share for the Middle and Outer Rings, in particular, shows that a small difference in mode share corresponds to a very substantial change in a zone's mode share ranking within the ring. In the Middle Ring, roughly 60 per cent of zones have car mode shares between 55 and 70 per cent.

Resident workforce density in a zone was weakly correlated with transit mode share, this weakness was especially marked in the Inner and Middle Rings. Zones in the Outer Ring exhibited a slightly stronger relationship.

Proximity to the rail network showed a more marked correlation for Middle Ring zones, with a log distance to nearest station relationship having an $R^2$ value of 0.57. Surprisingly, zones within 2 km of their nearest station had a weak linear relationship between distance to station and train mode share, with an $R^2$ value of 0.20.

The proportion of CBD workers in an origin zone had a very weak relationship with train mode share. However, when transit mode share was used, a positive linear correlation with an $R^2$ value of 0.63 was produced. When the car driver mode share was used, a negative correlation with an $R^2$ value of 0.69 resulted.

The proximity of a zone to the CBD does not show a strong relationship with train mode share, even when only zones within 3 km of the nearest railway station are included. However, other mode share for zones within 4 km of the CBD has a negative linear correlation with an $R^2$ value of 0.74.

The proximity of a zone to its closest regional centre does not provide a close relationship with transit mode share.

Zones along selected rail corridors had higher than average train mode shares for the rings in which they are located. Along the Main Western Line corridor, rail mode share declines as distance from the CBD increases, while on the Main Northern Line corridor, rail mode share increases with distance from the CBD.

The application of linear multi-variate analysis to explain rail mode share along three selected rail corridors produced models with improved explanatory power when compared with their single variable analyses. However, they still had modest correlation coefficients. Of greater concern was that they did not have consistent signs for all their coefficients, and some variables were statistically significant for one corridor but not for another.

This suggests that data will require relatively detailed segmentation to provide robust rules of thumb, in conjunction with multi-variate analysis. Disaggregation of the level of geographic information is probably also required in order to improve estimates of travel costs. This is moving away from the initial objective of this paper, i.e., to produce simple rules of thumb or relationships. Nonetheless, a detailed and systematic analysis of the journey to work dataset appears to be warranted, as some rules of thumb may well be in the data, somewhere.

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