EJTIR

Issue 15(1), 2015
pp. 66-77
ISSN: 1567-7141
tlo.tbm.tudelft.nl/ejtir

Do dissonants in transit oriented development adjust commuting travel behaviour?

Md. Kamruzzaman[1]
School of Civil Engineering and the Built Environment, Queensland University of Technology, Australia.

Douglas Baker[2]
School of Civil Engineering and the Built Environment, Queensland University of Technology, Australia.

Gavin Turrell[3]
School of Public Health and Social Work, Queensland University of Technology, Australia.

Residential dissonance signifies a mismatch between an individual's preferred and actual proximal land use patterns in residential neighbourhoods, whereas residential consonance signifies agreement between actual and preferred proximal land uses. Residential dissonance is a relatively unexplored theme in the literature, yet it acts as a barrier to the development of sustainable transport and land use policy. This research identifies mode choice behaviour of four groups living in transit oriented development (TOD) and non-TOD areas in Brisbane, Australia using panel data from 2675 commuters: TOD consonants, TOD dissonants, non-TOD consonants, and non-TOD dissonants. The research investigates a hypothetical understanding that dissonants adjust their travel attitudes and perceptions according to their surrounding land uses over time. The adjustment process was examined by comparing the commuting mode choice behaviour of dissonants between 2009 and 2011. Six binary logistic regression models were estimated, one for each of the three modes considered (e.g. public transport, active transport, and car) and one for each of the 2009 and 2011 waves. Results indicate that TOD dissonants and non-TOD consonants were less likely to use the public transport and active transport; and more likely to use the car compared with TOD consonants. Non-TOD dissonants use public transport and active transport equally to TOD consonants. The results suggest that commuting mode choice behaviour is largely determined by travel attitudes than built environment factors; however, the latter influence public transport and car use propensity. This research also supports the view that dissonants adjust their attitudes to surrounding land uses, but very slowly. Both place (e.g. TOD development) and people-based (e.g. motivational) policies are needed for an effective travel behavioural shift.

Keywords: *Brisbane, commuting behaviour, residential dissonance, transit oriented development, travel attitudes.*

[1] 2 George Street, Brisbane, Queensland 4000, Australia T: +61 7 3138 2510 F: +61 7 3138 1170 E: md.kamruzzaman@qut.edu.au
[2] 2 George Street, Brisbane, Queensland 4000, Australia T: +61 7 3138 2510 F: +61 7 3138 1170 E: d2.baker@qut.edu.au
[3] Victoria Park Road, Kelvin Grove, Brisbane, Queensland 4059, Australia T: +61 7 3138 8285 F: +61 7 3138 3130 E: g.turrell@qut.edu.au

1. Introduction

Urban and transport policy worldwide have been developed around the transit oriented development (TOD) concept because of its ability to foster the use of more sustainable transport modes (e.g. bus, train, walk, bicycle) and to reduce car-dependency; and consequently lowering greenhouse gas emissions and congestion levels (Transportation Research Board, 2001). TODs are characterised by moderate to high residential density, diverse land uses (e.g. mix of residential, commercial, recreational etc.), well-connected street networks (e.g. grid or semi-grid street systems as opposed to cul-de-sacs), and centred around high frequency public transport (PT) stops (Cervero and Kockelman, 1997). High residential density generates more passengers to support frequent transit services and increases the liveliness of a place (Lin and Gau, 2006). Mixed land uses provide opportunities for people to live closer to services, facilities and employment and can generate transit trips throughout the day (The City of Calgary, 2004). In addition, transit supported uses (e.g. shops) are high pedestrian generators that directly promote greater transit ridership and provide opportunities for multi-purpose trips (Cervero, 1996). Street connectivity facilitates walking by reducing walking time from transit stops to opportunities (destinations) or between opportunities. As a result, a combination of this flexibility (walkability and frequency) and speed of public transport services in TODs makes them a logical alternative to private transport (Bertolini et al., 2009).

Research has questioned the causality of urban form variables (density, diversity, connectivity) and the use of sustainable transport modes because such an association could be due to spuriousness (Handy et al., 2006; Mokhtarian and Cao, 2008; Singleton and Straits, 1999). Within this context, residential self-selection has commonly been identified as a spurious factor in the literature (Handy and Clifton, 2001). Self-selection refers to an individual's inclination to choose a particular neighbourhood according to his/her travel abilities, needs, and preferences (Guo and Chen, 2007; Litman, 2012; Olaru et al., 2011; Pinjari et al., 2007). In the context of a TOD this means, for example, that individuals who prefer transit services intentionally choose to live in TODs. Therefore, the observed relationship between urban form and mode choice behaviour is largely due to differences in travel attitudes and preferences, not urban form differences – although the effect will be captured by urban form variables in a model in the absence of variables related to travel attitudes and preferences. No matter whether it's because of urban form or self-selection, they both act in favour of public transit usage for a TOD. However, a clear understanding of the relationship is important from a policy perspective – i.e. whether barriers should be removed to facilitate people moving to a TOD (e.g. interest free loan to buy home at TODs) or whether urban form should be changed (e.g. increase diversity) or both. Barriers that inhibit residential relocation need to be removed in order to reduce the level of residential dissonance in TODs (Kamruzzaman et al., 2013b).

Residential dissonance is defined as the mismatch in land use patterns between individuals' preferred neighbourhood type (e.g. non-TOD) and the type of neighbourhood where they actually reside (e.g. TOD) (Schwanen and Mokhtarian, 2004). In contrast, residential consonance signifies agreement between actual and preferred proximal land use patterns in residential neighbourhoods (i.e. residents who currently live in TODs and who also like to live in TODs) (Kamruzzaman et al., 2013b). Residential dissonance has been identified as a significant barrier to the development of transport and land use policy, yet little understanding exists about this behavioural element in the literature. For example, the use of bus and active transport is significantly higher for urban consonants than urban dissonants (De Vos et al., 2012; Schwanen and Mokhtarian, 2005a). Urban dissonants also make longer distance car trips (Schwanen and Mokhtarian, 2005b). Therefore, it is critical to reduce the level of dissonance in TODs in order to enhance their effectiveness in terms of promoting the use of public transport, active transport, and a reduced reliance on motor vehicles.

The level of dissonance can be reduced (or the self-selection process can be enhanced) in two ways in a TOD (Schwanen and Mokhtarian, 2005b). First, TOD residents can relocate to non-TOD areas and non-TOD residents can relocate to TOD areas in order to match their preferences. However, a recent study did not find strong evidence to verify that such a process occurs in the context of a TOD over short-mid term periods (Kamruzzaman et al., 2013b). Rather, the study reported that the rate of residential mobility from TODs was not significantly higher for those who did not prefer TODs than those who preferred TODs. On the other hand, despite preferring to live in TODs, individuals from non-TOD areas were less likely to move into TODs due to costs and other associated factors. As a result, they either stayed or moved into another non-TOD area resulting in a mix of dissonance and consonance in both TOD and non-TOD areas. The point put forward is that once individuals have selected a neighbourhood, and become dissonants (over a long period of time), barriers of self-selection need to be removed for them so that they can move to their preferred neighbourhood. This self-selection process thereby reduces the overall level of dissonance in existing neighbourhoods.

The second process is more internal to individuals and is related to their attitudinal adjustments. For example, despite being TOD dissonants now, individuals can change their travel attitudes and living preferences over time and become TOD consonants. In such a case, public policy does not need to focus on attitudinal change, rather it should concentrate only on the built environment. However, there is a lack of empirical evidence to support this second proposition. Kamruzzaman et al. (2013a) analysed mode shift behaviour of TOD/non-TOD dissonants between 2009 and 2011 in Brisbane and found little behavioural evidence to support this adjustment process. The study analysed respondents' mode shift behaviour based on their chosen main modes of transport in weekdays in 2009 and 2011. Respondents were given five options to choose from: public transport, car or motorcycle, walk, bicycle, and other. A major problem with this modal shift analysis is that it is not able to detect even a large change in mode shift behaviour. For example, a person who uses a car 100% of the time in 2009 would indicate car as their main mode. Similarly, the person would indicate the car as their main mode of transport in 2011 despite using it only 26% of the time. Therefore, the modal shift was not captured precisely in the Kamruzzaman et al (2013a) study. The given five options were also not a complete set of alternative modes available in Brisbane. A second limitation of the Kamruzzaman et al. (2013a) study was that the chosen mode can be used for any purposes (e.g. work for employed individuals, shopping/recreation for non-working individuals). The chosen main mode for a working individual will have a different impact on the environment and road network than the chosen main mode of a non-working individual. For example, traffic congestion levels are higher during the morning and afternoon commuting periods which means that work-related journeys are the greatest challenge for transportation planners to manage. In contrast, policies can be targeted more effectively due to the routine and repetitive nature of commuting journeys (Commins and Nolan, 2011).

Based on the above discussion, this research aims to contribute to the literature by employing a more refined analysis in order to examine the empirical burden of proof is required either to accept or reject the hypothesis in two ways: first, to identify the commuting mode choice behaviours of dissonants/consonants living in TOD and non-TOD areas; secondly, if there are differences in mode choice behaviour, to evaluate whether dissonants adjust their attitudes and consequently, travel behaviour over time assuming minimal changes in the built environment. Section 2 outlines the data and methods used to conduct the evaluation and Section 3 outlines the findings of the research. Finally, Section 4 concludes this research by providing policy implications.

2. Data and method

2.1 Data

The HABITAT (**H**ow **A**reas in **B**risbane **I**nfluence **H**eal**T**h and **A**c**T**ivity) panel survey data were used in this research. The data were collected from adults (aged between 40 and 70 years who were still working, and living in 200 census collection districts (CCDs) in Brisbane. The study was focused on the baby-boomer cohort in Australia (born between 1946 and 1965). The HABITAT panel surveys were conducted in three phases (2007, 2009, and 2011) and questionnaire data were collected from 11036, 7866, and 6901 individuals in each respective year. As a sampling strategy, first, a stratified random sampling technique was used to select 200 CCDs from the Brisbane Local Government Area; and then a simple random sampling technique was used to recruit participants within each CCD. The participants are representative of the wider population in Brisbane for this age group (Burton et al., 2009; Turrell et al., 2010). This research used the 2009 and 2011 version of the surveys. Respondents who participated in both periods and were employed at each wave were retained for analysis. In addition, individuals who moved residences between the periods were excluded from this analysis because they might have adjusted their preferences through relocation. This exclusion resulted in an analytical sample of 2675 commuters.

2.2 Dependent variables

One of the objectives of this study is to address the identified weaknesses of previous studies in terms of the mode choice variable as discussed in the Introduction section of the paper. As a result, respondents were asked to choose the type of transport they used to travel to and from work based on a given complete set of transport mode available in Brisbane including bus, train, ferry, car, walk, motorcycle, bicycle, taxi, and other. Respondents were also instructed to choose multiple options if they used more than one type of transport. The responses were binary coded for each transport mode (i.e. 1 for using a particular mode e.g. bus, otherwise 0). Bus, train, and ferry were combined and referred to as public transport (PT). If a respondent chose any of these as their travel mode, they were coded as 1 otherwise 0. Walk and cycle were also combined and referred to as active transport (AT). Respondents who either walked or cycled were coded 1, otherwise 0. In contrast, car, taxi, and motorcycle were combined to indicate less sustainable modes of transport (LST) and a similar coding system was used for this. This coding system, therefore, allows us to investigate whether a particular group (e.g. TOD consonant) is likely to use more (e.g. PT, AT) or less a particular mode of transport.

2.3 Generation of 'TOD dissonants/consonants' variable as an independent factor

A four category 'TOD dissonants/consonants' factor was generated in order to examine both the commuting mode choice and mode adjustment behaviour of dissonants including: TOD dissonants, TOD consonants, non-TOD dissonants, and non-TOD consonants. A similar method to Schwanen and Mokhtarian (2004) was used for the generation of this factor. First, individuals' actual neighbourhoods (where they were actually living) were classified into either a TOD or non-TOD types based on four indicators related to urban form: residential density, land use diversity, street connectivity, and public transport accessibility (Kamruzzaman et al., 2013b). Second, individuals' preferred neighbourhood (where they would like to live) were also categorised into TOD and non-TOD types based on a factor analysis of 14 statements representing their travel attitudes and preferences (Handy et al., 2005). The statements representing both travel attitudes and preferences were selected from the literature (see, Handy et al., 2005; Lee and Moudon, 2006), and were operationalized together in the HABITAT survey. Therefore, the statements were not differentiated between attitudes and preferences in this paper. The combination of these preferences with the actual residential neighbourhood of the respondents results in the four categories of the 'TOD dissonants/consonants' factor. This factor, therefore, captures both travel preferences and built environmental characteristics together.

Residential density, land use diversity, and network connectivity indicators were calculated based on a 1km circular buffer from respondent's home location (Frank et al., 2005). Residential density was calculated based on the average size (m2) of residential zoned lands within the buffer – i.e. the higher the value, the lower the density (Wilson et al., 2012). Land use diversity was generated using an entropy equation as described by Leslie et al. (2007) that ranged from 0 (complete homogeneity) to 1 (even distribution) based on five land use classes located with the buffer: residential, commercial, industrial, recreational, and other. Intersection density indicator was used to represent network connectivity level. Intersection density was calculated based on the number of 4 or more way intersections located with the buffer. The three indicators were aggregated into a composite measure of 'urban compactness' and classified into compact and incompact areas following Kamruzzaman et al (2013b). The accessibility of public transport services was then combined to determine TOD/non-TOD areas. Public transport accessibility level was measured using the well-known PTAL approaches (Kamruzzaman et al., 2013a, 2014; Transport for London, 2010). This method takes into account the spatial accessibility of transit (whether PT services were located within a 600 metre network buffer from respondents home location), morning peak hour frequencies, directional connectivity, and reliability. Based on these accessibility and compact development criteria, respondents' actual home locations were then classified as either TOD type (when both compact and PT access criteria met) or non-TOD type.

The factor analysis resulted in a four factor solution (Table 1). Based on the literature, the four factors are interpreted to capture respondents' perceptions about public transport (PT), sensitivity to environmental externalities, car dependency, and safety of car travel (De Vos et al., 2012; Handy et al., 2005). The first factor was used to classify respondents into either preferring a TOD type of living environment or not. This is due to the fact that public transit services are key elements in facilitating travel in TODs and respondents with a negative perception about PT attitudes are less likely to choose TOD as a place to live (De Vos et al., 2012). As a result, respondents with a positive score in the first factor were classified as preferring non-TOD type of neighbourhood whereas respondents with a negative score in this factor were classified as preferring TOD type of neighbourhood.

Table 1. Pattern matrix showing variable loadings on travel attitude factors in 2009[a]

Statements	Factors			
	Perception about PT	Sensitivity to environmental externalities	Car dependency	Safety of car
Public transport is inconvenient and unreliable	.851			
Using public transport takes too much time	.650			
Travelling by public transport is not very pleasant	.619			
Public transport can sometimes be difficult than driving	.453			
Public transport is expensive	.407			
People need to walk and cycle more to improve the environment		.910		
People need to walk and cycle more to reduce global warming		.794		
People need to walk and cycle more to reduce traffic congestion		.744		
People need to use public transport more often to reduce traffic congestion		.529		
Driving a car is expensive		.295		
I need a car to do many of the things that I do			.746	
I could not manage pretty well without a car			.698	
Travelling by car is safer overall than taking public transport				.751
Travelling by car is safer overall than walking				.552
% of variance explained	23.092	13.558	6.119	3.849
Total variance explained (%)				46.618
Kaiser-Meyer-Olkin Measure of Sampling Adequacy				0.796
Principle Axis Factoring (Oblimin with Kaiser Normalisation)				
N				2675

[a] Statements with a factor loading less than 0.2 were not retained in pattern matrix.

2.4 Controlling factors

Commuting mode choice behaviour is not only dependent on the environmental and attitudinal factors as described above, but also on individuals' socio-demographics and trip characteristics (e.g. travel time). Based on findings reported in previous studies, ten socio-demographic variables and one trip characteristic variable were selected and used as controlling factors in this research in order to understand the true impact of the 'TOD dissonants/consonants' factor. These variables have been identified as significant predictors of commuting mode choice behaviour and include gender, age, availability of car, income, employment status, household size, health status, education, living arrangement and country of birth (Table 2) (Cervero, 1996; Commins and Nolan, 2011). Due to the changeable nature of some of the socio-demographic characteristics over time (e.g. income, availability of car) at the individual level, separate sets of socio- demographic variables were taken into account for 2009 and 2011(Meurs and Haaijer, 2001). Table 2 provides an overview of the minor changes in the socio-demographics that occurred between the periods.

Table 2. Socio-economic characteristics of the respondents participated in the surveys

Socio-demographics	2009		2011	
	Frequency	%	Frequency	%
Travel time				
0-15 minutes	719	26.9	697	26.1
15-30 minutes	1175	43.9	1174	43.9
30-60 minutes	702	26.2	708	26.5
More than 60 minutes	79	2.9	96	3.5
Gender				
Male	1263	47.2	1263	47.2
Female	1412	52.8	1412	52.8
Mean age	52.17 (SD 6.2)		54.17 (SD 6.2)	
Car availability				
Yes, always	2456	91.8	2474	92.5
Yes, sometimes	156	5.8	125	4.7
No	29	1.1	40	1.5
Do not drive	34	1.3	36	1.3
Employment status				
Working full time	1903	71.1	1872	70.0
Working part time	772	28.9	803	30.0
Level of education				
Upto year 12	799	29.9	799	29.9
Diploma/certificate	794	29.7	794	29.7
Bachelor or above	1082	40.4	1082	40.4
Current living arrangement				
Living alone with no children	360	13.5	389	14.5
Single parent with >=1 children	192	7.2	172	6.4
Single and living with friends/relatives	103	3.9	108	4.0
Couple living with no children	656	24.5	755	28.2
Couple living with >=1 children	1309	48.9	1223	45.7
Other	55	2.1	28	1.0
Average household size	2.96 (SD 1.4)		2.87 (SD 1.3)	
Income percentile				
First (lower)	453	16.9	398	14.9
Second	808	30.2	762	28.5
Third	483	18.1	456	17.0
Fourth	664	24.8	750	28.0
Missing	267	10.0	309	11.6
Average heath status	3.4 (SD 0.9)		3.5 (SD 0.9)	
Country of birth				
Australia	2051	76.7	2051	76.7
Other	624	23.3	624	23.3
N				2675

2.5 Data analysis

Given that the form of the questionnaire regarding commuting mode yielded a binary outcome, six logistic regressions were estimated in total, one for each of the modes (PT, AT, LST) and one for each of the 2009 and 2011 waves. A similar model has been used in other research contexts (Emond and Handy, 2012; Hine et al., 2012; Rose and Marfurt, 2007). Each outcome variable (e.g. PT) was regressed using the 'consonant/dissonant' variable while controlling for other socio-demographic variables, trip characteristics, and neighbourhood characteristics. Stata software (version 11) was used to estimate all models. The vce(cluster clustvar) option was applied in order to account for the clustering effect within each CCD. This technique allows to obtain a robust variance estimate after adjusting for within-cluster correlation (Greenwald, 2006). The CCD code was used as the clustering variable in the model. The odds ratios (ORs) for each explanatory variable were derived based on the binary logistic regression model. The ORs indicated how much more likely one group (e.g. TOD dissonant) used a certain mode (e.g. PT) when compared to its counterpart (e.g. TOD consonant), controlling for other variables in the model. Only statistically significant factors ($p<0.05$) were retained in the final models upon refinement of initial models that included all explanatory factors.

3. Results

Analysis shows that overall, 80.26% respondents used the car as their mode of travel to work in 2009, which slightly increased to 81.87% in 2011 (Table 3). In contrast, 23.89% respondents mentioned that they used public transport for their travel to work in 2009, which reduced substantially to 17% in 2011. Only 12.1% respondents used active transport for travelling to work in 2009, which remained almost same in 2011. As mentioned previously, respondents' travel behaviour was analysed using a binary mode choice indicator in this research. Table 4 shows the results obtained from the binary logistic regression models for the three modes analysed in this research for both periods. Table 3 also shows descriptive statistics related to travel to work mode choice behaviour of the different dissonant and consonant groups considered in this research in both time periods.

Table 3. Descriptive statistics showing the choice of travel mode to work[a]

Respondents			Transport mode use (%)					
			2009			2011		
	Frequency	%	PT	AT	LST	PT	AT	LST
TOD consonants	656	24.5	34.2	35.5	21.4	33.9	34.5	22.0
TOD dissonants	577	21.6	15.7	21.6	22.3	18.2	21.8	22.2
Non-TOD consonants	718	26.8	15.3	17.6	29.7	16.0	20.9	28.8
Non-TOD dissonants	724	27.1	34.9	25.3	26.6	31.9	22.7	27.0
N	2675		639 (23.89%)	324 (12.11%)	2147 (80.26%)	457 (17.08%)	330 (12.34%)	2190 (81.87%)

[a] The sum of the percentages may not equal to 100 due to multiple response dataset.

3.1 Public transport

The odds of using public transport were 2.8 times lower for TOD dissonants than TOD consonants in 2009. This difference reduced slightly in 2011. Like the TOD dissonants, the odds of using public transport for non-TOD consonants were also found to be 4 times lower compared to TOD consonants in 2009. This gap also slightly increased in 2011. The findings suggest that both attitudes and the built environment played a significant role in influencing this behaviour. Note that both TOD dissonants and non-TOD consonants possess similar travel attitudes but lived in different types of built environments. If built environment had no impact, then it was expected that both group would use public transport equally given they possess identical attitudes. On the other hand, if attitudes had no impact, then TOD dissonants and consonants were expected to use public transport equally. However, the odds ratios indicate that attitudes played a stronger role here than the built environment. In contrast, non-TOD dissonants used public transport equally compared with TOD consonants in 2009, again suggesting the important role of attitudes in choosing public transport services. These two groups lived in distinct neighbourhood types but possess similar travel attitudes. However, the likelihoods of using public transport services were reduced for non-TOD dissonants in 2011 suggesting that they adjusted their attitudes towards the surrounding land uses. This means that a lack of public transport services required this group to use alternative mode of transports over the time period. Similar adjustment behaviour was also evident in TOD areas where TOD dissonants slightly shifted their behaviour from 2.8 times less likely to use public transport service in 2009 to 2.4 times less likely in 2011. Therefore, availability of public transport services in TODs influenced this group to change their attitudes in favour of public transport services.

Table 4. Binary logistic regression analysis results showing the ORs associated with mode choice behaviour in 2009 and 2011 (Std. Err. adjusted for 200 clusters in CCDs)

Explanatory factors	Dependent variable: commute mode (1 = yes, 0 = no)					
	PT		LST		AT	
	2009	2011	2009	2011	2009	2011
Dissonants/consonants in 2009						
TOD dissonants (ref: TOD consonants)	0.36	0.42	2.22	2.09	0.76	-
Non-TOD consonants (ref: TOD consonants)	0.28	0.24	3.42	2.88	0.71	-
Non-TOD dissonants (ref: TOD consonants)	-	0.67	1.69	1.83	-	-
Urban form characteristics in 2009						
Residential density (continuous - higher values represent lower density)	0.99	0.99	-	-	1.00	-
Network connectivity (continuous)	-	-	-	-	1.02	1.02
Trip characteristics ('09, '11)						
Travel time: 15-30 minutes (ref: 0-15 minutes)	10.24	6.72	1.52	1.60	0.32	0.44
Travel time: 30-60 minutes (ref: 0-15 minutes)	43.70	26.34	0.58	0.56	0.55	-
Travel time: more than 60 minutes (ref: 0-15 minutes)	50.35	33.76	0.49	0.49	-	-
Socio-demographics						
Gender: female (ref: male)	1.48	1.39	1.38	1.42	0.68	0.70
Age (continuous) ('09, '11)	-	0.97	-	-	-	-
Car availability: yes, sometimes (ref: yes, always) ('09, '11)	5.81	6.59	0.17	0.17	3.56	4.97
Car availability: no (ref: yes, always) ('09, '11)	14.77	4.74	0.04	0.09	5.32	6.23
Car availability: do not drive (ref: yes, always) ('09, '11)	16.26	11.49	0.04	0.05	7.65	5.90
Education: diploma/certificate (ref: upto year 12)	-	-	-	1.30	-	-
Education: bachelor or above (ref: upto year 12)	-	-	-	-	1.47	-
Household size (continuous) ('09, '11)	-	0.81	-	-	-	-
Country of birth: other (ref: Australia)	-	-	-	-	0.73	-
Income percentile: third (ref: first) ('09, '11)	-	-	0.73	-	-	-
Income percentile: missing (ref: first) ('09, '11)	-	-	-	0.73	-	-
Health status (continuous) ('09, '11)	-	-	0.85	0.80	1.16	1.28
Log pseudolikelihood	-884.57	-933.13	-1137.00	-1088.48	-887.79	-908.30
Wald Chi^2	343.90[a]	357.10	329.10	317.69	202.08	213.80
Pseudo R^2	0.26	0.23	0.14	0.13	0.09	0.09
N						2675

[a] Coefficients are significant at the 0.05.

3.2 Car (less sustainable transport)

The odds of using the car was 2.2 times higher for TOD dissonants compared to TOD consonants in 2009 and this gap reduced slightly to 2 times in 2011. The odds of using the car for non-TOD consonants were 3.4 times higher in 2009 compared to TOD consonants. This gap also reduced to 2.9 times in 2011. Whilst it might be expected that both TOD dissonant and non-TOD consonant groups would use the car equally given similar travel attitudes, it appears that individuals may have experienced difficulty using their car due to physical constraints in TOD areas, such as congestion and parking problems (De Vos et al., 2012), or access to PT in TOD decreases car use, or both. The differences in car use between TOD consonants and non-TOD dissonants were marginal in both periods. Non-TOD dissonants were 1.7 times more likely to use the car compared to TOD consonants, which remained almost equal in 2011. The above findings suggest that travel attitudes are still the most dominant factor in choosing the car, but the built environment had marginally less influential roles in shaping commuting mode choice behaviour.

3.3 Active transport

TOD dissonants were less likely to walk and cycle in 2009 for their travel to work compared to TOD consonants. Both of these groups live in the same neighbourhood (TOD) but possess different attitudes. This attitudinal difference, therefore, impacted significantly in choosing this travel mode. They, however, used active transport equally to TOD consonants in 2011 suggesting their attitudinal shift towards surrounding land uses. A stronger attitudinal influence was evident for non-TOD dissonants group in 2009. Despite living in distinct environment, this group used active transport equally to those TOD consonants in 2011.

4. Discussion and conclusion

The findings from the cross-sectional analyses for both time periods (2009, 2011) are consistent with previous cross-sectional studies. Most of the literature provides a static analysis within one time period. The primary contribution of this research has been to provide a longitudinal evaluation of travel behaviour of TOD and non-TOD dissonance and consonance. Given the validity of the cross-sectional analyses – the observations from this study confirm the literature findings on behaviour change – that it is a rather slow process. Minor behavioural differences were observed in the two year period amongst different groups. The evidence examined here suggests that travel preferences are more important in choosing transport mode than the built environmental factors; however, the built environment has some influence on commuting travel mode, with the largest impact on public transport and car. Attitudes and preferences seem to dominate commuting mode choice over the two years surveyed, with minor changes occurring between survey periods. The correlation of attitudes among the consonants and dissonants living in dissimilar living environments provides valuable insight into the importance of an individual's ingrained preferences on travel behaviour.

Critical to this study is group-specific attitudes regarding the built environment. In the case of both 2009 and 2011 data, TOD dissonant groups and non-TOD consonant groups were 2.8 times and 4 times less likely to use public transport. These gaps reduced slightly in 2011 for both groups. In addition, the built environment may contribute to the reduction of car usage and increase of public transport usage over a time, albeit slowly.

The results reported in this paper clearly indicate that the built environment alone is not enough to change behaviour of residentially dissonance mode choosers, at least over the short-term. TOD dissonance tended to change attitudes and behaviour very slowly. Major policies with the potential to influence mode choice in Brisbane have remained relatively static, including parking availability, parking pricing, public transport fares and tolling. TODs are often considered as a first step to encourage the use of more sustainable transport and consequently to reduce car dependency; however, this research shows that attitudes will remain a significant factor on mode choice. Well-designed policies to support TODs with positive and negative reinforcement may increase their effectiveness substantially. Specifically, policies that offer “a carrot or a stick” approach based on dissonance are required. What this means is that dissonance must be recognised and reduced in TOD areas to ensure an appropriate uptake of this type of urban design. This reinforces the construct that policy has to address both built environment factors and attitudes in its formulation. Thus, for dissonance, how do we develop incentives and disincentives to reduce dissonance in TOD areas? This is a critical question for on-going research.

This present research complements and supports the findings of earlier work (e.g. Kamruzzaman et al., 2013a): the latter used aggregated mode-choice data to investigate the attitudinal adjustment process of dissonants, whereas we have used a more sensitive measure of mode-choice and found that dissonants adjust their attitudes and preferences according to surrounding land uses, however, the process is protracted. This paper adopted a conservative approach in the longitudinal analysis. Mode choice behaviours of an individual were analysed in two different time periods in order to examine whether a shift occurred or not indirectly. A more direct measure of mode choice such as the distance travelled by mode would allow monitoring marginal changes which was not possible to capture here. In addition, the behaviour shift was investigated between 2009 and 2011. This two year time span might not be long enough for an attitudinal adjustment. Future studies should seek to investigate this issue using a longer time span and also based on other travel behaviour matrices such as number of trips, or vehicle kilometres of travel by mode which might provide a more in depth analysis and offer additional insights not provided here. This research focused on commuting mode choice which supports previous findings on this topic. However, other trip purposes might be evaluated (recreation and shopping) to enhance the understanding of behavioural adjustment processes for both working and non-working individuals with residential dissonance. Although this research assumes that the changes in the built environment were minimal given that the analyses were conducted over a two year time span, further research capturing changes in all types of factors (e.g. built environmental, attitudes, socio-demographics, and behaviour) is warranted in order to robustly infer about the adjustment process.

References

Bertolini, L., Curtis, C., Renne, J.L. (2009) 'Introduction', in Curtis, C., Renne, J.L., Bertolini, L. (eds) *Transit Oriented Development: Making it Happen*, Ashgate Publishing Limited, Surrey.

Burton, N.W., Haynes, M., Wilson, L.-A.M., Giles-Corti, B., Oldenburg, B.F., Brown, W.J., Giskes, K., Turrell, G. (2009) 'HABITAT: A longitudinal multilevel study of physical activity change in mid-aged adults', *BMC Public Health*, 9(1), 76.

Cervero, R. (1996) 'Mixed land-uses and commuting: Evidence from the American Housing Survey', *Transportation Research Part A: Policy and Practice*, 30(5), 361-377.

Cervero, R., Kockelman, K. (1997) 'Travel demand and the 3Ds: density, diversity, and design', *Transportation Research Part D: Transport and Environment*, 2(3), 199–219.

Commins, N., Nolan, A. (2011) 'The determinants of mode of transport to work in the Greater Dublin Area', *Transport Policy*, 18(1), 259-268.

De Vos, J., Derudder, B., Van Acker, V., Witlox, F. (2012) 'Reducing car use: changing attitudes or relocating? The influence of residential dissonance on travel behavior', *Journal of Transport Geography*, 22(0), 1-9.

Emond, C.R., Handy, S.L. (2012) 'Factors associated with bicycling to high school: insights from Davis, CA', *Journal of Transport Geography*, 20(1), 71–79.

Frank, L.D., Schmid, T.L., Sallis, J.F., Chapman, J., Saelens, B.E. (2005) 'Linking objectively measured physical activity with objectively measured urban form: Findings from SMARTRAQ', *American Journal of Preventive Medicine*, 28(2, Supplement 2), 117-125.

Greenwald, M.J. (2006) 'The relationship between land use and intrazonal trip making behaviors: Evidence and implications', *Transportation Research Part D: Transport and Environment*, 11(6), 432-446.

Guo, J.Y., Chen, C. (2007) 'The built environment and travel behavior: making the connection', *Transportation*, 34(5), 529-533.

Handy, S., Cao, X., Mokhtarian, P. (2005) 'Correlation or causality between the built environment and travel behavior? Evidence from Northern California', *Transportation Research Part D: Transport and Environment*, 10(6), 427-444.

Handy, S., Cao, X., Mokhtarian, P.L. (2006) 'Self-Selection in the Relationship between the Built Environment and Walking', *American Planning Association. Journal of the American Planning Association*, 72(1), 55-74.

Handy, S., Clifton, K. (2001) 'Local shopping as a strategy for reducing automobile travel', *Transportation*, 28(4), 317-346.

Hine, J., Kamruzzaman, M., Blair, N. (2012) 'Weekly activity-travel behaviour in rural Northern Ireland: differences by context and socio-demographic', *Transportation*, 39(1), 175-195.

Kamruzzaman, M., Baker, D., Washington, S., Turrell, G. (2013a) 'Residential dissonance and mode choice', *Journal of Transport Geography*, 33(December), 12-28.

Kamruzzaman, M., Baker, D., Washington, S., Turrell, G. (2014) 'Advance transit oriented development typology: Case study in Brisbane, Australia', *Journal of Transport Geography*, 34(January), 54-70.

Kamruzzaman, M., Washington, S., Baker, D., Turrell, G. (2013b) 'Does residential dissonance affect residential mobility?', *Transportation Research Record*, 2344, 59-67.

Lee, C., Moudon, A.V. (2006) 'Correlates of walking for transportation or recreation purposes', *Journal of Physical Activity & Health*, 3(Suppl 1), S77-S98.

Leslie, E., Coffee, N., Frank, L., Owen, N., Bauman, A., Hugo, G. (2007) 'Walkability of local communities: using geographical information systems to objectively assess relevant environmental attributes', *Health and Place*, 13(1), 111-122.

Lin, J.J., Gau, C.C. (2006) 'A TOD planning model to review the regulation of allowable development densities around subway stations', *Land Use Policy*, 23(3), 353-360.

Litman, T. (2012) 'Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior', Victoria Transport Policy Institute.

Meurs, H., Haaijer, R. (2001) 'Spatial structure and mobility', *Transportation Research Part D: Transport and Environment*, 6, 429–446.

Mokhtarian, P.L., Cao, X. (2008) 'Examining the impacts of residential self-selection on travel behavior: A focus on methodologies', *Transportation Research Part B: Methodological*, 42(3), 204-228.

Olaru, D., Smith, B., Taplin, J.H.E. (2011) 'Residential location and transit-oriented development in a new rail corridor', *Transportation Research Part A: Policy and Practice*, 45(3), 219-237.

Pinjari, A., Pendyala, R., Bhat, C., Waddell, P. (2007) 'Modeling residential sorting effects to understand the impact of the built environment on commute mode choice', *Transportation*, 34(5), 557-573.

Rose, G., Marfurt, H. (2007) 'Travel behaviour change impacts of a major ride to work day event', *Transportation Research Part A*, 41(4), 351-364.

Schwanen, T., Mokhtarian, P. (2004) 'The extent and determinants of dissonance between actual and preferred residential neighborhood type', *Environment and Planning B: Planning and Design*, 31(5), 759-784.

Schwanen, T., Mokhtarian, P. (2005a) 'What affects commute mode choice: neighbourhood physical structure or preferences toward neighborhoods?', *Journal of Transport Geography*, 13 (1), 83–99.

Schwanen, T., Mokhtarian, P. (2005b) 'What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled', *Transportation Research Part D: Transport and Environment*, 10(2), 127–151.

Singleton, R.A., Straits, B.C. (1999) *Approaches to Social Research*. Oxford University Pres, New York and Oxford.

The City of Calgary (2004) 'Transit Oriented Development: Best Practices Handbook', Land Use Planning and Policy, Calgary.

Transport for London (2010) 'Measuring Public Transport Accessibility Levels (PTALs): Summary', London.

Transportation Research Board (2001) 'Making transit work: insight from Western Europe, Canada, and the United States', Transportation Research Board Special Report 257.

Turrell, G., Haynes, M., Burton, N., Giles-Corti, B., Oldenburg, B., Wilson, L.-A.M., M.Giskes, K., Brown, W.J. (2010) 'Neighborhood disadvantage and physical activity: baseline results from the HABITAT multilevel longitudinal study', *Annals of Epidemiology*, 20(3), 171-181.

Wilson, L.-A., Giles-Corti, B., Turrell, G. (2012) 'The association between objectively measured neighbourhood features and walking for transport in mid-aged adults', *Local Environment*, 17(2), 131-146.