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Mixed land use index and public transport catchments

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Abstract

A mix or diversity in land use has been broadly recognised as having a positive correlation with active and public transport. Increasingly questions are raised about the characteristics of public transport trips particularly in relation to the fact that most actually consist of two walk components and one public transport component. This paper seeks to gain a greater understanding of walk only trips to public transport, especially train stations. Does a greater level of land use mix, or more equal land use mix around train stations in northern Melbourne correlate with higher levels of walking to that station or is the need to access the station itself sufficient to support walk only trips to the station? What is the potential of mixed use to increase and encourage greater levels of walking to stations? Could the application and use of a mix index as part of station area development assist in planning environments that contribute to increases in walking to access train stations?

This paper aims to take the first step in addressing these questions in the Melbourne context to identify any broad trends and patterns, any relationships and additional data requirements and directions for further research. To address these questions this paper adopts and tests a Dutch mix index that identifies an equal mix of residential and non residential uses as the optimum land use mix. This index will be applied in the Melbourne context to analyse the mix of land uses within a 1km catchment of train stations in the northern corridor of Melbourne and to examine the relationship between the land use mix and levels of walking to each train station.

1. Introduction

This paper examines the extent of the existing mix of uses in train station catchments in the northern region of Melbourne, within three local government areas Yarra, Darebin and Whittlesea. For this study, a variation of the 'mixed use index' (MXI) developed by van den Hoek (2008) has been used and tested. This index identifies the ratio of residential to non-residential land use. The index was developed to make the complexity of the functional mix in an urban district discussable, comparable and measurable through a simple index.

In the research a mixed use index developed by van den Hoek (2008) was adopted and tested which develops a ratio of residential to non-residential land use. For the MXI the ideal score to achieve a vibrant and walkable city has been defined as 50, reflective of a 50/50 mix of residential and non-residential land uses. In contrast, an area with the MXI = 100 has only residential uses and an area with the MXI = 0 has no residential uses. The index is measured on the walkable scale of urban blocks within an urban district and in terms of floor space (Van den Hoek 2008:5). Van den Hoek argues that 'It does not come as a surprise that inside the city ring of Barcelona the proportion of residential vs non-residential has always been kept on the same 50/50..since the very beginning of the 19th century (Busquets 2005).

The metropolitan urbanity of Barcelona within the ring and the canal zone of the Amsterdam provide proof from experience that in order to create a lively and vibrant city centre the 50/50 proportion works' (Van den Hoek 2008:4). The advantage of this index is its (intended) simplicity. However, this translates at the same time into a shortcoming as a 50/50 mix can mean an area with 50 per cent residential uses and 50 per cent open space/park uses as well as 50 per cent residential uses and 50 per cent commercial uses. This makes the 50/50 index somewhat opaque. Nevertheless, this 50/50 ratio will be tested in the analysis of public

transport catchments in Melbourne's north, in order to be able to assess the usefulness of the index better.

Mixed land use is commonly cited as a built environment characteristic that has an important role to play in the amount of walking trips. Rodriguez (2004) states that research has suggested that the presence of certain attributes of the local environment is related to a higher number of (non-motorised) non-work trips. In particular, pedestrian trips tend to increase in the presence of mixed uses of land, improved street connectivity and higher employment and population density at the origin and the destination (Greenwald and Boarnet, 2000; Cervero, 1996; Frank and Pivo, 1994; Handy, 1996; Kitamura et al., 1997)

The index used in this paper is based on an analysis of mixed use as indicated through land use zoning. The index identifies the area within the specified catchments of residential and non residential zoning. Residential zoning included for the purposes of the paper were residential zone one (R1Z) and two (R2Z). Using this index, the analysis identifies areas of more equal residential and non residential land use mix and examines their correlation with walking to public transport. To examine correlations and make comparisons the 50/50 ratio is converted to a single figure, for example 50/50 equals a Mix Index single figure of 1. A 25/50 ratio converts to a Mix Index single figure of 0.5. It is recognised that a variety of other factors will influence the access and egress modes to trains stations and public transport stops. These will vary from the role of the station in the system, such as an interchange, to the daily routines of people using public transport, such as the opportunity to save time in the morning and perhaps get a lift to the stations rather than walk.

2. Literature review

Precedent papers that specifically examine the relation between mix of land use proximate or adjacent to public transport and the share of walking as access and egress modes are few. Papers that contribute to parts of this discussion are summarised below.

Proximity to transit or public transport is often included as part of a definition of walkability. An area is typically considered 'walkable' if it has all or some of the following attributes: high street intersection density or permeability, good mixed use, medium to high density, and is proximate to public transport. Increased land use mix tends to reduce the distances that residents must travel for errands and allows more use of walking and cycling for such trips. It can reduce commute distances (some residents may obtain jobs in nearby businesses), and employees who work in a mixed-use commercial area are more likely to commute by alternative modes (Modarres, 1993; Kuzmyak and Pratt, 2003). 'Land Use Mix refers to locating different types of land uses (residential, commercial, institutional, recreational, etc.) close together. This can occur at various scales, including mixing within a building (such as ground-floor retail, with offices and residential above), along a street, and within a neighborhood.

A 2010 Adelaide based study by Duncan et al. (2010) examines a GIS based LUM (Land Use Mix) analysis measured by Census Collection Districts (CCD) area, and levels of 'utilitarian walking'. Utilitarian walking or walking for transport is defined by Duncan et al. as walk trips with a destination in a land use other than recreation (2010:786). Their findings suggest that the relationship between CCD-level LUM and walking for transport is best assessed using LUM measures that account for geographic scale (of the CCD); include only theoretically relevant land uses (relevant to walking as transport) or both. Bus and train stops were included in this work as theoretically relevant to walking for transport. The authors argue that 'accurate assessment of LUM and development of more precise benchmarks through further research may be needed to assist informed decisions about the planning and design of activity friendly neighbourhoods' (Duncan 2010:792).

A 2005 study by Ryan and Frank of the San Diego Metropolitan Transit system found a small but significant positive correlation between walkability of the built environment and transit ridership. The research assessed the relationship between transit ridership and the quality of the pedestrian environment near bus transit stops. Higher levels of walkabilty in a station area are associated with higher bus ridership at any particular station. Walkability was defined as using a walkability index comprised of land use mix, residential density, retail floor area ratio and intersection density. Ryan and Frank argue that 'This work supports an approach to transit planning where transit stops are centrally located within dense, mixed use activity centres, rather than skirting the periphery of the activity centres which has traditionally happened to placate transit resistant neighbours' (Ryan and Frank 2005).

McConville et al. (2009) attempt to define the mix of uses that most promotes walking based on a sample of individuals in Montgomery County, Maryland. The study found that the intensities of bus stops, grocery stores, offices and retail stores were positively correlated with transportation walking and that land use diversity more broadly was positively associated with walking for transportation. Further work was required to identify the method for ranking the relative influences of land uses and for understanding their individualised effects. In an American study on public transport and health Litman found that 'neighbourhood design features that support transit, such as walkability and mixed use, also support public health. Of people with safe places to walk within ten minutes of home, 43% achieve physical activity targets compared with just 27% of less walkable areas' (2011:1). The article however does not address the level of mixed use associated with walking as access and egress to public transport.

3. Methodology

To draw a comparison between the inner, middle and outer areas of Melbourne a corridor approach was adopted for the study area. Three local governments, comprising a 9% sample of the total 31 were selected as the study areas for this research. These three local government areas form the northern corridor and are Yarra, Darebin and Whittlesea. Each local government area (LGA) has different travel, density and demographic characteristics (see Table 1). The stations within these are further categorised by their distance from the GPO or CBD for analysis.

Table 1 Comparison of Yarra (Inner Stations), Darebin (Middle Stations) and Whittlesea (Outer Stations characteristics

	Yarra	Darebin	Whittlesea
Total area (sq km)	20	53	490
Total Population	78,041	139,608	146,132
Total Jobs	38,441	55,909	55,269
Gross density*	58.24	36.89	4.11
% of households with no motor vehicles	67 %	17 %	6 %
Residents using one method of travel to their destination	17 %	7 %	2 %
Residents using one method of travel + public transport to their destinations	20 %	14 %	4.2 %

*Gross Density = Population plus Jobs divided by area in hectares.
Source: ABS 2006 Census

3.1 Public Transport Catchment Areas

The catchment areas used in this study are 1km catchments for train stations. This catchment was established with reference to analysis of data from the 2007 Victorian Integrated Survey of Travel and Activity (VISTA) by Sinclair Knight Merz (SKM 2009). The average walking distance for a train station is 800 metres and the 75th percentile is 1.3 kilometres. This means that half the people walking to the train stations walk 800 metres and a quarter of the people walking to the train walk more than 1.3 kilometres. A 1km radial catchment for trains was adopted for the analysis of land use. The same analysis shows that across Melbourne the average access mode share of walking to train stations is 59%.

Table 2 Average Access mode share

		Percentile				
		10th	25th	50th	75th	90th
Access to trains						
By car	40%	1.3	2.2	3.4	5.5	9.1
By walking	59%	0.4	0.6	0.8	1.3	1.8
Access to trams						
By all modes		0.1	0.2	0.3	0.6	1.1
By walking	95%	0.1	0.2	0.3	0.6	0.8
Access to Buses						
By car	7%	1.1	1.4	2.2	3.6	7.1
By walking	92%	0.1	0.3	0.5	0.8	1.4

Source: SKM 2009 based on VISTA data. Note - Units are in kilometres

3.2 Mixed Use Zoning Analysis

An analysis of planning scheme zoning areas was used to obtain an indication of the mix of land use within the identified catchments. The catchment areas were measured and the percentage of areas zoned residential zone one. Non residential land use refers to all the other land uses including commercial industrial and public use zones. It is recognised that land uses in Melbourne do not always correlate exactly to the land use prescribed in the Victorian Planning Scheme and that complementary land uses are allowed within some zoning categories.

3.3 Metlink Origin Destination data and other data sets

The Metlink origin destination data survey collects data on the type of access and egress modes to stations across Melbourne. Access refers to the trip stage arriving at the station and egress refers to the trip stage leaving the station. This data indicates percentage mode shares for walk only access and egress to and from stations. This data will be used as the proxy measure for the level of walk only trips to stations and the potential relationship within the mix of land use within the catchment. The percentage mode share for walk only as access and egress varies significantly across Melbourne and in the northern region. If we assume that the predominate use of the train station is to make a daily return journey, say to and from a workplace then we may expect to find that travel patterns are the same for each day. Therefore this raises questions about the variation in the walk only access and egress percentages. Metlink origin destination data collected are every three years. The data used in this paper is 2009 data. Other datasets that are being considered in this analysis are Census data for 2006 looking at overall travel patterns at an LGA level.

4. Transport catchment analysis

Nearly all of the stations in the three northern councils, Yarra, Darebin and Whittlesea (excluding Richmond and Clifton Hill) have been selected for analysis. A number of the selected stations and their respective catchments fall within two council areas. For this reason the stations have been categorized by their distance from the city rather than their council area.

The catchments have been aggregated and the stations categorised into groups based on their distance from the GPO. Stations that are less than 5 kilometres are included as inner stations, stations between 5 and 10 kilometres are categorised as middle and stations that are more than 10 kilometres from the GPO are categorised as outer stations (Table 3). Two train stations (Richmond and Clifton Hill) that fall within the study area are train line interchanges. The access and egress mode patterns reflect this role in the train system and are excluded for this reason.

Table 3 Train Stations included in the analysis

Inner (Mostly Yarra)	Middle (Mostly Darebin)	Outer (Mostly Whittlesea)
West Richmond, North Richmond, Collingwood, Victoria Park, East Richmond, Burnley, Rushall, Merri, Westgarth	Dennis, Fairfield, Croxton, Alphington, Thornbury, Darebin, Preston,	Reservoir, Ruthven, Keon Park, Thomastown, Lalor, Epping

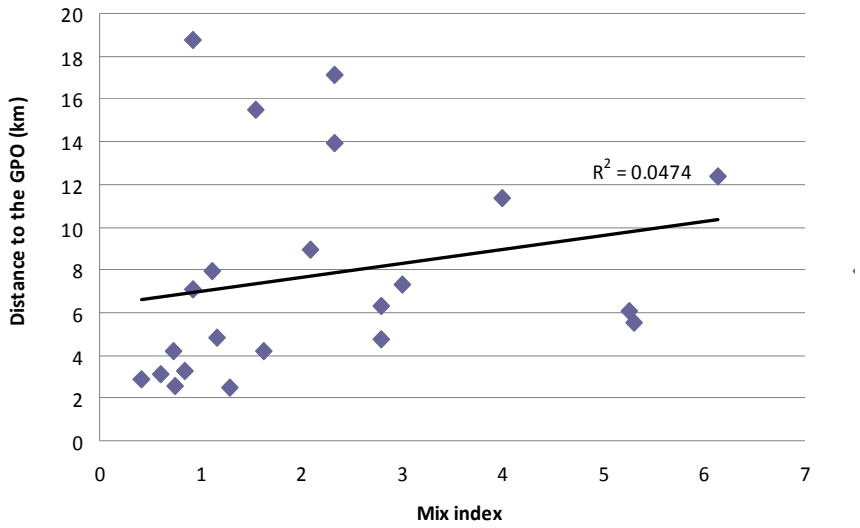
4.1 Train - 1 kilometre radius Mix index residential to all non-residential

Existing Land Use Mix

The following analysis is of a 1km catchment for each station irrespective of the council boundary. Broadly across the three station categories the existing land use mixes were closer to equal around the inner stations and more unequal around the middle and outer stations

Figure 1 Relationship between the distance to the GPO and the Mix Index

Each dot in the table below represents a station



If a mix of 50/50 equal one then a mix of 86/14 equals 6. This table illustrates the broad pattern that land use mixes were closer to equal around the inner stations and more unequal around the middle and outer stations

The average mix for inner train stations is 49/51. This is a good reflection of the mix in the catchments of the 6 stations, most are closer to equal than not. The average mix for the middle train stations is 69.7/30.5. This is also a good reflection of the mix in the catchments of the 10 stations; most have a ratio of residential / non residential close to 70/30. The average mix for the outer train stations is 69.16/30. This is reasonable however not entirely accurate reflection of the mix in the catchments of the four stations. One station Epping has a close to equal ratio while the others are much more unequal.

Some train stations have a low ratio of residential but a high number of walk percentages of access and egress modes. For example Collingwood has a ratio of residential to non-residential of 30/70 but one of the highest walking access percentages at 94.4%, similarly Victoria Park has a ratio of 38/62 and a walk access percentage of 83.9%. This suggests that some people accessing these stations within these catchments walk further than one kilometre to the train station.

Across the three areas the stations with the most equal land use mix catchments are East Richmond with 46/54, and North Richmond with 43/57. In the city of Yarra Richmond and Clifton Hill both have close to equal mixes, 56/44 and 51/49 respectively (however these are not being included in the analysis). In the Cities of Darebin and Whittlesea Alphington (48/52), Westgate (54/46), Darebin (52/48) and Epping (48/52) are the stations with the most equal mix.

The differential between the access and egress mode share has been used as a further dimension to the analysis. If we assume that the majority of travel overa typical day follows the pattern of walk to the station, catch the train, and then walk to the destination and the reverse on the return journey (in the case of walk only access/egress trips) then we might expect to see a greater consistency between the walk access and egress percentages for each station. Examining the differential is considered to be a way to broadly understand walking patterns across the daily patterns of travel behaviour. A low differential between walking as access and egress may broadly indicate a more consistent travel pattern of walking generally to the train station by more of the people accessing that particular train station. This may be related to elements of the environment that support walking but it mat also be related to other factors and other travel behaviour patterns. For completeness the relationship between the mix index the differential is analysed

Inner Station Patterns

There seems to be a pattern in the inner stations of a significantly higher access or egress percentages across most of the stations, with the exception of North Richmond station. This is shown in the table below.

Table 4: Inner Stations Analysis

Station	Mix Ratio Residential / All Non residential	Mix Index	Walk Access percentage	Walk Egress percentage	Difference between access and egress
Victoria Park	38/62	0.61	83.9%	54.7%	29.2%
Burnley	44/66	0.74	54.5%	74.0%	-19.5%
Collingwood	30/70	0.42	94.4%	75.1%	19.3%
East Richmond	46/54	0.85	85.4%	69.9%	15.5%
North Richmond	43/57	0.75	80.5%	87.1%	-6.6%
West Richmond	58/42	1.3	96.7%	66.6%	30.1%
Rushall	62/38	1.63	89.2%	73.7%	15.5%
Westgarth	54/46	1.17	67.8%	76.4%	-8.6%
Merri	74/26	2.8	92.5%	80.9%	11.6%
Average	**49/51**	**1.14**	**82.76%**	**73.15%**	**11.55%**

Source: DOT internal analysis of planing scheme zoning and Metlink data

Middle Station Patterns

Overall the average access percentage is lower than the average egress percentage for the middle stations. There seems to be a pattern in of a more even access and egress percentages irrespective of the mix ratio. This is reflected by a low differential percentage of 5.33% between the average access and the average egress.

Table 5: Middle Stations Analysis

Station	Mix Ratio Residential / All Non residential	Mix Index	Walk Access percentage	Walk Egress percentages	Difference between access and egress
Fairfield	84/16	5.25	74%	83.3%	-9.3%
Dennis	85/15	5.31	72.5%	82.9%	-10.4%
Alphington	48/52	0.93	77.1%	82.4%	-5.3%
Croxton	74/26	2.8	92.8%	80.1%	12.7%
Bell	59/41	1.4	75.0%	69.7%	5.3%
Northcote	70/30	2.3	70.8%	82.4%	-11.6%
Preston	68/32	2.1	71.1%	74.6%	-3.5%
Regent	80/20	4	56.9%	75.5%	-18.6%
Darebin	54/48	1.12	63.8%	72.5%	-8.7%
Thornbury	75/25	3	67.8%	76.4%	-8.6%
Average	**69.7/30.5**	**2.82**	**72.45%**	**77.78%**	**-7.62**

Source: DOT internal analysis of planing scheme zoning and Metlink data

Outer Station Patterns

For outer stations the analysis shows much greater percentages of egress walking than access walking. This may suggest that the distance to the station is greater. In the mornings when time is likely to be more important another mode may be used to save time, while in the evening the time required to walk is more available. Epping is the only station that had a close to equal ratio of 48/52 residential to non residential land use has the lowest access walk mode share of 28.8% across all stations considered and an average egress walk mode share of 77.5%.

Table 6: Outer Station Analysis

Station	Mix Ratio Residential / All Non residential	Mix Index	Walk Access percentage	Walk Egress percentages	Difference between access and egress
Epping	48/52	0.92	28.8%	77.5%	48.7%
Lalor	70/30	2.33	41.6%	76.1%	34.5%
Thomastown	61/39	1.54	44.9%	81.8%	36.9%
Keon Park	70/30	2.33	42.1%	72.5%	30.4%
Reservoir	80/20	4	60.9%	76.2%	15.3%
Ruthven	86/14	6.14	78.0%	72.2%	5.8%
Average	**69.16/30**	**2.87**	**49%**	**76.5%**	**28.6%**

Source: DOT internal analysis of planing scheme zoning and Metlink data

On initial examination there seemed to be some tendency for a lower difference between the access and egress walk mode share percentages at stations where the land use mix ratio is closer to 50/50. There are clear exceptions to what seems to be a potential pattern, Ruthven and Fairfield. Further examination shows that there is no strong correlation between the equality of mix and the access/egress differential. This is shown for all stations in the figure below.

Relationship between access and egress modes and mix index

There was no relationship found between the mix index and the mode share percentage patterns of access and egress to and from train stations within the study area.

Figure 2 Relationship between Mix and Access/Egress differential

Each dot in the table below represents a station

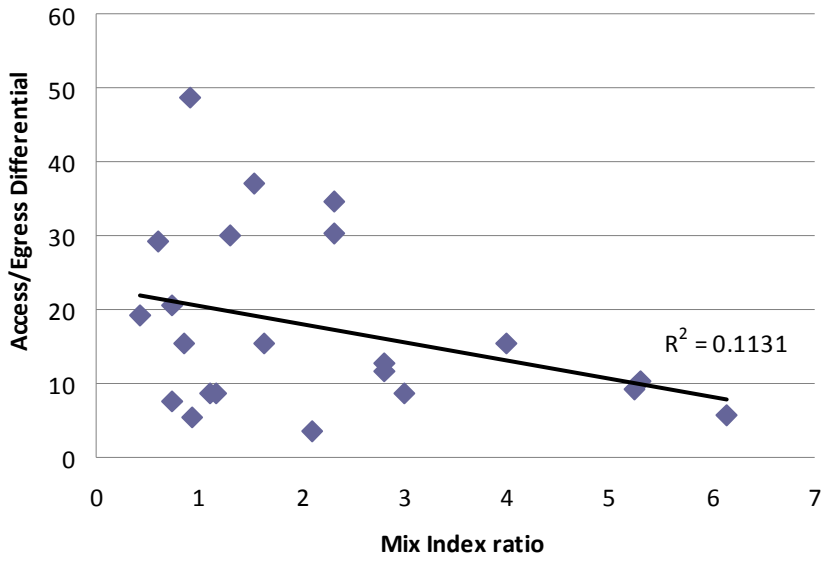


Figure 3 Relationship between Mix and Access

Each dot in the table below represents a station

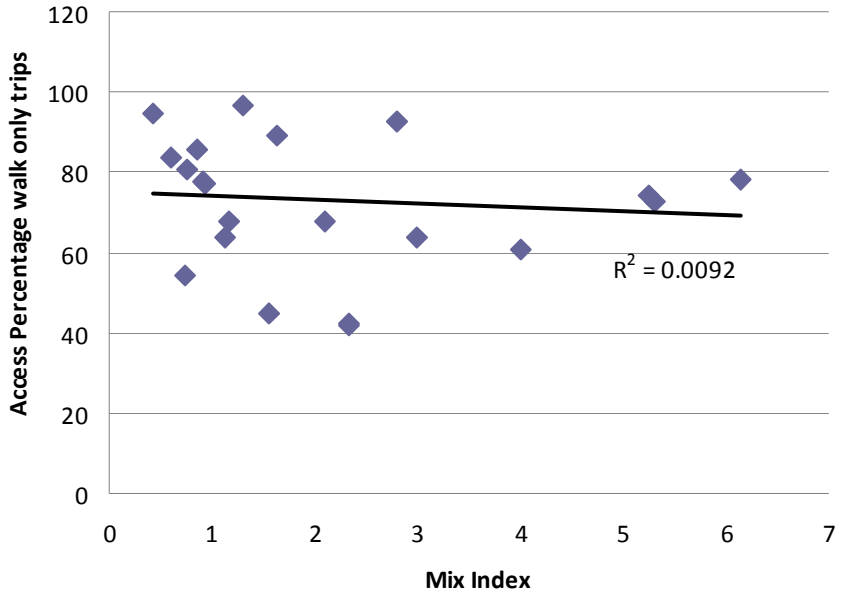
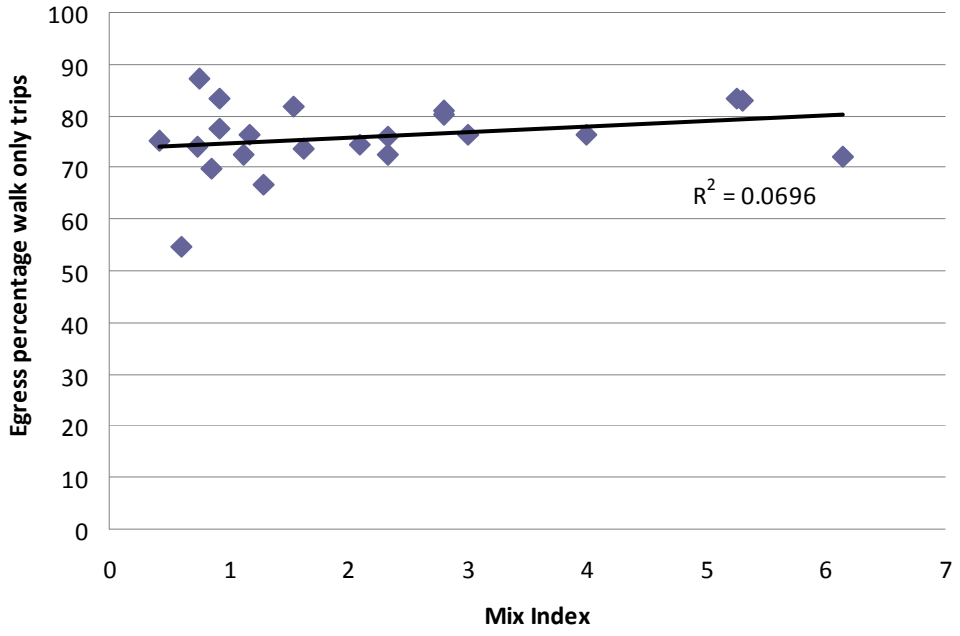


Figure 4 Relationship between Mix and Egress

Each dot in the table below represents a station



4.2 Train - 1 kilometre radius - Mix index residential to business zone one

Further investigation was undertaken to examine the relationship between the amount of residential zoned area and the amount of retail of business zone one area within the 1 kilometre catchments of each of the stations. Business zone one is a zoning used to encourage the intensive development of business centres for retailing and other complementary commercial, entertainment and community uses. It has been evidenced that greater levels of walking occurs in areas where there is activity and high numbers of people in public space (Gehl ,1987, 1996, 2005, Alexander,1977).

Around Melbourne these areas tend to be areas zoned business zone one, often with a combination of retail, restaurants and other entertainment venues. For this reason the authors decided to examine the relationship of walking to the train station and the area of business zone one within the train station catchment.

Inner Stations

The investigation of the relationship between the residential area and business zone one areas around inner stations indicates an overall lower mix index which indicates that there is a greater ratio of retail or business zone one around stations less than 5 kilometres from the GPO than the middle and outer stations. The mixed use index varies from 4.2 to 18.25 and the average is 15.15.

Table 7: Residential/Business mix index for Inner Stations

Station	Mix Ratio Residential / Business Zone 1	Mix Index	Walk Access %	Walk Egress %	Difference between access and egress
Victoria Park	38/5	7.6	83.9%	54.7%	29.2%
Burnley	44/5	8.8	54.5%	74.0%	20.5%
Collingwood	30/7	4.2	94.4%	75.1%	19.3%
East Richmond	46/6	7.6	85.4%	69.9%	15.5%
North Richmond	43/8	5.3	80.5%	87.1%	7.5%
West Richmond	58/7	8.2	96.7%	66.6%	30.1%
Rushall	62/4	15.2	89.2%	73.7%	15.5%
Westgarth	54/1	54	67.8%	76.4%	8.6%
Merri	73/4	18.25	92.5%	80.9%	11.6%
Average	**49.7/5.2**	**15.15**	**82.76%**	**73.15%**	**17.53%**

Source: DOT internal analysis of planing scheme zoning and Metlink data

Middle stations

The investigation of the relationship between the residential area and business zone one areas around middle stations indicates a higher mix index which indicates that there is a lower ratio of retail or business zone one around stations between 5 and 10 kilometres from the GPO. The Mix index around middle stations varies from 9.25 to 80 and the average is 33.69

Table 8: Residential/Business mix index for Middle Stations

Station	Mix Ratio Residential / Business Zone 1	Mix Index	Walk Access %	Walk Egress %	Difference between access and egress
Fairfield	83/3	27.66	74%	83.3%	9.3%
Dennis	85/2	42.5	72.5%	82.9%	10.4%
Alphington	71/2	35.5	77.1%	82.4%	5.3%
Croxton	74/8	9.25	92.8%	80.1%	12.7%
Bell	59/5	11.8	75.0%	69.7%	5.3%
Northcote	70/7	70	70.8%	82.4%	11.6%
Preston	68/2	34	71.1%	74.6%	3.5%
Regent	80/0	80	56.9%	75.5%	18.6%
Darebin	51/3	17	63.8%	72.5%	8.7%
Thornbury	75/8	9.25	67.8%	76.4%	8.6%
Average	**69.7/4**	**33.69**	**72.45%**	**77.78%**	**-7.62%**

Source: DOT internal analysis of planing scheme zoning and Metlink data

Outer stations

The investigation of the relationship between the residential area and business zone one areas around outer stations indicates a mix index in between the inner and middle, at an average of 29.88 for stations between 10 and 15 kilometres from the GPO. The Mix index around the outer stations varies from 14 to 70 and the average is 29.88.

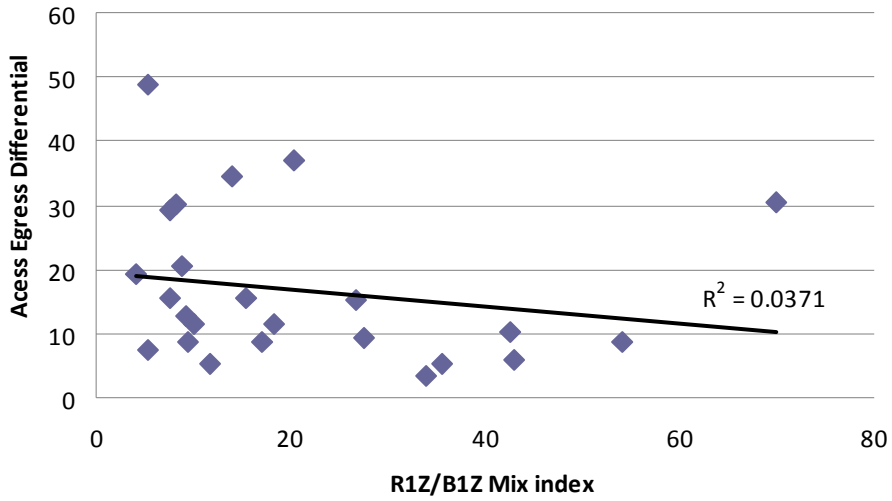
Table 9: Residential/Business mix index for Outer Stations

Station	Mix Ratio Residential / Business Zone 1	Mix Index	Walk Access percentage	Walk Egress percentages	Difference between access and egress
Epping	48/9	5.33	28.8%	77.5%	-48.7%
Lalor	70/5	14	41.6%	76.1%	-34.5%
Thomastown	61/3	20.33	44.9%	81.8%	-36.9%
Keon Park	70/1	70	42.1%	72.5%	-30.4%
Reservoir	80/3	26.66	60.9%	76.2%	-15.3%
Ruthven	86/2	43	78.0%	72.2%	5.8%
Average	**69.16/3.8**	**29.88**	**49%**	**76.5%**	**-17.78%**

Source: DOT internal analysis of planing scheme zoning and Metlink data

Figure 5 Relationship between ratio of R1Z and B1Z and access/egress differential

Each dot in the table below represents a station



Correlation between the residential and business zone one

The investigation of the relationship between the residential area and business zone may indicate a weak relationship between the mix of residential and retail and walking to trains stations across the northern corridor, however a broader sample base is required to test the relationship. This likely reflects that walking to public transport is essential as part of daily transport irrespective of the opportunity to walk in areas where there are interesting environments, other people or the opportunity to pick up some shopping as part of the journey.

5. Discussion

The analysis investigated the linear relationship between mix use index values and walking percentages of access and egress to train with Pearson's r values ranging between r= 0.192 and r=0.336. The mix index in isolation would not be able to be used as an accurate predictor of walking access and egress to trains stations.

Contrary to expectations a weak correlation (with a Pearson's r = 0.218) was found between the level of land use mix and proximity to the CBD (GPO). Some stations within the study corridor contained low levels of residential zoning within the 1km catchment of the station combined with high access and egress walk only percentages which seemed to indicate that around those stations people are walking further than 1km to access the station.

Comparison across Inner, Middle and Outer for residential and all non-residential areas

The Inner stations have an average mix ratio of 49/51 while the Middle and Outer areas have similar average mix ratios of 69.7/30.5 and 69.1/30 respectively. However the Middle and Outer stations differ in the averages of walk only access and egress, the middle average percentage differential is the lowest of all three at 9.4% and the Outer average percentage differential is 27.5%. The Inner stations average percentage differential is 17.53%. This suggests that perhaps the pattern of travel in and around middle stations may be overall more uniform or consistent than the travel patterns in and around the inner and outer stations.

Comparison across Inner, Middle and Outer for residential and business zone one land areas

The Inner stations have an average mix index of 15.15 while the Middle stations have an average of 33.69 and the Outer has an index of 29.88. The relationship or mix between residential and business across the three areas shows greater difference than the relationship or mix between residential and all non-residential. It was expected that the relationship or mix between residential and business would become greater closer to the CBD however this was not the case.

The Mix Index

The application of the Mix Index in this study has shown that it is a useful tool in developing a greater understanding of the relationship between walking to train stations and the level of land use mix the current Melbourne context. The application of the Mix Index in this work has demonstrated the need to use this index in conjunction with other indicators and a broader information base. Van den Hoek draws a similar conclusion in his work stating that 'the combination of Floor Space Index (FSI) and Mix Index (MXI) potentially provides for a powerful determination of district characters' (Van den Hoek 2008:10). In the context of this analysis of walking and public transport, these other potential influencing factors need to be identified and tested to determine the potential further use of a Mix Use Index in the context of sustainable transport planning.

6. Conclusion

The Mixed Use Index has provided a way to gain greater understanding of the actual mix of land uses and the context of walk only access and egress to train stations. However it seems that the perceived strength of the index, its simplicity, was in fact a weakness that did not provide an accurate way to predict walking access and egress to train stations

This study found a weak correlation (with the greatest R2 value of xxx) between the levels of land use mix at the scale used in this study and the patterns of walking to and from train stations. The study indicates that walking as part of the public transport system seems to occur irrespective of the level of mixed use and retail use within typical walking catchments of public transport; that the destination of a train station in and of itself is sufficient to support walking as part of the transport system.

The application of the Mixed Use index in this work has shown that mixed land use and the level of mix alone do not correlate with walking to public transport in northern Melbourne. Other factors that contribute to walkable areas may play a role, in conjunction with mixed use or as factors in their own right, such as permeability, density and quality of the walking environment.

7. Further research

The application of the Mixed Use index has identified opportunities for further research. The first is the differential between the walking access and egress to train stations. This seems to be an opportunity to identify why there are differences and if some of these differences could offer opportunities for more sustainable trip choices. The second is the opportunity to further test the relationship between walking and train station catchments with the mix use index and other indicators of walkable environments such as density, size of the activity centre (if co-located with the train station) and quality of the walking environment. The third is a further exploration of the relationship between residential and business zone one and walking to a broader sample of train stations. The fourth is the potential to explore the impact of analysing a larger catchment size of 2 kilometres.

The fifth is the role of behaviour and lifestyle choices, such as the opportunity to save time and drive to the station in the morning and walk home from the station in the evening. The sixth area is around the question of what the influence of trip purpose is in walking to train stations. Furthermore it would be interesting to explore the relationship of walking to car ownership and the provision of car parking at train stations.

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