

**WORKERS' HOMES & WORKPLACES - HOW
WELL DO THEY MATCH?**

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ABSTRACT

Providing for travel to employment has traditionally been seen as one of the most important components of transport planning. However, due to the lack of comprehensive data, we do not have a real understanding of the relationship between choice of home location and choice of work location; for example do people live near where they work, or work near where they live? This paper provides a detailed examination of the distribution of workers residences and workplaces in Melbourne.

Data is derived from Australian Bureau of Statistics Census Data, and the Victorian Integrated Travel Activities and Land-Use (VITAL) toolkit produced by the Transport Research Centre. Geographic Information Systems enable us to use new methods of data presentation to obtain new insights into the spatial distribution of workers. Workers' homes and workplaces are disaggregated to a census collection district level and by industry. A ratio of employment density to residential density is produced for each zone and the journey to work trip lengths examined for residential zones with different ratios. It is shown that journey to work distance tends to decline as the ratio increases, providing tentative support for the concept of mixed use residential developments as a way of reducing journey to work distances.

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Introduction

Providing for travel to employment has traditionally been seen as one of the most important components of transport planning. However, due to the lack of comprehensive data, we do not have a very good understanding of the relationship between choice of home location and choice of work location; for example, do people live near where they work, or work near where they live? As transport planners, we have developed modelling techniques where land use is a key input. However, we still lack a real understanding about the interactions between transport and land use.

Because of this lack of understanding, we are unable to answer fundamental transport planning questions such as: How does residential development follow employment development? How does employment follow residential development? How does employment and residential development follow transport development? Once we begin to understand the interaction between transport and land use, we can begin to answer these questions.

Another question which many people want answered is what is the desired structure for an efficient city? This question assumes we have at least one definition of efficiency which, of course, depends on the personal or ideological stance of those performing the analysis. This last point often appears to be denied by planners and is worthy of a more thorough discussion. Unfortunately, this topic cannot be accommodated within this paper except to say that transport planning, like economics, is a blend of the study of science and the humanities, and involves both the mathematical purity and human subjectivity associated with both.

The relationships between transport and land use have not been without debate in recent times. A well known claim by Newman & Kenworthy (1989) is that higher population densities produce more public transport travel and reduce fuel consumption. The empirically-based hyperbolic relationship between fuel consumption per capita and population density is refuted by Brindle (1994), where it is shown that a hyperbola is the inevitable shape produced by having people as the denominator in annual gasoline use per capita and also as the numerator in persons per hectare.

Another hypothesis is that it is not urban density on which we should be concentrating, but that we should be mixing land use; that is, mixing employment and residential areas to reduce journey to work travel distances. As with the density hypothesis, which looks at manipulating urban structure to obtain a desired transport outcome, this idea also leaves itself open to be attacked as a policy based on an idea rather than a policy based on knowledge. The aim of this paper is not designed to attack this idea but rather to add knowledge to it.

This paper attempts to look at the effects which mixed land use has on travel behaviour, in particular how mixing workers' homes and workers' workplaces may affect the average journey to work distances. We attempt this by looking at the location of individual industries, how they are distributed and how well they match with the location

of workers' homes for those industries. This paper investigates whether there is, in fact, a relationship between degree of land use mix and average journey to work distances, and discusses implications this should or should not have for planning policy.

Data Sources

There were three main databases needed for the analysis; an employment database giving to location of employment activity, a demographic database giving the location of workers' homes (these two databases are in the same format), and a journey to work database with information about journey to work trips which can be related to the first two databases. By the end of the study, five databases had been made with the creation of two extra employment databases.

An employment database which gives some measure of employment activity is essential for most land use and transport studies. These databases can hold different indicators of employment such as the total amount of floor space in a region or the total amount of employment sites in a region. More commonly, employment databases measure the total amount of work places in a given region. The workplace databases can vary by their spatial aggregation, that is the size and shape of the employment zones. They can also be disaggregated by the type of employment, that is into industry or profession, part-time or full-time employment, or disaggregated by gender.

Most researchers or planners would prefer to have employment databases as highly disaggregated as possible both spatially and by employment type. However, there is no easily obtainable employment database of this type for Melbourne. The Australian Bureau of Statistics (ABS) produces an origin destination matrix from the journey to work data provided by the census. This data is disaggregated by type of industry and by gender and also by mode of travel. However it is spatially aggregated to the relatively high level of statistical local area (SLA). There are only fifty-eight SLAs within the Melbourne Statistical Division, therefore for the sake of creating a spatially disaggregate employment database this data appears inadequate by itself.

An employment database with fine spatial disaggregation was therefore developed by the combination of different data sources using a technique developed by Loeis et al (1995) as part of the Victorian Integrated Travel, Activities and Land-Use (VITAL) toolkit. This database is disaggregated by industry in accordance with the Australian Standard Industrial Classification (ASIC) system, and is spatially disaggregated to the census collection district level (CCD). The ASIC system is widely used and importantly is the system used by the ABS in the 1991 census. CCDs have been the basic building block used by the ABS, with approximately 5,000 CCDs within the Melbourne Statistical Division.

The two main sources used to develop the employment database were the Journey to Work Data from the 1991 Census and the Telecom (now Telstra) Business FinderTM (TBF). The TBF is an electronic version of the Yellow Pages and contains the type of business and street address of businesses which are found in the Yellow Pages. The TBF provides a database of workplaces which can potentially be geocoded with the

disaggregation level being that of address location. Therefore we have a very fine distribution of worksites which can be aggregated up into any zone of suitable size. Census Collection Districts were the zones chosen to aggregate the TBF data, giving a database of worksites spatially aggregated to the CCD level.

Furthermore, the TBF follows the same business classification system as the Yellow Pages. This classification system, however, is based on the product or service produced or sold at the site rather than the ASIC defined industry. As a result when ASIC codes are assigned to the TBF codes in some cases there are multiple ASIC codes for the one TBF code. Therefore it is possible to further disaggregate the TBF database by ASIC codes so long as it is realised that there could be multiple countings of work sites.

The ABS Journey to Work (JTW) data is used to convert the database from number of sites to actual number of workers. The JTW data contains the total number of people who travelled to work with home origins and work destinations given at Statistical Local Area (SLA) level. The data is disaggregated by ASIC industries, by sex and by mode of travel. Therefore the difference between the TBF database and the JTW database is that the TBF is an employment site database at the small CCD level, whereas the JTW is the total amount of employment at the larger SLA level. The problem now becomes one of distributing the values for the number of workers from SLA level to CCD level based on the number of worksites at CCD level. This is done by distributing the number of workers in proportion to the number of workplaces in each CCD for each ASIC group. This assumes that the size of each workplace for a given industry is constant across a given SLA. While this is known not to be strictly correct, it has proven to be a useful working assumption.

The second database which gives the location of workers' homes, disaggregated to the CCD and ASIC levels, is taken straight from CDATE91 (the 1991 Census CD-ROM).

The third database is derived from the Victorian Activity and Travel Survey (VATS) produced by the Transport Research Centre (TRC). VATS is a household-based survey providing a detailed description of daily travel and activity patterns of household members in Victoria. The survey records all travel by all modes by all people in responding households in the survey sample. Each household is asked to provide this information for a specified travel day, however the survey is a continuous process, covering all 365 days of the year.

The data obtained from the survey falls into seven major categories (files):

- household information
- person information
- stop (trip-stage) information
- trip (all stages on a single purpose trip) information
- vehicle information
- trip chain information
- route information

The database used in this study is taken from the trips file from VATS. It contains all trips which are the first trip of the day to a location where the purpose was given as work. Not all of these were home to work trips, however, due to the complex nature of trip chaining. An approximate home to work distance was calculated for these trips based on the rectangular grid distance.

The final two extra employment databases were derived from the above VATS journey to work database. They were the VATS work origin database and the VATS work destination database. They were not as finely disaggregated as the first two employment databases, however they can be related directly back to the trip database therefore gaining trip information. All of the databases are stored in a GIS format so they can be viewed graphically.

Distribution of Workers' Homes and Workplaces

The first two databases provide interesting viewing, as shown in Figure 1. The map on the left shows the density of workers' residences. This map is very similar to a map of total population density with perhaps slightly lower relative densities in the outer suburbs, where the ratio of workers per capita is lower than in inner suburbs. The map on the right shows the densities of workplaces drawn at the same scale as its neighbour. Both maps are disaggregated to the census collection district level with the white areas being densities less than 1,000 people or jobs per square kilometre and the black areas being greater than 3,000 people or jobs per square kilometre with grey areas representing between 1,000 and 3,000 people per square kilometre.

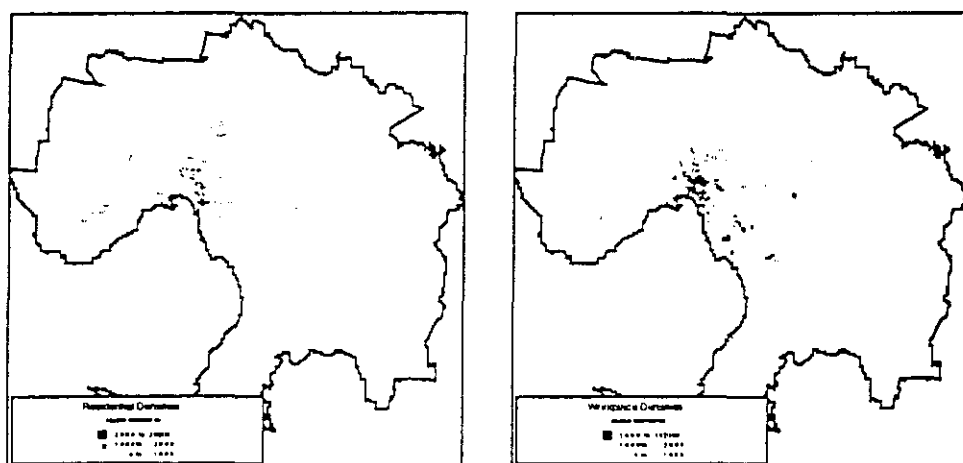


Figure 1 Densities of Workers' Homes and Workplaces

Over the entire area, the average density of workplaces is equal to the average density of workers' residence if it is assumed that the in-migration of workers balances the out-migration of workers (a reasonable assumption for Melbourne). However the workplaces tend to concentrate together in high density pockets with the CBD being the most obvious concentration of workplaces. From a distance, the distribution of workplaces appears to stretch out along the radial public transport corridors with the residential areas filling in the rest of the city. The employment map could be seen as an historic view of Melbourne before in-fill between transport corridors occurred.

These two maps show an aggregation of all industries. However, there is further interest in viewing these maps when separated into individual industries. The examples shown in Figure 2 and Figure 3 are for Manufacturing workers and Wholesale & Retail trade workers respectively. Manufacturing workers are seen to live in the northern and western suburbs as well as the outer south eastern suburbs. Manufacturing jobs are also found in these regions although in slightly smaller pockets and in higher densities. The manufacturing jobs are also found more in the inner suburbs and the far eastern suburbs. Although the jobs are found in the same general regions as the homeplaces there seem to be very few zones with both a large number of workplaces and homeplaces.

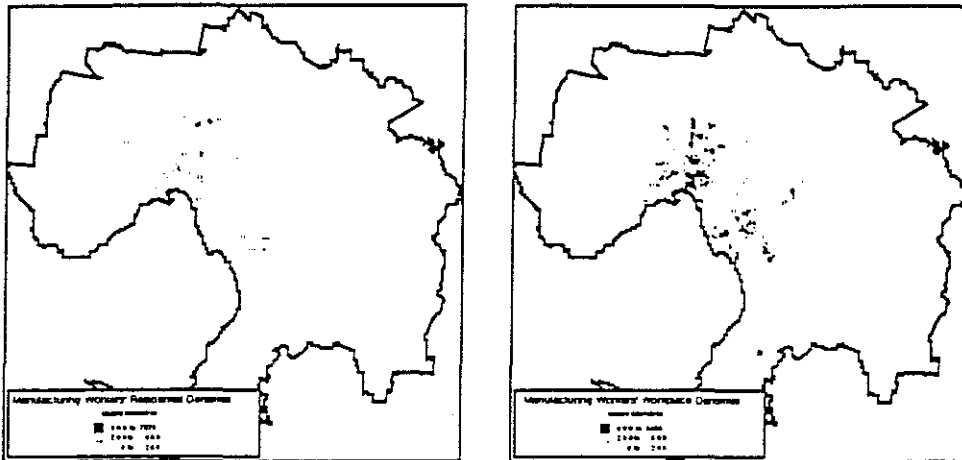


Figure 2 Manufacturing Workers' Homeplaces and Workplaces

The wholesale and retail trade (WRT) workplaces and homeplaces have a different distribution to that of manufacturing. The WRT workers live across the entire city with no particular area having a disproportionate amount of workers' homes. The workplaces have a slightly different distribution, again covering the entire metropolitan area but slightly more concentrated along transport routes and minor centres. In both Figure 2 and Figure 3 the white areas represents fewer than 200 jobs or people per square kilometre while the black areas represents greater than 600 jobs or people per square kilometre with grey areas representing between 200 and 600 people per square kilometre.

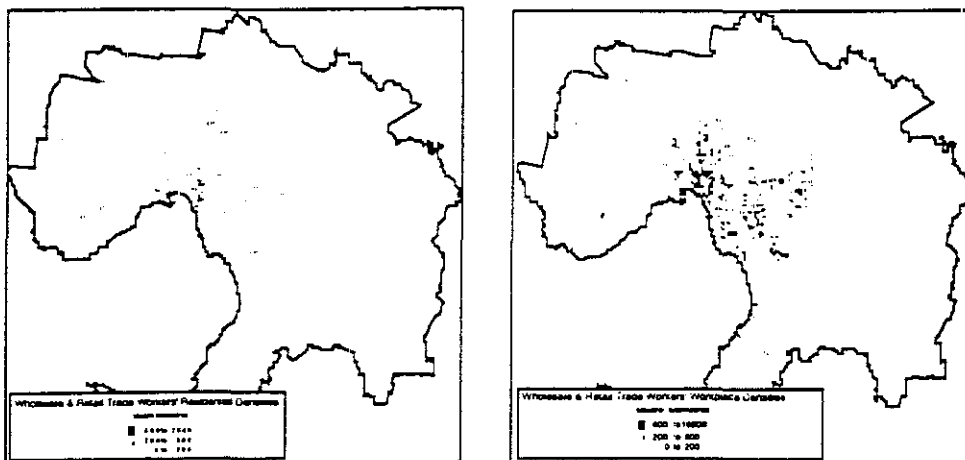


Figure 3 Wholesale and Retail Workers' Homeplaces and Workplaces

Density Ratios

A simple measure for determining how well workplaces and homeplaces match is to calculate a ratio for each residential zone of the density of employment in each zone to the density of workers living in that zone. A ratio of greater than one means that there is more employment in a zone than there are workers living in that zone, with a ratio of less than one meaning the opposite. However before calculating the density ratios, the size of the zones to be used must be determined. Initially, the employment databases are disaggregated to the Census Collection District (CCDs) level from which larger zones can be created. CCDs would appear to be too small for this type of analysis because, being defined in terms of number of households, they would show a very large variance in ratios with extreme values possibly foiling meaningful analysis of the results. Statistical Local Areas (SLAs) were likewise seen to be too large an area causing a reduction in any reasonable variance on which to conduct analysis. Therefore the Census Sub-Division (CSDN) was chosen as the zone to use, there being 465 CSDNs in the Melbourne Statistical Division compared to 4,983 CCDs and 58 SLAs.

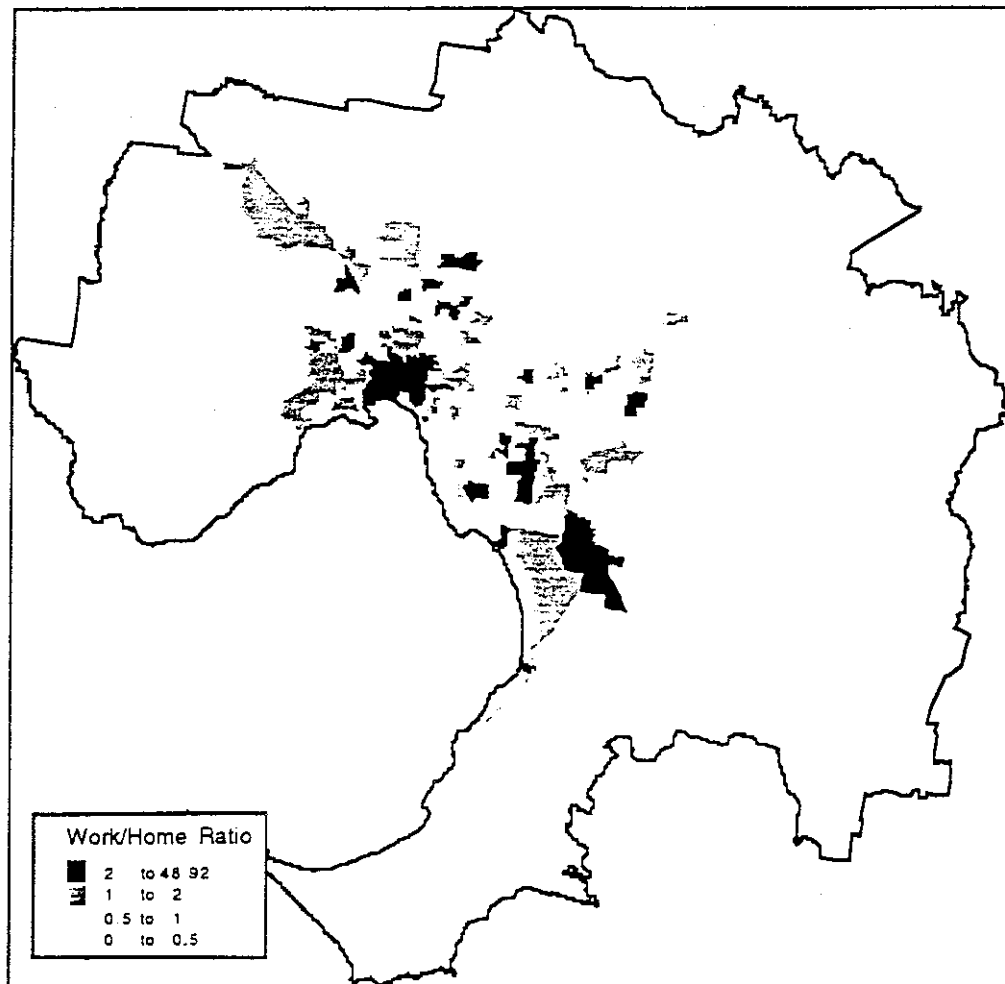


Figure 4 Density Ratios for all Employment Groups

Figure 4 shows the results of calculating the density ratios for all of the CSDN zones in Melbourne. The white area is for density ratios between 0 and 0.5, the lightest grey between 0.5 and 1 followed by 1 and 2 with the darkest being for ratios greater than 2.

The distribution of density ratios can be graphed to determine how many zones have ratios greater than one or less than one. More importantly, it can show how many people live in zones with density ratios greater than one or less than one, and how many people work in zones with ratios greater than one or less than one. Figure 5 shows the distribution of the number of workers' residences and the number of workplaces in zones of different ratios. It can be noted that the second distribution can be created from the first by multiplying by the density ratio for that zone. Therefore, the two curves must cross at a ratio of 1.0. The Central Business District is excluded from this graph as it has an extreme ratio of 48. The range shown of 0 to 5 was chosen to give a clear picture of the distribution at the low end of the scale. From Figure 5 it appears that many more people live in zones with density ratios less than one. Figure 6 is a cumulative graph showing the percentage of workers living in zones with various density ratios.

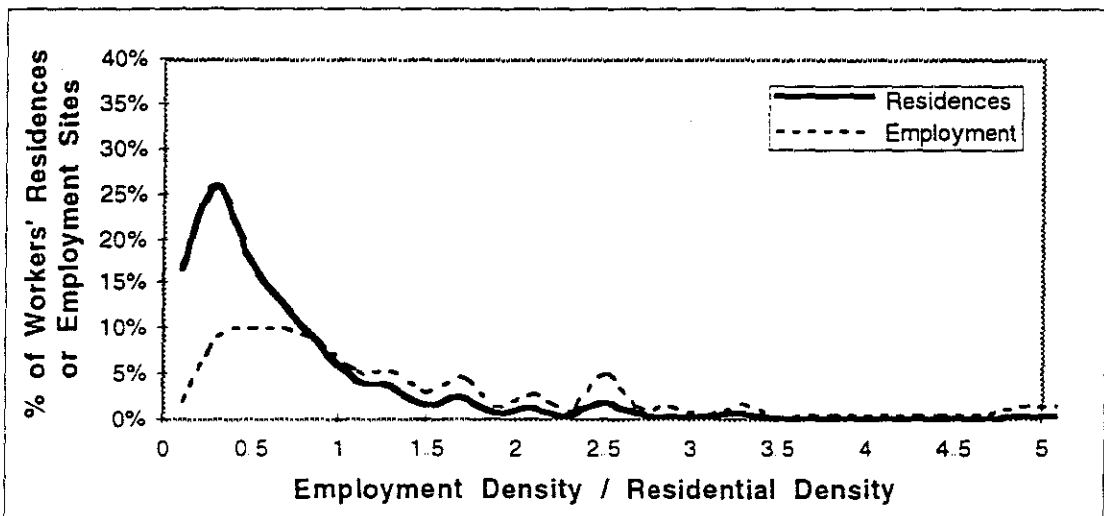


Figure 5 Distribution of Workers and Employment by Density Ratio

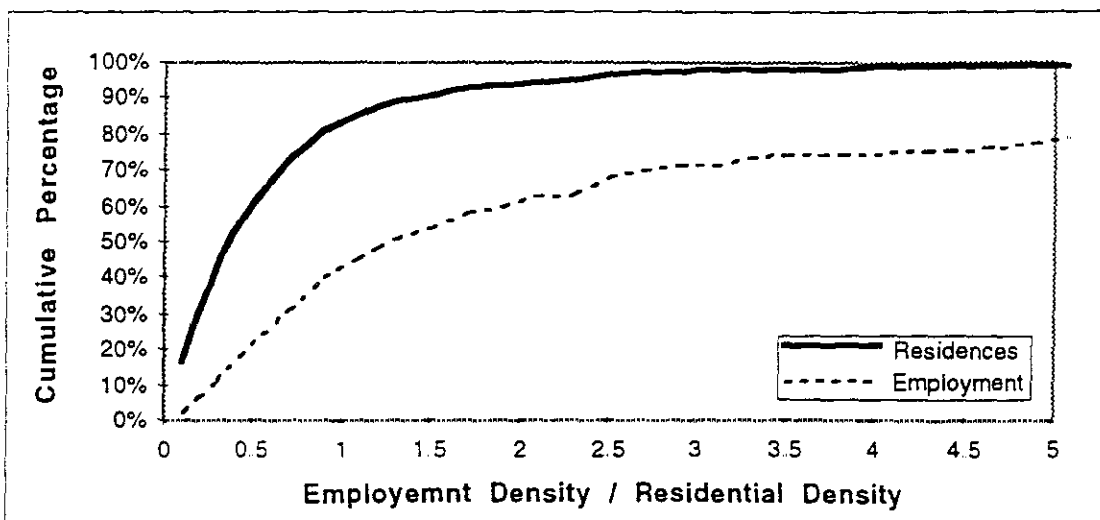


Figure 6 Cumulative Percentage of Workers and Employment by Ratio

From here it can be seen that approximately 80% of the working population live in zones with a ratio less than one and approximately 40% of jobs are found in zones with ratio values less than one. One could then ask the question "What is the average value of the density ratio for all workers residences?". The answer to this question is that the average ratio for workers' residence is equal to one, and will always be equal to one no-matter what the distribution looks like. This surprising result can be simply explained by the fact that the density ratio is defined as the number of employment places divided by the number of worker residences in a zone. For an entire region, where the total number of workers and total number of employment places is equal, the total ratio will be one. The average value of density ratio for employment places is approximately 7.4. This number, which is not even within the scale of the graph, is high due to the extremely high value of 48 for the Central Business District.

This average density ratio of one for residential locations may in fact be more than just a trivial mathematical fact. It may have planning implications, especially if there is a push to increase the amount of mixed land use. For example, the reason most workers live in areas with a small ratio is because, by definition, there is a small amount of people living in zones with very high density ratios. Therefore, if a desired policy outcome is to have more regions with density ratios greater than one, this cannot be achieved without reducing density ratios in another part of the city.

Disaggregation by Industry

One of the advantages of having employment databases disaggregated both spatially and by industry is that it gives a large number of sub-samples of the data which can be analysed. Results are shown below for the distribution of density ratios for selected industries. Of key interest is whether any industries appear to have better correlations between the locations of the workplaces and the locations of the workers' homes. This can, in part, be examined by an analysis of the distribution of density ratios for each industry.

Figure 7 shows maps of CSDN zones shaded by the density ratio for four different industries. The problem with these maps is that they hide the actual amount of activity in each zone; for example, a zone with 1000 jobs and 200 workers' residences will have a density ratio of 5, as will a zone with 10 jobs and 2 workers living there.

To gain a better understanding of the patterns shown in Figure 7, the distributions of density ratio are shown in Figures 8 through 11 for the four industries. Figure 8 shows the worker and employment distributions by density ratio for Manufacturing. This shows that a very large proportion of manufacturing workers live in zones where there is no or very little manufacturing work. This does not necessarily mean that manufacturing workers must travel a long way to get to work. It simply shows that manufacturing jobs are generally not in the same CSDNs as manufacturing workers' residences. This could be due to planning regulations, which separate manufacturing areas from residential areas, or a low demand for housing in areas where there is manufacturing industry. Most workers in this industry live in the western, northern and outer south eastern suburbs of Melbourne, generally considered the working class areas of Melbourne.

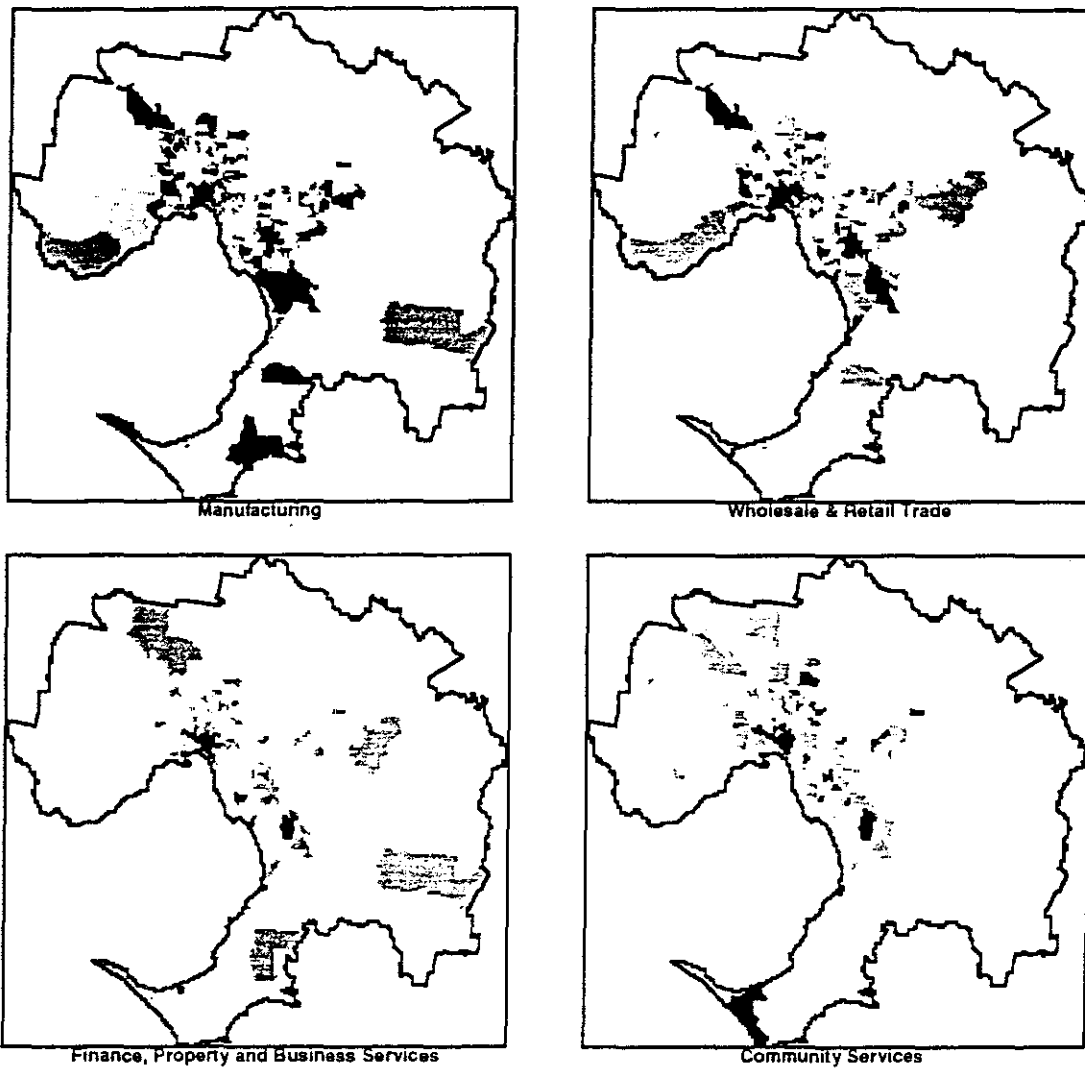


Figure 7 Density Ratios for Various Industries

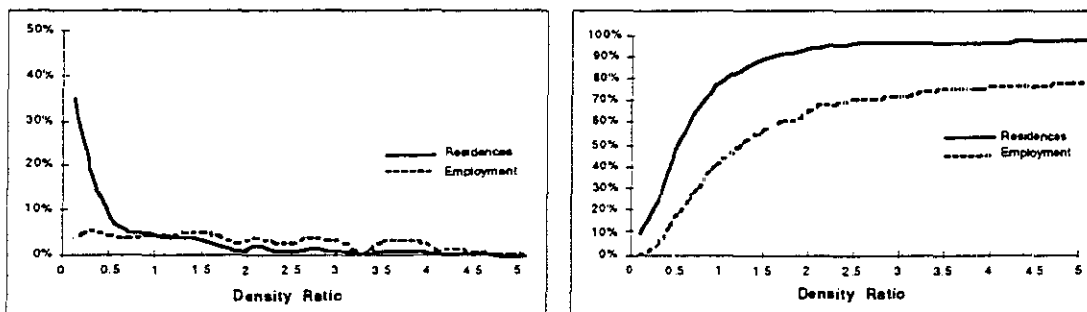


Figure 8 Distributions of Workers and Employment by Density Ratio for Manufacturing

Figure 9 shows the worker and employment distributions by density ratio for Wholesale and Retail Trade. These graphs indicate that WRT workers, more often than manufacturing workers, live in zones which also have jobs in their industry. This would seem appropriate for jobs such as part-time sales assistants. The cumulative curves for these two industries are slightly different but show some similar characteristics.

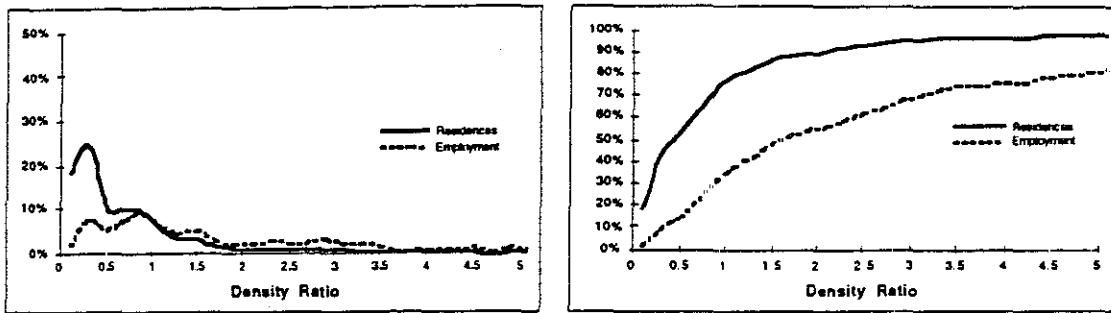


Figure 9 Distributions of Workers and Employment by Density Ratio for Wholesale and Retail Trade

Figure 10 shows the worker and employment distributions by density ratio for Finance, Property and Business Services. Although the frequency distribution appears similar to that for WRT workers, the cumulative frequency distribution shows that a substantial amount of jobs in this industry are found in zones with ratios greater than five. A large number of these jobs are found in the Central Business District. It appears that this type of industry prefers to be around other jobs rather than people, although some are also found in residential areas. Most workers in this industry live in the inner or inner eastern suburbs of Melbourne, generally areas with high property prices and high incomes.

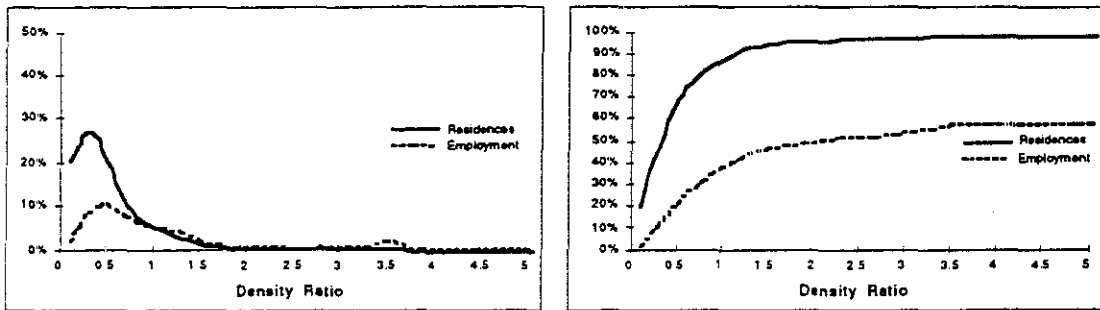


Figure 10 Distributions of Workers and Employment by Density Ratio for Finance, Property and Business Services

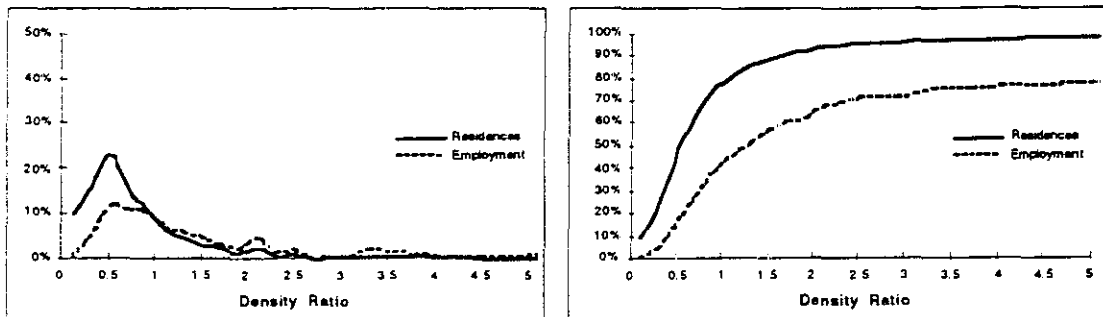


Figure 11 Distributions of Workers and Employment by Density Ratio for Community Services

Figure 11 shows the worker and employment distributions by density ratio for Community Services. These distributions show that this industry has the best matching of workers and jobs of the four shown in this paper. Community Services includes

education and health, which are services which tend to follow the population in order to spread the accessibility of these services around for everybody.

Work Trip Lengths

A hypothesis to be tested in this section of the paper is that workers living in areas of mixed land use will travel less distance to work than those living in predominantly residential areas (Kaufman & Morris, 1995). We can test this using the journey to work database produced by the trip file in VATS. This database contains the workers' home and work destination as geocoded points. Therefore the trip distance can be calculated in addition to producing density ratios by dividing the number of destination points by the number of origin points in each zone.

It is assumed that other factors such as distance from the Central Business District may influence trip length as much as the local land use mix, so the metropolitan area was divided into regions of varying distance from the CBD, as shown in Figure 12.

For each CSDN zone within these regions, an average journey to work distance and a density ratio is calculated. It is therefore possible to plot the average trip length per CSDN zone by the density ratio value for each zone. Furthermore, this can be separated by the regions shown in Figure 12. Regions based on distances from the Central Business District will account for trips to the CBD which may dominate the analysis. It also separates the metropolitan area into regions of similar total accessibility as accessibility has a correlation with centrality.

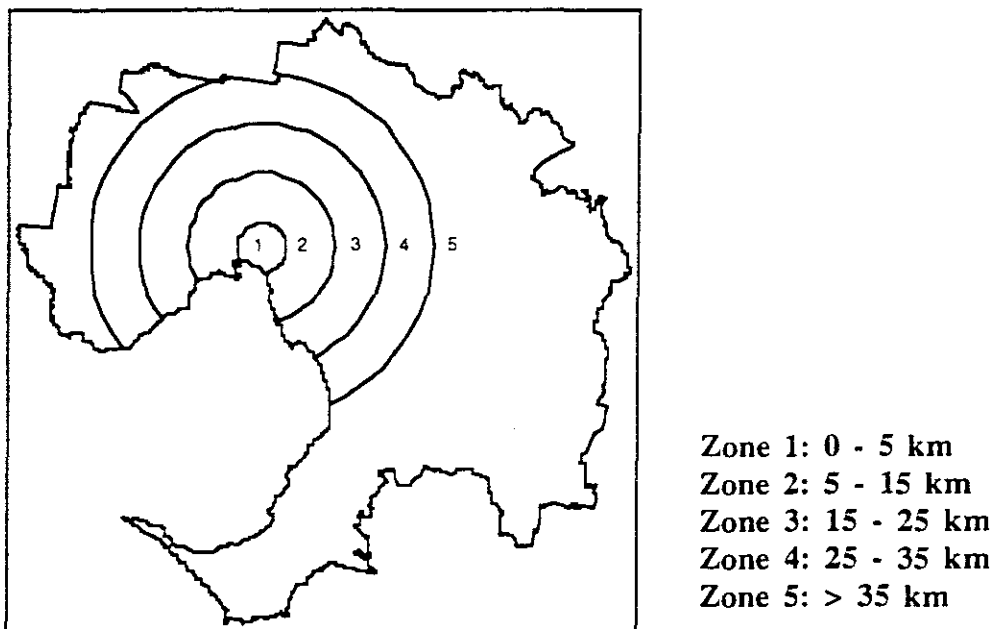


Figure 12 Regions at Varying Distance from CBD

Figure 13 shows plots of average trip distance for each CSDN zone by CSDN density ratio for different distances from the CBD. Linear regressions are fitted to these plots. The r-squared values for the regressions are very small due to the large amount of scatter,

which raises doubts as to whether any real trend can be determined with any statistical confidence. However, all of the regressions displayed a negative slope indicating that for a given region, at a certain distance from the CBD, the average trip length of the journey to work is smaller in zones with higher density ratios. That is, areas with a mixture of homes and worksites tend to produce shorter journey to work distances.

The final graph in Figure 13 compares the regression lines for the different regions. It can be seen that for any given density ratio, the trip distance in region 1 is less than the trip distance in region 2 which is less than the trip distance in region 3 and so on. That is, regions further from the CBD have higher journey to work distances. This graph also indicates that the difference between the trip distances in each region reduces as the density ratio increases. This suggests that there is a very high density ratio at which the trip lengths are at a similar low value no matter where the zone is located. However there seems to be only minor variation in trip lengths for ratios which vary between 0 and 2.

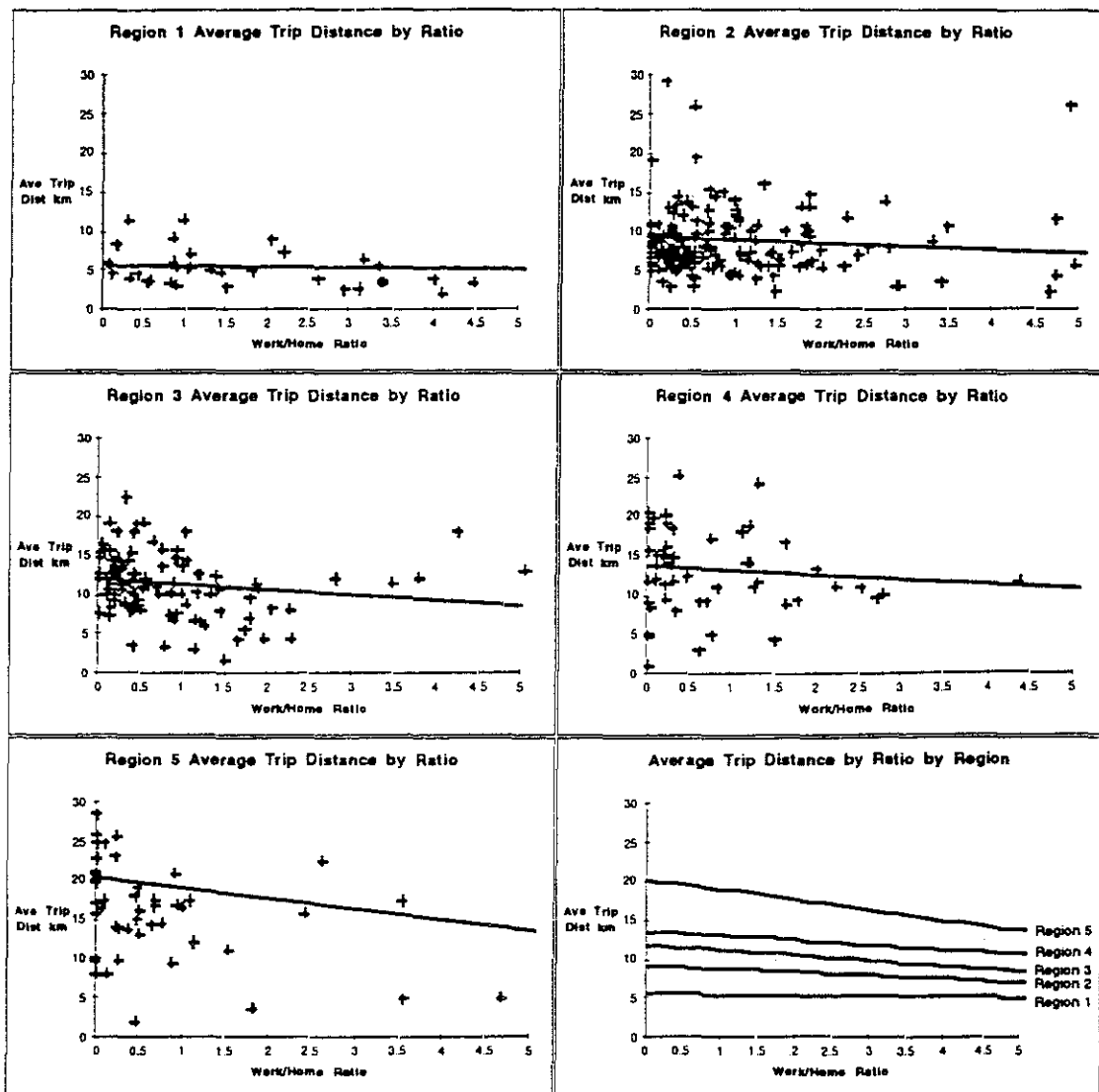


Figure 13 Average Work Trip Distance by Density Ratio by Region

The high degree of scatter in these plots suggests that a relationship between work trip length and density ratio for a particular zone is not strong. The density ratio is used as a very localised form of measuring accessibility which raises a problem when zones with low ratios are surrounded by zones with high ratios. Perhaps a wider measurement of accessibility is needed for these cases. Another measure which could be used is the degree of internal trips made in zones. It is the assumption that internal trips increase with mixed land use (which leads to an overall reduction in trip lengths) that needs to be tested.

Planning Implications

What are the planning implications from this research? One obvious but perhaps overlooked fact when considering mixing land use is that if we add a particular land use to a zone or region then we must be taking it from some other part of the system. This fact has long been supported by those who believe in the zero sum society. This has an effect with regards to density ratios; for example, if we wanted to increase the amount of employment places in predominantly residential areas, in order to increase the density ratio, we must somewhere else reduce a ratio in order to gain these jobs.

Increasing the degree of mixed land use then becomes a balancing act. The zone in metropolitan Melbourne which has the highest capacity to lose jobs, and still retain a high density ratio, is the Central Business District. The decentralisation of employment from the CBD to the suburbs is a real and continuing occurrence and has been cited by many as a factor in reducing public transport use and increasing fuel consumption. This may be true. However, according to the density ratio theory it will also reduce the overall trip lengths of journey to work.

An alternative would be to keep the jobs where they are and move people to them. In particular, we could move people into and around the CBD where the highest ratios exist. This would require an increase in population density in the inner suburbs, a policy which has been pursued with very limited success in recent times. This again leads us to the question of whether or not we should try to manipulate urban structure to reach a desired transport outcome. It could be argued that it is more important to manipulate transport structures to reach a desired urban outcome.

All of the above assumes that there is a real relationship between land use mix and trip distances. This research shows that there may be a link. However, it does not appear strong, and other more complex issues may be deciding household and workplace locations.

Conclusion

How well workers' homes match with the location of their industries has been analysed, and the concept of the density ratio as a measure of land use mix has been developed. When disaggregated by industry, the distribution of these ratios gives a new way of analysing the structure of urban society.

This paper has investigated a possible link between land use mix and work trip lengths. In doing so, it has ignored all other influences on travel behaviour except household distance from the Central Business District. Although a possible link was found between land use mix and work trip length, further work needs to be done which takes into account the complexity of the decision making process, including household commitments, and the effects of the moves towards trip chaining. The search for an understanding of the relationship between transport and land use continues.

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