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The Impact of Bus Rapid Transit on Housing Price and Accessibility Changes in Sydney: a Repeat Sales Approach

By
Corinne Mulley and Chi-Hong Tsai

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TITLE: **The impact of bus rapid transit on housing price and accessibility changes in Sydney: a repeat sales approach**

ABSTRACT:

New public transport infrastructure is expected to improve the accessibility for local residents, and thus contribute to the land value uplift. The contribution that a bus rapid transit (BRT) system can make to land value uplift is less certain than for rail based systems with the literature mostly containing bus-based examples from developing countries with extensive BRT networks. This paper considers a BRT system named the "Liverpool-Parramatta Transitway" (LPT) was implemented in the South-West of Sydney in 2003 to improve public transport accessibility in the local area.

A repeat sales model is constructed to investigate the impact of the LPT on residential housing prices and accessibility changes using repeat sales data from before and after the opening of the LPT. This identified little price difference between properties close to LPT stations and outside of the area that could be considered as affected by the LPT service coverage. This outcome is at variance with the theoretical underpinning of land value uplift and other empirical evidence relating to the LPT. Hedonic models using the same repeat sales data investigate the study area in more detail, stratifying the sample by housing type and by comparing separate before and after models. These research outcomes identify the extent to which the BRT system has an impact on local housing prices through accessibility improvements to the study area and provide a deeper understanding as to how the quantification of land value uplift from BRT represents one element of the wider economic benefits of a BRT system.

KEY WORDS: ***Bus, rapid transit, land value uplift, repeat sales model, accessibility value***

AUTHORS: **Mulley and Tsai**

CONTACT:

INSTITUTE OF TRANSPORT AND LOGISTICS STUDIES (C13)

The Australian Key Centre in Transport and Logistics Management

The University of Sydney NSW 2006 Australia

Telephone: +612 9114 1824

E-mail: business.itlsinfo@sydney.edu.au

Internet: http://sydney.edu.au/business/itls

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1. Introduction

Transport interventions are expected to create economic benefits and opportunities of land development. By improving accessibility, new transport infrastructure can deliver economic benefit in the form land value uplift. Increasingly, governments are looking for new ways of funding transport infrastructure and capturing the land value uplift has been put forward as a potential funding source as well as being a measure of evaluating how successful a transport project has been. With transport interventions coming in many different forms and affecting and delivering new opportunities with different modes, it is important to understand whether different modes deliver different amounts of land value uplift.

Bus Rapid Transit (BRT) is a high capacity urban public transport system, typically with its own right of way (as for rail based modes) which is gaining in popularity in cities around the world because of its better cost effectiveness (vis a vis light rail), quicker implementation and its provision for large numbers of passengers with high passenger attractiveness. However, the impact of BRT infrastructure on land value uplift is a relatively under-researched area in the literature although a growing body of studies have been identified in cities with successful BRT systems in developing countries.

As BRT has been drawing more attention from policy makers some cities have started to implement new BRT routes as a trial or as an alternative to other rapid public transport systems. These small-scale BRT systems have not yet been fully examined for their potential economic benefits on land values. Sydney, as an example, built its first BRT system in 2003 (the Liverpool-Parramatta Transitway (LPT)). The economic impact of the LPT in terms of its contribution to any land value uplift has not yet been evaluated although this could provide important policy information for the potential public transport projects under consideration in Sydney.

This paper examines the impact of the LPT on residential property prices using properties that have been sold more than once (repeat sales) between 2000 and 2006. Following this introduction, a critical review of the theoretical background of the association between land value and transport infrastructure as is provided together with a brief review of the international evidence. This is followed by an introduction to the study area and the LPT.

Methodology and data is then presented, followed by a presentation of the research findings. The final section concludes this paper.

2. Literature Review

The land rent theory, developed in an urban context by Alonso (1964) and Muth (1969), is the theoretical framework for the relationship between accessibility and land values. These theories purport that land rent (and therefore the underlying land values) reflects accessibility gradients with higher values of rent reflecting higher accessibility to goods and services.

A substantial body of literature has demonstrated that transport infrastructure provides improvements in accessibility and therefore land value uplift with uplift benefits being distributed in relation to the proximity of the location to the infrastructure and to both residential and commercial properties. The impact of new transport infrastructure can vary over time, with expectations increasing land values after the announcement of new transport infrastructure and before its completion giving rise to different short-term and long-term impacts. RICS (2002) and Smith and Gihring (2006) and Smith et al. (2009) reviewed over 100 international studies on the impact of public transport on property values, and these studies identified worldwide examples of the contribution of public transport infrastructure on property values.

Early studies on land value capture and public transport infrastructure have focussed on railed based systems including rail, light rail or metro investments (Cervero and Duncan, 2002; Du and Mulley, 2007; McDonald and Osuji, 1995; McMillen and McDonald; 2004). Rail based infrastructure is often perceived as fixed once built and so changes in accessibility are regarded as permanent. In contrast, BRT, despite often having its own right of way, is perceived as more flexible and, as Rodriguez and Targa (2004, p.589) noted '*ironically, it is BRT's flexibility that also appears to be one of its main weaknesses*' with planners, funders and importantly users judging it as less permanent than an equivalent rail system. These perceptions may well impact on BRT's ability to capitalise accessibility into land values.

The contribution of BRT investments on land value has been receiving more attention recently. In Bogotá, Columbia where BRT has been hugely successful with an extensive network, property values have been identified as rising for properties close to BRT stations (Munoz-Raskin, 2010; Rodriguez and Targa, 2004). In Asian cities, Cervero and Kang (2011) found land value premiums of between 5 to 10 percent for residential properties within 300m of BRT stations in Seoul, Korea. Deng and Nelson (2010) found qualitative and quantitative evidence of the attractiveness of BRT on people's relocation choice as well as a significant impact on land value uplift in Beijing, China. BRT is becoming more common in developed countries and associated studies, such as Cervero and Duncan (2002) investigating the effect of BRT in Los Angeles found no evidence of value uplift (although in this study BRT was more high performance bus services running in mixed traffic with signal prioritisation and other service enhancements). Perk and Catala (2009) studied BRT in Pittsburgh where uplift values of around 16 percent were found and this is in excess of the uplift value attributed to new light rail, although they identified that other positive factors may have been responsible. Dubé et al. (2011) in Quebec, Canada, found value uplift of 3 percent to 7 percent but confined to properties located far enough away to avoid noise but close enough to use the BRT. The evidence suggests BRT may have a positive impact on land value, although this may not be evident in cities where BRT is not a major transport mode such as Los Angeles.

In term of the methodologies used for capturing the value uplift from transport intervention, the review by Salon and Shewmake (2011) suggested the simplest method is to compare the price change between the 'before' and 'after' of the intervention of new transport infrastructure for properties close to the transport infrastructure (the 'treatment' or 'catchment' area) and a 'control' area or areas which are similar but without the new infrastructure. However, house prices are not only affected by the intervention of transport infrastructure but also by other factors such as property attributes and neighbourhood characteristics. These factors cannot be simply captured by the before-and-after approach even when comparing catchment and control areas and a hedonic modelling approach has been commonly employed (Cervero and Kang, 2011; Concas, 2013; Dube et al., 2011; McMillen and McDonald, 2004; Mikelbank, 2004; Rodriguez and Mojica, 2009).

Another approach to identifying land value uplift is to use repeat sales data (Billings, 2011; Billings and Thibodeau, 2011; Chatman et al., 2012; Dube et al., 2011; McMillen and McDonald, 2004). A repeat sales model estimates the difference between the price of the same properties sold before and after the transport intervention. This approach has the advantage of mitigating the omitted variable bias and endogeneity problems which may exist in hedonic models by eliminating the unobserved heterogeneity in the model estimation process through the use of this paired data. The disadvantage of a repeat sales approach is the potential selection bias if the housing market is not strong enough to generate sufficient repeat sales or if only particular types of property are more likely to be sold (Chatman et al., 2012).

3. Liverpool-Parramatta Transitway

3.1 Study area

The Liverpool-Parramatta Transitway (LPT), opened in February 2003, was the first BRT system in Sydney, Australia, and connects the major centres of Liverpool and Parramatta in the South-West of Sydney as shown in Figure 1. The termini are in Liverpool Local Government Area (LGA) and Parramatta LGA respectively but the route traverses the LGAs of Fairfield and Holroyd. The intention of the infrastructure was to provide North-South public transport services connecting Liverpool in the south, Parramatta in the north and suburbs along the route to major employment in warehousing in particular, education and recreation centres (The Audit Office of New South Wales, 2005). The 31 km route with 33 stations includes 20 km of new dedicated bus-only infrastructure and 10 km of on-road bus priority. LPT stops were designed to emulate rail-based public transport rather than simple bus stops.

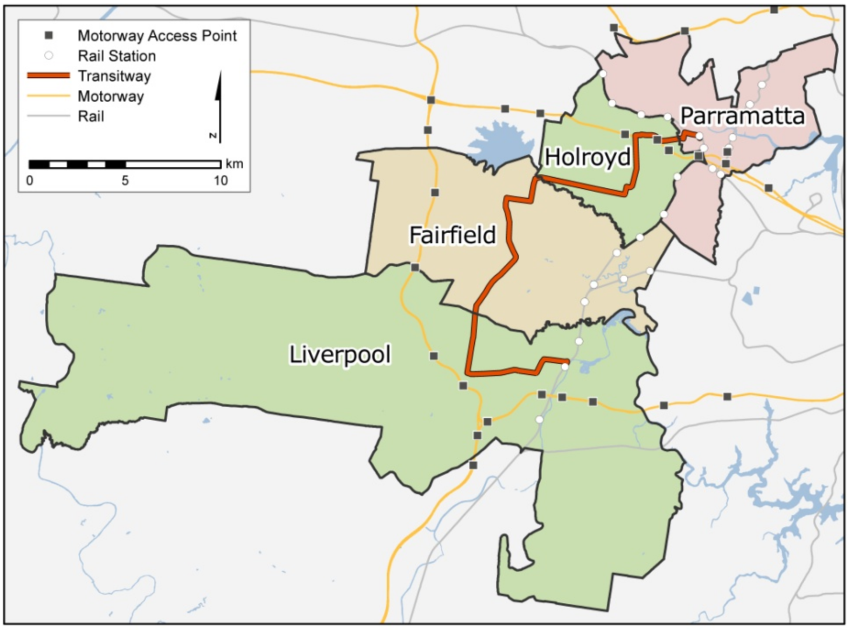

FIGURE 1 The Liverpool-Parramatta Transitway

(Source: developed from GIS layers)

The aim of the LPT was to create a step change improvement in accessibility for south-west Sydney with this new north-south public transport link in an area where existing bus services provided local east-west links. The LPT uses dedicated infrastructure to provide a high quality public transport experience with faster, more reliable services. In the first year of operation, the actual patronage was just under one million passengers per annum and this rose to nearly 2 million in 2006. Patronage on the LPT continues to grow with the most recent figures for 2011/2012 showing patronage at 2.7 million (State Transit Authority , 2012).

3.2 Property Sales Data

This research uses the residential property sales data between 2000 and 2006 collected by a commercial firm, RP data. Properties sold more than once before and after the LPT opening in 2003 are identified as repeat sales data for this research. The catchment area of the LPT coverage is defined by a 1600m buffer around a light rail station following Chatman et al. (2012) who used one mile buffer to define the service catchment area.

The LPT and its service catchment area are shown in Figure 2. A total of 786 repeat sales properties in the catchment area were sold at least once before and after the LPT opening. Figure 2 distinguishes the property types where units (or apartments), coloured blue, are clustered around the major business centres of Parramatta and Liverpool with trains connecting to the Sydney Central Business District (CBD). In contrast, houses are widely distributed across the catchment area and residents living in houses are more likely to have access to a car with less reliance on easy access to trains for accessing their destinations. The distribution of houses and units in Figure 2 suggests that travel behaviour may depend on the type of property of residence and differences in 'need' to access public transport may influence the degree of price appreciation arising from the new BRT. This is discussed further in below.

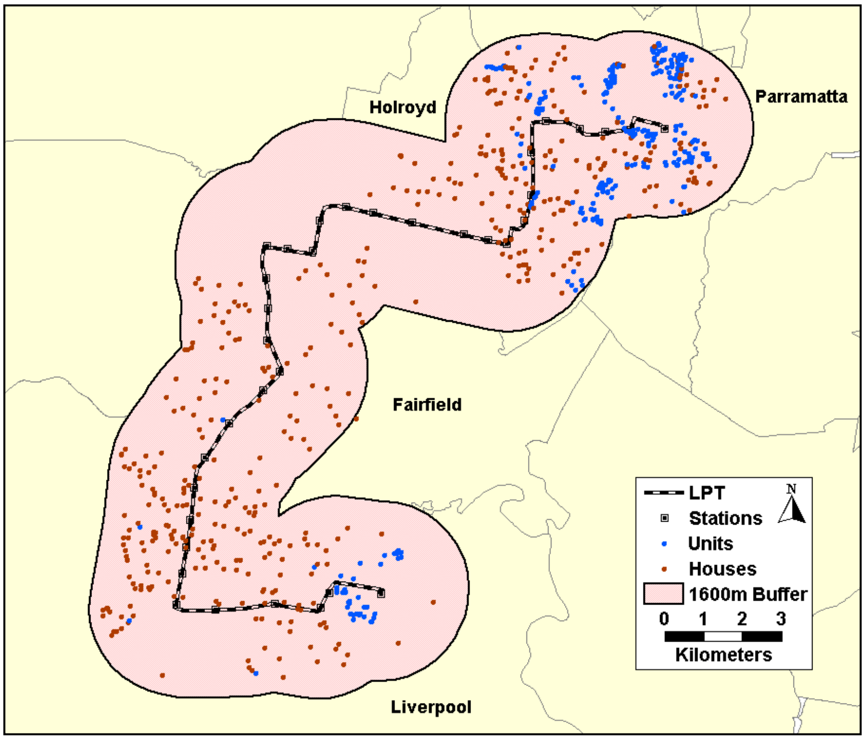

FIGURE 2 The Catchment Area of Liverpool-Parramatta Transitway

(Source: developed from GIS layers)

3.4 The Repeat Sales Model

The repeat sales model is defined in equation (1). The logged ratio of the price of a property sold before the LPT opening ($\boldsymbol{P_1}$) and after the opening ($\boldsymbol{P_2}$) is predicted by vectors of property attributes ($\boldsymbol{X}$), neighbourhood attributes ($\boldsymbol{N}$) and accessibility measures ($\boldsymbol{A}$), together with a distance gradient ($\boldsymbol{G}$) measuring the distance from the property to the nearest LPT station, and error terms ($\boldsymbol{\varepsilon_i}$). An alternative dependent variable, $\boldsymbol{ln}\ (\boldsymbol{P2} - \boldsymbol{P1})$, was initially examined but not used in the final model partly because missing values occur when $\boldsymbol{P2}$ is less than $\boldsymbol{P1}$ (since logarithms cannot be negative) and the plot of residuals showed distinctive distributions by property type.

$$\ln(\frac{P_2}{P_1}) = constant + \sum_j \alpha_j X_j + \sum_j \beta_j N_j \sum_j \gamma_j A_j + \delta \cdot G + \varepsilon_i \quad (1)$$

Conventionally, time-invariant variables such as property attributes are not included in a repeat sales model which is constructed through differencing the price for the same properties. In equation (1), these variables are retained because a model incorporating the time-invariant variables has the advantage of controlling for selection bias from repeat sales (Chatman et al., 2012). It is also possible that the price appreciation of properties may vary by property types such as the number of bedrooms and bathrooms, and this can be captured by equation (1).

The neighbourhood attributes are measured by the unemployment rate and income to represent the socio-demographics of the neighbourhoods. The unemployment and income data are retrieved from Australian Census Data in 2006 and are assumed to be either time-invariant or changing slowly because of the lack of availability of appropriate annual data at this disaggregate level.

In estimating equation 1, real prices are used (adjusted to 2000 real values using Australian Consumer Price Index of Established Houses). When a property was sold more than once before or after the LPT opening in 2003, the mean value of the sold prices in real terms is used to represent $\boldsymbol{P_1}$ or $\boldsymbol{P_2}$ in the dataset.

As the aim of the LPT was to provide improved accessibility of the study area with a rapid bus route connecting Liverpool and Parramatta through existing and developing areas of work and shopping, the impact of these accessibilities on price appreciation is particularly of interest. The new LPT provided services running north to south in contrast to the previously existing bus network which provided only east-west accessibility. Accessibility measures represented in this vector in equation (1) include the smaller of the straight line distance to Liverpool or Parramatta stations, warehousing (as employment opportunities), school, and shopping malls since these were the stated aim of the new transport infrastructure. Access to motorway entry points were included because of the potential importance of the car, as a competitor, to the new public transport infrastructure in what is essentially a suburban area. Whilst many models include the distance to the Central Business District, this is not included since it is highly correlated with the distance to Liverpool or Parramatta and the location of the LPT makes these latter business centres of greater importance in accessibility terms.

A distance gradient identifies whether the straight line distance to the nearest LPT station has an impact on land value uplift. The hypothesis here is that properties closer to stations will benefit more from the improved accessibility as compared to properties further away. Buffers of 400m, 800m, 1200m and 1600m around each LPT station are included in the model, identified using GIS, where the 800m buffer includes only properties further than 400m but less than 800m from the stop. A 100m gradient is also included to investigate possible negative impacts on the price appreciation from noise or air pollution from the BRT as found by a number of studies (Du and Mulley, 2007; Dube et al., (2011)). The definitions and descriptive statistics of the data are summarised in Table 1.

TABLE 1 Definitions and Descriptive Statistics of Variables (n=786)

Variable	Definition	Unit	Mean	S.D.	Min	Max
P_1	Average sold price before LPT opening	AU$	242311	82601.3	70961	663551
P_2	Average sold price after LPT opening	AU$	276931	90444	89237	694214
P_2/P_1	The ratio of P_2 to P_1		1.18	1.18	0.30	0.44
100m buffer	=1 if property located within 100m of LPT station		0.03	0.03	0.16	0.00
400m buffer	=1 if property located between 100m to 400m of LPT station		0.15	0.15	0.35	0.00
800m buffer	=1 if property located between 400m to 800m of LPT station		0.25	0.25	0.43	0.00
1200m buffer	=1 if property located between 1200m to 1600m of LPT station		0.29	0.29	0.46	0.00
1600m buffer	=1 if property located between 1200m to 1600m of LPT station		0.29	0.29	0.45	0.00
LIVPAR	Distance to Liverpool or Parramatta station, whichever is closer	km	2.50	1.57	0.23	7.16
MOTORWAY	Distance to the nearest motorway entry point	km	1.60	0.96	0.07	5.26
WAREHOUSE	Distance to the nearest employment area in the warehouse area	km	4.62	1.69	0.89	8.76
SCHOOL	Distance to the nearest school	km	0.45	0.25	0.00	1.35
SHOPPING	Distance to the nearest shopping mall	km	1.94	1.04	0.16	5.00
BEDROOMS	Number of bedrooms		2.76	2.76	0.93	1.00
BATHS	Number of bathrooms		1.32	1.32	0.56	1.00
PARKING	Number of parking spaces		0.95	0.95	0.81	0.00
TYPE	Property type (0=house; 1=unit)		0.45	0.45	0.50	0.00
UNEMPLOYMENT	Ratio of unemployment	percentage	0.04	0.01	0.00	0.09
INCOME	Ratio of weekly income more than AUD $1,600	percentage	0.02	0.01	0.00	0.08

4. Analysis Results

4.1 The price ratio model

The objective of the repeat sales model is to identify property price changes following the introduction of the LPT. The hypothesis is that properties closer to a LPT station are more likely to benefit from the LPT will have significantly greater price increases. Figure 3 shows the price change of each property against its distance to the closest LPT station and identifies little variation between change in price and the distance to LPT station.

The repeat sales model used in this paper also incorporates other explanatory variables to identify the significance of the impact of distance to LPT station on price changes, as well controlling for other determinants of property price. The estimation results shown in Table 2 shows low explanatory power given the adjusted R-square value of 0.100 which is unsurprising given the lack of variation in price change evident in Figure 3 (although the adjusted R-square is statistically different from zero, p-value>0).

The only two significant parameters at 95 percent confidence level are property type and income. The negative sign of the income parameter suggests that price increases are higher in neighbourhoods with lower incomes suggesting the introduction of the LPT may have a positive impact on balancing the socio-demographics of the study area, with poorer areas benefiting more than richer areas in terms of the property price increases. On the other hand, the negative sign of the property type shows that changes in house prices are significantly higher than that of units. Houses and units tend to have distinctive household structures and lifestyles which underpins the decision to separately investigate the price change of houses and units in the next section.

TABLE 2 Estimation Results of the Repeat Sales Model (n=786)

	Coef.	S.E.	t	Sig.	VIF
(Constant)	0.065	0.067	0.96	0.335	-
Distnace100m	-0.018	0.050	-0.36	0.721	1.16
Distnace400m	0.019	0.025	0.76	0.446	1.49
Distnace800m	-0.005	0.022	-0.22	0.823	1.65
Distnace1200m	0.029	0.020	1.45	0.148	1.51
Bedrooms	0.022	0.012	1.82	0.069	2.42
Baths	0.002	0.015	0.10	0.917	1.37
Parking	-0.016	0.009	-1.68	0.094	1.07
Type	-0.083	0.023	-3.57	0.000	2.47
MOTORWAY	-0.002	0.012	-0.21	0.836	2.33
WAREHOUSE	0.007	0.005	1.31	0.190	1.42
SCHOOL	-0.026	0.031	-0.82	0.411	1.11
LIVPAR	0.003	0.010	0.35	0.727	4.53
SHOPPING	0.017	0.011	1.66	0.098	2.22
Unemployment	1.062	0.641	1.66	0.098	1.53
Income	-2.168	0.593	-3.65	0.000	1.37

[1]VIF: Variance Inflation Factor

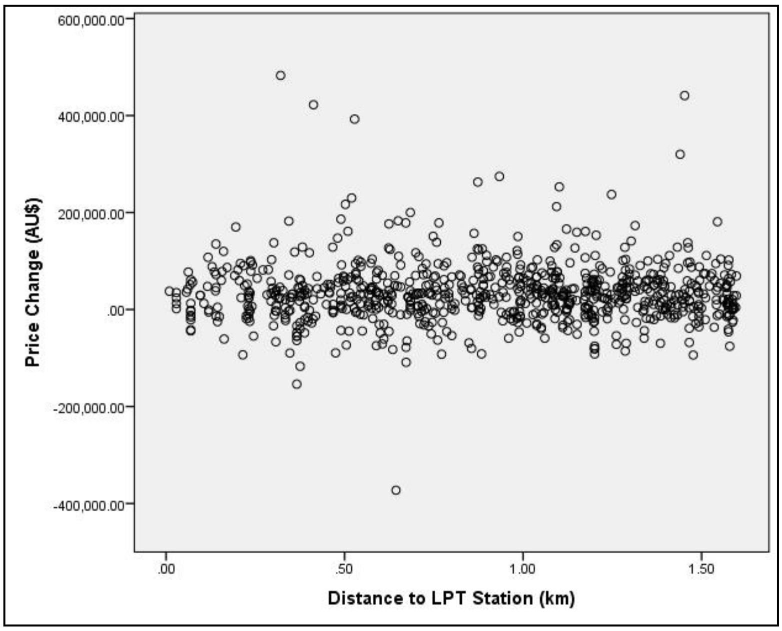

FIGURE 3 The Scatter Plot of Price Change versus Distance to LPT Station

5. Price models before and after the LPT opening

This section treats houses and units as separate subsets of the same dataset to mitigate this heterogeneity of property types identified above. Moreover, instead of using the logged value of the price ratio which lacked variation (see Figure 3), the logged values of the house prices before and after the LPT opening are used as dependent variables in estimating the relative impact of the explanatory variables between houses and units replacing the price ratio ($\boldsymbol{ln}\ (\boldsymbol{P_2}/\boldsymbol{P_1})$) in equation (1) by $\boldsymbol{ln}\ (\boldsymbol{P_2})$ and $\boldsymbol{ln}(\boldsymbol{P_1})$ respectively for two separate hedonic models for houses and units. The descriptive statistics of houses and units are presented in Table 3.

TABLE 3 Descriptive Statistics of Houses and Units

		Houses (n=433)				Units (n=353)			
Variable	Unit	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
P1	AUD	271,712	80,341	131,731	663,551	206,267	70,203	70,962	560,748
P2	AUD	325,883	83,123	157,025	694,215	216,916	56,604	89,237	506,140
P2/P1		1.25	0.33	0.44	3.28	1.09	0.22	0.66	3.05
BEDROOMS		3.32	0.85	1.00	13.00	2.07	0.44	1.00	3.00
BATHS		1.43	0.63	1.00	6.00	1.19	0.41	1.00	3.00
PARKING		1.05	0.94	0.00	6.00	0.84	0.61	0.00	3.00
LIVPAR	km	3.34	1.50	0.40	7.16	1.46	0.87	0.23	4.57
MOTORWAY	km	1.94	1.07	0.10	5.26	1.19	0.58	0.07	2.85
WAREHOUSE	km	4.40	1.92	0.89	8.69	4.89	1.31	2.00	8.76
SCHOOL	km	0.50	0.26	0.00	1.35	0.39	0.22	0.00	1.01
SHOPPING	km	2.33	1.04	0.39	5.00	1.45	0.81	0.16	4.38
UNEMPLOYMENT	percentage	0.03	0.01	0.00	0.08	0.05	0.01	0.02	0.09
INCOME	percentage	0.02	0.01	0.00	0.07	0.03	0.02	0.00	0.08

Houses in Sydney usually have a higher market price than units. The different characteristics between houses and units can be seen from the number of parking spaces (houses on average have 1.05 parking spaces as opposed to 0.84 for units, which indicates the higher car-dependency for house residents) and accessibility (units are on average located closer to the centres of Liverpool and Parramatta in Western Sydney, as well as being closer to motorway access, schools, and shopping centres). The descriptive statistics show residents living in units have better accessibility to activity destinations supporting an investigation of the impact of LPT on property prices segmented by property type.

The estimation results of the separate regressions on houses and units before and after the LPT opening are summarised in Table 4. In general, the model fits are better than the repeat sales model presented in Table 2. The property attributes in terms of bedrooms and bathrooms as well as the neighbourhood attributes (unemployment and income) are significant with an expected sign, that is, property prices are higher with more bedrooms and bathrooms, and with lower unemployment rate and higher income in the neighbourhoods for each of the four regressions. The variables of interest for this paper, the distance gradient and accessibility variables, show various results between houses and units. These differences are investigated using two sample t-test with the results shown in Table 5.

TABLE 4 Model Estimation Results for Houses and Units Sold before and after the LPT opening

	House (n=433)				Unit (n=353)			
	Before		After		Before		After	
Variable	Coef.	t	Coef.	t	Coef.	t	Coef.	t
(Constant)	12.363	130.43	12.420	162.22	11.845	90.23	11.814	124.79
100mbuffer	-0.178	-1.72*	-0.174	-2.08**	-0.053	-0.72	-0.082	-1.55
400mbuffer	-0.071	-1.84*	-0.039	-1.26	-0.035	-0.69	-0.010	-0.26
800mbuffer	0.016	0.55	0.004	0.16	-0.092	-1.81*	-0.078	-2.12**
1200mbuffer	-0.017	-0.59	-0.019	-0.82	-0.079	-2.13**	-0.021	-0.78
BEDROOMS	0.077	5.26***	0.101	8.52***	0.207	5.82***	0.223	8.68***
BATHS	0.062	3.23***	0.085	5.51***	0.223	5.79***	0.154	5.52***
PARKING	-0.004	-0.35	-0.010	-1.02	0.009	0.42	-0.028	-1.87**
MOTORWAY	-0.044	-2.91***	-0.051	-4.15***	-0.056	-1.65	-0.053	-2.15**
WAREHOUSE	-0.031	-4.50***	-0.028	-4.96***	-0.048	-3.07***	-0.029	-2.59**
SCHOOL	0.097	2.23**	0.014	0.41	-0.043	-0.69	0.022	0.48
LIVPAR	0.005	0.43	0.009	1.02	0.007	0.12	0.069	1.50
SHOPPING	-0.047	-3.64***	-0.026	-2.47**	-0.039	-0.62	-0.070	-1.55
UNEMPLOYMENT	-2.290	-2.06**	-0.990	-1.10	-2.459	-2.56**	-1.711	-2.47**
INCOME	6.259	5.18***	4.218	4.32***	6.418	7.20***	4.926	7.66***
Adj. R-square	0.338		0.424		0.520		0.587	
Observations	433		433		353		353	

***p-value<0.01;**p-value<0.05;*p-value<0.10

TABLE 5 Results of Two Sample t-test for Accessibility Variables

Variable	House Before & After	Unit Before & After	Before House & Unit	After House & Unit
	t-value			
100mbuffer	0.20	-	**5.92**	-
400mbuffer	-	-	**2.36**	-
800mbuffer	-	0.90	**-7.43**	-
1200mbuffer	-	-	**-4.71**	-
MOTORWAY	-0.84	-	-	-0.20
WAREHOUSE	0.63	**2.15**	**-2.19**	-0.24
SCHOOL	-	-	-	0.52
LIVPAR	-	-	-	-
SHOPPING	**2.89**	-	-	-

Note: Highlighted in bold if significant at 95% confidence level;
Insignificant parameters in Table 3 are not tested

For the house price models before and after the LPT opening, the 100m buffer is significant with a negative sign, and this is more significant (at 95 percent confidence level) after the LPT opening although the change in coefficient value is insignificant (Table 5) . This indicates that houses may receive a negative impact from the LPT, possibly due to the environmental impact of noise and air pollution. On the other hand, before the opening of the LPT, the price of houses located between 100m and 400m of a LPT station (400m buffer) is significantly lower than the houses located between 1200m and 1600m (1600m buffer), but the 400m buffer becomes insignificant after the LPT opening. This result suggests that the price of houses between 100m and 400m of a LPT station has increased relative to the reference group after the opening of LPT, possibly as a result of better accessibility to public transport. The other important finding is that some accessibility variables have smaller coefficients after the LPT opening such as distance to shopping centre (from -0.047 to -0.026), as well as distance to the nearest primary school (from 0.097 to insignificant), with statistically significant differences as tested in Table 5. This finding implies that the introduction of the LPT appears to improve the local accessibility so that the accessibility variables become less important in determining house prices after the implementation of the LPT as compared to the price before the LPT opening.

For the prices of units before and after the introduction of LPT, a noticeable change is the parameter of the 1200m buffer, which changes from -0.079 and significant before the LPT opening to insignificant after the LPT opening. This shows that units located between 1200m and 1800m benefited from the implementation of LPT as a result of improved accessibility to public transport. The parameter of warehouse changes from -0.049 to -0.029 which suggests the distance to warehouse on unit prices becomes less important after the introduction of LPT: this may reflect the type of work available in warehouses and a lower suitability for this work by the type of residents of units. The relative coefficients of the accessibility variables and the distance gradients give partial confirmation as to the impact of the improved accessibility brought about by the LPT on unit prices.

Comparing houses and units in terms of their price determinants in Table 4, it can be observed that the 100m buffer is insignificant for units in contrast to being significant for houses. This reflects the fact that more units are built close to Liverpool and Parramatta stations with good access to the existing train stations and units, which are in multi-floor buildings, may be less influenced by traffic noise or air pollution than houses. Another important finding is that the distance to school is insignificant for units in contrast to being significant for houses and this is possibly because households in units are less likely to have children to attend primary schools and thus distance to the primary school is not a factor of the unit prices. Distance to shopping centres is also insignificant for units as compared to its significant impact on house prices and this is likely to be affected by the way in which most units in this area are already located close to major shopping centres as shown in Table 3 (2.33 km for houses and 1.45 km for units).

6. Conclusion

This paper uses a repeat sales model and segmented hedonic models to identify the effect of the LPT on residential property prices. The repeat sales model shows low explanatory power due to the lack of the variation in price changes but nevertheless does identify accessibility variables and the property type having a significant influence on the housing prices. However, combining houses and units in the same estimation appears to provide more average type values which confound the interpretation.

The segmented hedonic models for the houses and units before and after the introduction of the LPT provide more information about the relationship between house prices and the improved accessibility contributed by the LPT. Houses located between 100m and 400m, as well as units located between 800m and 1200m of a LPT station, appear to benefit from the LPT given their relatively insignificant or smaller coefficients after the LPT opening. The hedonic models also identify the distinctively different requirements for accessibility between residents of houses and units. Distances to the primary school and shopping centres are more influential on house prices than unit prices, possibly as a result of the different level of car-dependency and household structures between house and unit residents. In general, the impacts of accessibility on property prices are distinctively different between houses and units.

As the first BRT system in Sydney, the impact of this transport intervention on property prices are not as substantial as noted in international literature, where BRT systems appear more successful in Beijing, Seoul and Bogotá. The finding of this research is more similar to Cervero and Duncan (2002) who also found the BRT system in Los Angeles did not contribute significantly to residential housing price changes although this was for higher performance bus services that what is typically pictured with the concept of BRT. It is possible that the benefits of the LPT, as the first BRT system in Sydney, have been undervalued by the market through a lack of understanding of what BRT can offer or that, through choice of residential location, the LPT is not more valuable to residents than their previous public transport options. Alternatively, given its location, the LPT may have increased accessibility in specific ways (as suggested by its ridership) but that overall it may be necessary for a BRT system to be the backbone of the wider transport network and not located in a suburb of a large city to achieve the highest benefits from a BRT system. This latter point is particularly pertinent for low density cities as found in Australia and an area requiring further research.

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