Announcement, construction or delivery: when does value uplift occur for residential properties? Evidence from the Gold Coast Light Rail system in Australia

Barbara T.H. Yen^{1,3*}, Corinne Mulley², Heather Shearer³, Matthew Burke³

¹Griffith School of Engineering, Griffith University, Gold Coast, Australia

²Institute of Transport and Logistics Studies, The University of Sydney, Sydney, Australia

³Cities Research Institute, Griffith University, Brisbane, Australia

Abstract

This paper examines the timing of the increases in land value on residential housing following the delivery of the Light Rail Transit (LRT) system in the Gold Coast, Queensland, Australia. This paper thus addresses one of the most pertinent questions for policy and practice around the timing, shape and conditions for increases in land value or value uplift. Increasingly governments face funding constraints in the implementation of new infrastructure and so are keen to understand if capturing this land value uplift is a practical proposition to augment or provide funding for new transport infrastructure. This in turn depends on knowing how much uplift is generated, when it occurs, the size of the catchment effect, and the contours of the effects with increasing distance from the public transport facility. This paper uses a Difference-in-Differences model to show differences in impacts for properties, as measured by property prices, in catchment areas versus those in control areas across time. The results show property prices in the catchment areas start to increase after announcement with the highest increment of increase being found after solid financial commitment is made by government. Property prices then slow during construction and the operation period. These results provide an evidence base for operators, planners and government sectors in their planning for future LRT systems and for quantifying the potential funding that can be achieved through capturing the increases in land value.

Keywords

Land value uplift; Light Rail; Difference-in-Differences model; Value Capture.

1 Introduction

Urban settlements are the powerhouses of our economies and their ongoing sustainability depends on the ability of citizens to access goods and services. This accessibility is particularly important to the Gold Coast, Queensland, Australia where the economy is heavily dependent on tourism and the ability of tourists to access the different attractions.

*Corresponding author. Tel: +61-7-37359247

E-mail address: t.yen@griffith.edu.au (Dr Barbara T.H. Yen)

Australian cities are typically low density and suffer from urban sprawl, much as in the US and in contrast to the more compact and mixed-use cities often found in Europe. In recent years, the increasing number of private vehicles has made public transport development more imperative because of traffic congestion problems, safety issues, oil vulnerability, and environmental pollution. A well-developed public transport system can deliver broad economic and social benefits to communities, including cost savings associated with reduced traffic congestion, increased productivity through job creation, competitiveness and liveability. However, the growth and development of public transport are heavily conditioned by available funding sources, particularly as infrastructure provision is very expensive. Traditional funding sources such as fuel taxes or income taxes are either inadequate or have competing pressures to meet the demands for sustainable public transport development.

These imperatives have driven the investigations for alternative funding and financing mechanisms, one of which is value capture (Enoch, 2005; Smith and Gihring, 2006; Iacono et al., 2009; Zhao et al., 2011; Zhao et al., 2012). Smith and Gihring (2006) describe value capture as the “appropriation of land value gains resulting from the installation of specific public infrastructure improvements in a limited benefit area” (p. 752) and the partial use or total use of these revenues to fund improvements. In short, value capture utilises the increased value of nearby properties that benefit from better accessibility as a result of public transport provision. The interest in this mechanism in Australia has led the New South Wales (NSW) government to re-label value capture as “value sharing” to emphasise the mutual benefit nature of the uplift and its capture.

Although the literature contains a considerable number of individual case-study investigations as to the nature of the uplift brought about by increased accessibility, the results are quite varied (and discussed below in the literature review). However, *when* the uplift to land values occurs is under-represented in the literature. This aspect is however particularly important for informing policy. For residential properties, does the uplift occur upon announcement of a project, the delivery (as characterised by the building of the project) or its opening when citizens can finally use it? It is likely that the timing will be different for commercial properties where it is more likely that entrepreneurs will internalise any uplift in their business plans and activities. The aim of this paper is to quantify when residential property value uplift occurs by using Gold Coast Light Rail Transit (GCLRT) system in Queensland, Australia as the context.

The paper is structured as follows. The next section provides a state of the art literature review for land value uplift for public transport investment in terms of mode, quantity and timing of uplift and the sort of factors which influence these aspects. The paper then turns to the case context of the GCLRT system before addressing the methodology adopted and the

data used in this analysis. The results are then provided and interpreted. The final section discusses the results and concludes with recommendations for future research.

2 Literature Review

The theoretical underpinnings of value uplift, where land value increases as a consequence of improvements in accessibility, derive from the land rent theory of Alonso (1964) and Muth (1969). In essence, rents are higher for land with higher accessibility since this offers land holders greater opportunities in terms of destinations. This theory therefore underpins the notion that investments in high-capacity public transport systems will generate positive ‘uplift’ in land values for surrounding catchments. It is worth noting that the change in accessibility is, in theory, related to unimproved land, i.e. land with no structures on it.

In practice a specific tax is not always required for value uplift to be captured and provide a revenue flow: cities around the world typically have some form of land taxation in place and so benefit from the value uplift through the ‘back door’ if the property valuations upon which the land tax is based reflects the higher value. However, despite these ‘back door’ contributions, governments are increasingly contemplating the creation of special financial instruments to more specifically ‘capture’ uplift and to use it to help with the funding of public transport investments.

Most rail systems are of particular policy interest given their high capital and operating costs and significant operating subsidies and have been the subject of successful value capture instruments. There are many successful examples that use land value capture instruments to fund public transport, such as Hong Kong’s metro rail (MTR) where the development of property above stations has delivered funding for rail development (the rail plus property model) and in London, businesses have contributed to the Crossrail project through a business rate supplement (Medda 2012:156-157). How value uplift is captured is the central tenet of an increasing literature base, particularly considering joint development schemes in the US (Mathur and Smith, 2013) or London (Transport for London, 2017) and covering innovative financing schemes as well as the more established methods such as Stamp Duty Land Tax, Capital Gains Tax, Business rates, Council tax. This is extended in Mathur (2014) to cover more instruments that have been used in the US context (special assessment districts, tax increment financing, transit impact fees) recognising the movement away from direct subsidy and of a movement towards the idea of the beneficiary paying.

Important as developing a mechanism for capturing uplift is, it is irrelevant if there is no uplift to be captured. The premise of this paper is that it is important to identify *when* the uplift occurs so that capture can be effective in its timing.

This section encompasses a variety of peer reviewed literature. First the section considers the method to identify value uplift and the pros and cons of the different methods used in the literature. The section then turns to look at results: how much value uplift has been identified in the literature that can be linked to the provision of transport infrastructure? Finally, the section identifies the research gap which is the fundamental aim of this paper to address.

2.1 How value uplift is identified

Transport and land use researchers have placed significant effort on both identifying uplift and describing its characteristics, with over 60 studies now completed in North America alone (Higgins and Kanaroglou 2016:611). Methodologically this work expanded greatly from the late 1990s with the emergence of geo-spatial property datasets that allow empirical analysis of contours in land rents across urban areas.

Commencing with relatively simple matched pairs or spatial regression techniques in cross-sectional hedonic pricing studies, researchers began to reveal varying and mostly positive uplift around heavy rail and light rail investments (i.e. see McDonald and Osuji, 1995; Cervero and Duncan, 2002; McMillen and McDonald, 2004, Du and Mulley, 2007). However, these simple models were not able to take account of the different contexts of the different locations in terms of neighbourhood and other effects. More sophisticated models began to appear based on Lancaster's theory of consumer demand which argues consumers demand is influenced by the characteristics of the good rather than the good as a single entity (Lancaster, 1966).

Rosen (1974) extended Lancaster's ideas to provide the theoretical framework for understanding the market clearing prices for goods that are defined in terms of characteristics. This allowed a translation of the bid rent ideas of Alonso (1964) and Muth (1969) to be examined as a series of implicit prices in a hedonic model. Hedonic price models typically use market clearing prices of the house as the dependent variable and identify the value of accessibility by controlling for the characteristics of the house itself and the neighbourhood in a multivariate regression model.

The earliest hedonic models have been criticised for the lack of account taken of spatial influences. More recently there have been concerns about endogeneity effects too. A plethora of spatial tools has been developed, made possible by increases in computing power and the analytical opportunities offered by the availability and improved quality of geospatial data, to address spatial concerns. Mohammad et al. (2015) indicated that advances such as difference-in-differences approaches have also helped with possible concerns over endogeneity.

In advancing value uplift research, more recent studies have variously sought to trial improved methods, to explore a wider set of research questions and to look at a broader set of modes. The methodological improvements include the addition of a richer set of control variables in analyses such as crime data (Billings, 2011), the introduction of longitudinal studies using repeat sales data (Pagliara and Papa, 2011), techniques to address spatial dependence effects (Cao and Porter-Nelson, 2016) and advanced techniques including geographic weighted regression (Du and Mulley, 2006, Mulley, 2014) and pseudo-panel data (Mohammad et al. 2015). When matched pair or geographic weighted regression studies are used, the heterogeneity of uplift (and downlift) across stations and geographical areas becomes clear. Both uplift and downlift were identified around different public transport stops in the Brisbane ferry system (Tsai et al., 2017) and the Buffalo light rail system (Hess and Almeida, 2007) such that while, on average across the study areas there was uplift, at specific sites local contextual factors prevent public transport investment from producing beneficial impacts on land value.

2.2 Value uplift outcomes from transport infrastructure

Almost all the major modes in use in urban public transport today have now been covered with researchers also finding uplift effects for light rail (Billings, 2011; Murray, 2016), busways systems (Deng and Nelson 2013; Zhang and Liu, 2015; Stokenberga, 2014), urban ferries (New York City Economic Development Corporation, 2013) and bicycle sharing stations (El-Geneidy et al., 2014) as well as high speed rail stations (Hensher et al., 2012). The results of previous research are mixed although many of the studies conclude there are some positive uplift effects (e.g., Tsai et al. 2017; Mulley et al., 2016). However, there is other research where there is evidence of a negative impact from the introduction of a light rail systems (e.g., Crocker et al., 2000; Du and Mulley, 2007; Knowles and Ferbrache 2016; Mohammad et al., 2013). Some authors have suggested that different outcomes might be partially due to the use of different methods with earlier methods lacking the ability to expose the complexity of different factors that could affect the housing market (Salon and Shewmake, 2011). Also, as Knowles and Ferbrache (2016) identify, location matters as does the motivation for the introduction of the light rail infrastructure whether this is to provide new land for development or perhaps to reorganise land use in a city. The reasons for light rail implementation together with the economic environment can also dictate delayed impacts on house prices (Forrest et al., 1996; Ovenell 2007 in Senior, 2009) and, of course, expectations play an important part in when the uplift might occur with governments renowned for cancelling projects leading to uplift only being seen after building has commenced (Mulley, 2014)

Two significant meta-studies provide evidence on a range of modes and contexts. Debrezion et al. (2007:161) reported that residential properties within a quarter mile of rail stations average around 4.2% more than other properties, whereas the difference is around 16.4% for

commercial properties. Uplift effects were around 14.1% higher for commuter rail stations as compared to light rail stations, which in turn had higher effects than for bus rapid transit stations (Debrezion et al., 2007:176-177). Mohammad et al. (2013) reported that of 23 studies analysed, most reported positive gains in land value, though some had negative gains where it seemed noise, pollution and crime may have increased. The greatest uplift effects were seen in Asian and European projects which may relate to differences in densities and urban structure. Studies have also found that effects were higher for commercial properties, as compared to residential properties (Mohammad et al., 2013:169). Across the studies surveyed, the greatest uplift tended to be between 500m and 805m from a rail station, as compared to distances further away (ibid, p169).

Urban space is produced by the specific political-economy of different cities (Lefebvre, 1991). Modes of transport also take on different characteristics across nations and it is not surprising that value uplift does differ significantly across city types. Australian cities with their very strong CBD employment and extensive heavy rail systems differ from similarly low-density US cities. Recent research on value uplift from public transport in Australia has shown reasonably healthy uplift effects from heavy rail in Perth (McIntosh et al. 2014), the GCLRT (Murray, 2016), the Brisbane busways (Zhang et al., 2015; Mulley et al, 2016) and Brisbane ferry systems (Tsai et al. 2017). Yet Mulley and Tsai (2016) found a mixed picture for a Western Sydney busway with less positive effects close to the joint freeway-busway corridor and greater effects in a band 1200-1600m further away, suggesting interactions with road infrastructure and possibly feeder lines. These studies have used a variety of methods, some spatial and others difference-in-difference or multi-level modelling. Two have used land valuation data which are the values put on each individual block by the responsible government agency and is a price that excludes the value of the structure on it, if one exists. Using unimproved land values gives the advantage of a large dataset but is disadvantaged by not being determined by market clearing prices and assumes that the government agency has set the valuation correctly. Other studies have used market clearing house prices from house sales which provide smaller datasets but mean that the analysis must take account of the property characteristics so as to identify the underlying land value.

2.3 What is the research gap?

Though the existence of value uplift is no longer in dispute there remain significant gaps in knowledge. The exact causal mechanisms in producing uplift across different project types remains opaque. There are only limited understandings of effects from less common modes or more unusual variants of rail or busways. But the most pertinent questions for policy and practice are around the timing, shape and conditions for uplift. If effective and politically saleable value capture schemes are to be implemented then understanding exactly when uplift occurs, the size of the catchment effect, and the contours of the effects with increasing distance from the public transport facility, need to be well understood. Evidence has been

provided previously for uplift to occur well ahead of a rail line opening (McDonald and Osuji 1995) or to occur only when opportunities for transit-oriented development were taken up well after a rail line opened (Mathur and Ferrell 2013, Mulley and Tsai, 2016) suggesting local context and project type will produce widely different outcomes. Experiences in St Paul, Minneapolis, suggest that proactive land use planning may be helpful in stimulating an earlier uplift response (Cao and Porter-Nelson, 2016). Differential uplift effects by distance from the public transport node have also been reported, mostly showing a decline in uplift contribution to property price with distance from the station (i.e. Landis et al. 1995). In the case of London's Jubilee Line this effect was approximately 500m from each station for commercial properties and 750m for residential properties (Banister and Thurstain-Goodwin 2011:221). Refining these understandings is necessary to help fashion more effective and socially-acceptable value capture schemes.

This paper takes a particular look at timing issues using a difference-in-difference modelling approach. It uses market clearing prices for properties sold at different points over the development of the GCLRT scheme and this is discussed next in the section describing the study area and context.

3 Gold Coast Light Rail

3.1 Study Area

The study area encompasses the GCLRT Stage One operation which connects the Gold Coast University Hospital in the North to Broadbeach in the South as shown in Figure 1. The GCLRT Stage One is a single 13-kilometre line of 16 stations which opened to the public on 20 July 2014. The Stage Two of the GCLRT system began construction in mid-2016 and it is a 7.3-kilometre northern extension of the track to the Helensvale heavy rail station (which provides interchange to Queensland's capital city, Brisbane).

Figure 1 The Gold Coast Light Rail Transit system map (source: Goldling, 2017)

3.2 Timeline of GCLRT System

The detailed timeline of the public development leading to the construction of GCLRT Stage One and Stage Two is provided in Figure 2. The timeline can be divided into five key periods that are used to understand when uplift effects could happen. The baseline is before the announcement. After the announcement is the first phase in which uplift could occur: this occurred in 1998 when the first plan for the GCLRT was set out in the Gold Coast City Council (GCCC) transport plan, a joint document between GCCC and the Queensland State Government (QLD Gov, 1998, as cited by Murray, 2016). The start of the solid commitment period is identified by the publication of the GCLRT Feasibility Study draft report in 2004, which included a proposed timeline and stations plan. The financial commitment from GCCC and QLD Government was confirmed between 2008 and 2011 with construction starting in June 2011 and finishing in July 2014 marking the start of the fourth period. The final period includes the Stage One start of operation and the beginning of the Stage Two construction.

Figure 2 Timeline of key dates of the GCLRT construction

Whilst residential sales data exists for each of the time periods identified in Figure 2, these sales data are for improved land values (i.e. land values with structures on them). As will be seen below, and as discussed in the literature review above, the theory on land value uplift relates to unimproved land. Hence the method used takes account of the different property characteristics and also the neighbourhood attributes that lead to parcels of land achieving different market prices. Neighbourhood factors are provided by the census, collected in Australia every five years with the census date closest to the event being used in the modelling of the timeline of potential uplift. Hence 1996 is the base year or ‘before’ announcement, 2001 is used for the ‘after’ announcement, 2006 census data is matched to ‘solid commitment’, and 2011 represents the start of the construction period with 2016 being the Stage One operation and Stage Two construction period.

4 Material and Methods

4.1 Difference-in-Differences Model

The objective of this paper is to evaluate the incremental effects of accessibility to a light rail network on residential property values over time. The difference-in-differences (DD) model contains an interaction term that is the product of the group and time indicators, with the DD indicating as a difference in the differences between groups across time (Puhani, 2012). More specifically, DD models are employed to investigate whether there are significant differences between a treatment group (in this case properties close to the light rail stations) and the control group (in this case properties not close to the light rail station) in terms of residential property sale price changes (first difference) before and after the announcement, construction or delivery of light rail system (second difference). DD estimation is recognised as one of the more important tools to estimate the effects of policy implementation in applied economics (Bertrand et al., 2004; Athey and Imbens, 2006; Lechner, 2011; Puhani, 2012). The DD model in this study is specified as:

$$\ln(p_{it}) = \beta_0 + \beta_1 X_{it} + \beta_2 N_{it} + \beta_3 LR_{it} + \beta_4 T_{is} + \sum \theta_t LR_{it} \cdot year_{it} + \varepsilon_{it} \quad (1)$$

where, p_{it} represents the transaction price of property i at time point t ($t=1996, 2002, 2006, 2011, 2016$) which is predicted by a vector of observable attributes. The observable attributes include X_{it} , a vector of property attributes for property i in year t ; N_{it} , a vector of neighbourhood attributes for property i in period t ; LR_{it} is an indicator variable that equals to 1 if property i is in the GCLRT catchment area of the LRT station and 0 otherwise; T_{is} is a seasonal time series variable over the period between 1996 to 2016 capturing quarterly seasonal time trends for property i in the quarter running from 1 (first quarter 1996) to 83 (third quarter 2016); $year_{it}$ is an indicator variable that equals to 1 if property i sold in year t ; and ε_{it} is the error term for property i in year t . The term $\beta_4 T_{is}$ controls for general increases in price due to inflation and seasonal variation. The interaction of LR_{it} and $year_{it}$ is the difference-in-difference estimator, and the estimated parameters can be tested to investigate whether there is a difference in property sale price change over year among the properties that located within different GCLRT catchment areas (treatment) and those not (control), for the different time periods discussed above: θ_t is therefore the coefficient of interest.

4.2 Catchment and Control Areas

Using a DD approach, it is first necessary to define the catchment (treatment) and control areas for the residential property sales data. Figure 3 shows the property price data from 1996 to 2016 which were sourced from RP data (RP data is a business company that provides property information in Australia and New Zealand. <http://www.corelogic.com.au/>). Similar to previous studies, residential sales properties located within 800m of each GCLRT station were grouped into a catchment area, while those located beyond 800m but within 1600m of each station were grouped into a control area. This location selection method is based on the literature that 800m is a walkable catchment area for rail based public transport (Guerra et al., 2013). As can be seen from Figure 3, the catchment areas overlap to provide almost linear catchment and control areas although the eastern side of the control area is curtailed by the coastline. The catchment area is further divided into three levels, 0-100m, 101-400m and 401-800m from the stations. This is because properties within 0-100m of a station may suffer from negative environment impacts such as noise, air pollution and higher crime rates even though they have very good accessibility to the stations (Cervero and Kang, 2011, Mulley et al., 2016 and Mulley and Tsai, 2016).

Figure 3 Catchment and control areas.

4.3 Data Description

Table 1 shows summary details of each variable used in the model. The following subsections present information on each variable in turn.

4.4 Dependent Variable

The market clearing property price is the dependent variable in the model as provided by RP data and only residential properties are included. All properties sold in 1996, 2002, 2006, 2011 and mid-2015 to mid-2016 (hereafter 2016) in the Gold Coast were used for the longitudinal analysis. The timing of the transaction data was chosen to match with the census data, which provides the data for neighbourhood effects and were then linked to different stages of the project development as described above.

The transaction price in the model is transformed to natural logarithms. This transformed variable has the advantage of mitigating heteroscedasticity as a result of reducing scale of the values (Rodriguez and Mojica, 2009). The descriptive analysis of the variables is presented in Table 2 for the catchment area and the control area, respectively.

4.4.1 Property Attributes

Several property attributes were provided by RP data including the contract date of the sale (characterised by the ‘event date’), property type (house or unit/apartment), area size, the number of bedrooms, bathrooms, parking spaces and the latitude and longitude. Unfortunately, the area size of the property, which has been shown to be significant in many non-Australian studies in the literature, cannot be used in this analysis since for apartments, area size relates to the total land area of all units within a development. This study uses the number of bedrooms, bathrooms and parking spaces to control for the size of the property. The property type is controlled by a dummy variable (Property Type=0 if house; Property Type=1 if unit). The Gold Coast features some very high priced properties and for this reason another dummy variable for the property with a sale price over \$1 million Australian dollars to capture any effects of these higher price properties.

4.4.2 Neighbourhood Attributes

Neighbourhood attributes are used to capture the external characteristics influencing property prices. The neighbourhood attributes selected for this study include the percentage of unemployment population, the percentage of older people (>65 years old), the percentage of the population with college and higher qualification, and the percentage of English only speaking people. These variables are derived from the Australian Bureau of Statistic census data at the Census Collection Districts (CCD) level for the year 1996, 2002, and 2006 but at Statistical Area Level 1 for the year 2011. Statistical Area Level 1 (SA1s) is the new base unit of output geography for the 2011 Census and are the smallest level at which census data is

reported having an average population of 400 persons. The earlier Census Collection Districts (CCDs) were made up of around 200 dwellings and were originally designed for the delivery and retrieval of Census forms by one collector rather than making sensible output units (Australian Bureau of Statistics, 2011). This study has needed to use both CDs and SA1s because of the longitudinal nature of the data. It is not envisaged that this will make a significant difference.

Census data in the year 2016 have not yet been released. However, as can be seen from Table 1, the average values over the period 1996 and 2011 are quite different although there is only a small difference between 2006 and 2011. Given the unavailability of 2016 data as yet, 2011 neighbourhood attributes are used for 2016.

4.4.3 Accessibility Attributes

Accessibility variables were calculated using Geographic Information System (GIS) and are the road network distances for each variable. A variety of accessibility variables were calculated – to the nearest school (primary school, high school or university), to the nearest beach, to the nearest park, to the CBD (Southport), to the major tourism site (Surfers Paradise), to the nearest heavy rail station (Helensvale Station). In general, it would be expected that there is a negative relationship between these accessibility variables and house prices reflecting that a longer distance of access serves to decrease property prices, everything else being equal.

4.4.4 Time and Catchment Dummies

As identified above, five separate years of data are used in this longitudinal investigation, each year representing a period when uplift may accrue (see Figure 2) giving rise to five year variables. A quarterly seasonal time series variable is introduced to capture the overall price change over time and inflation between 1996 and 2016. The interaction terms of the catchment dummies and year variable are used to measure the average price difference between properties in the catchment area and control area. There are three-level catchment areas giving 12 interaction terms (3 catchment level * year 2002, 2006, 2011 and 2016 with the year 1996 as the base year for comparison).

Table 1: A summary of the variables in the DD model

Variable	Description	Source
Dependent variable: lnPrice	Transaction price of property in natural logarithms (AUD)	RP data
Independent variable		
SeasonalTimeSeries	Seasonal Time Series number	RP data
Property attributes		
Property type	=0 if house; =1 if unit	RP data

Bedrooms	number of bedrooms	RP data
Baths	number of bathrooms	RP data
Parking	number of parking spaces	RP data
Sale Price Over 1 million	=1 if transaction price over \$1 million; =0 otherwise	RP data
Catchment variable		
C100m	=1 if within 100m of Light Rail station; =0 otherwise	GIS
C101-400m	=1 if in 101-400m of Light Rail station; =0 otherwise	GIS
C401-800m	=1 if in 401-800m of Light Rail station; =0 otherwise	GIS
Interaction term		
CY2002_100m	=1 if property sold in 2002 within 100m of light rail; =0 otherwise	GIS*
CY2006_100m	=1 if property sold in 2006 within 100m of light rail; =0 otherwise	GIS
CY2011_100m	=1 if property sold in 2011 within 100m of light rail; =0 otherwise	GIS
CY2016_100m	=1 if property sold in 2016 within 100m of light rail; =0 otherwise	GIS
CY2002_101-400m	=1 if property sold in 2002 within 101-400m of light rail; =0 otherwise	GIS
CY2006_101-400m	=1 if property sold in 2006 within 101-400m of light rail; =0 otherwise	GIS
CY2011_101-400m	=1 if property sold in 2011 within 101-400m of light rail; =0 otherwise	GIS
CY2016_101-400m	=1 if property sold in 2016 within 101-400m of light rail; =0 otherwise	GIS
CY2002_401-800m	=1 if property sold in 2002 within 401-800m of light rail; =0 otherwise	GIS
CY2006_401-800m	=1 if property sold in 2006 within 401-800m of light rail; =0 otherwise	GIS
CY2011_401-800m	=1 if property sold in 2011 within 401-800m of light rail; =0 otherwise	GIS
CY2016_401-800m	=1 if property sold in 2016 within 401-800m of light rail; =0 otherwise	GIS
Neighbourhood variable		
% Older	The percent of older persons (older than 65 years old)	Census
% English speaking only	The percent of English only speaking people	Census
% Unemployed	The percent of unemployed population	Census
% Married	The percent of married population	Census
% College	The percent of population with college and higher qualification	Census
Accessibility variable		
D_School	Network distance from property to the nearest school	GIS
D_Beach	Network distance from property to the nearest beach	GIS
D_Park	Network distance from property to the nearest park	GIS
D_Surfers	Network distance from property to the major tourism site (Surfers Paradise)	GIS
D_CBD_Southport	Network distance from property to CBD (Southport)	GIS
D_Heavy Rail_2011	Network distance from property to the nearest Heavy Rail station and if property sold in 2011	GIS
D_Heavy Rail_2016	Network distance from property to the nearest Heavy Rail station and if property sold in 2016	GIS

* The route network data, e.g., catchment variables) was derived from the South East Queensland GTFS (General Transit Feed Specification) provided by the Queensland Department of Transport and Main Roads (Queensland Department of Transport and Main Roads, 2016). Accessibility variables, such as distance to school, were downloaded from the Queensland Government Spatial Data Catalogue (Queensland Government, 2017).

Table 2: Descriptive analysis of variables

Catchment areas (0-800m)											
Year		1996		2002		2006		2011		2016	
n		2157		4355		3105		1607		3653	
Variable	Unit	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Price	AUD*	235561	191352	326015	311848	573110	724259	540126	617538	521911	479512
Bedrooms	number	3.04	0.03	2.84	0.35	2.61	0.50	2.43	0.98	2.31	0.75
Baths	number	2.27	0.03	2.12	0.16	1.91	0.39	1.82	0.54	1.72	0.52
Parking	number	1.98	0.02	1.85	0.05	1.67	0.35	1.56	0.55	1.45	0.54
% older	%	30.70	9.97	20.85	7.73	19.50	10.10	17.06	8.17	17.49	7.60
% English speaking only	%	68.13	14.22	60.25	20.43	64.08	15.13	65.69	11.79	66.43	11.05
% Unemployed	%	0.52	1.74	3.64	2.43	3.00	2.38	4.53	1.63	4.53	1.78
% College	%	3.48	4.32	4.03	2.09	4.87	3.54	3.97	2.68	3.95	2.83
School	km	0.90	0.40	0.92	0.40	0.88	0.40	0.90	0.40	0.89	0.40
Beach	km	0.79	0.95	0.74	0.93	0.78	0.87	0.78	0.86	0.73	0.81
Parking	km	0.18	0.08	0.17	0.08	0.17	0.08	0.17	0.08	0.17	0.08
Surfers Paradise	km	2.26	1.33	1.92	1.40	2.09	1.35	2.08	1.42	2.01	1.35
Southport	km	3.81	2.13	3.79	1.89	3.61	2.11	3.49	2.11	3.69	2.08
Heavy Rail 2011	km	0.00	0.00	0.00	0.00	0.00	0.00	11.30	2.09	0.00	0.00
Heavy Rail 2016	km	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.59	5.95
Control areas (801-1600m)											
Year		1996		2002		2006		2011		2016	
n		765		1801		1139		557		527	
				Std.							
Variable	Unit	Mean	Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Price	AUD	181015	124554	292057	267898	479584	463059	547703	444257	650603	977470
Bedrooms	number	3.04	0.04	2.90	0.36	2.82	0.68	2.95	0.92	2.83	1.09
Baths	number	2.26	0.04	2.11	0.17	1.89	0.46	1.86	0.68	1.81	0.78
Parking	number	1.98	0.05	1.84	0.07	1.70	0.48	1.79	0.85	1.72	0.84
% older	%	28.68	10.40	18.73	7.92	15.41	7.04	16.56	8.10	17.62	9.49
% English speaking only	%	80.11	5.88	80.73	7.62	76.17	8.84	77.76	8.81	75.44	10.68
% Unemployed	%	0.31	0.95	4.67	2.18	3.26	1.39	4.06	1.60	4.25	1.67
% College	%	2.54	3.55	4.25	1.85	5.47	3.80	8.08	3.82	7.32	3.81
School	km	0.89	0.36	0.93	0.39	0.89	0.36	0.88	0.37	0.75	0.37
Beach	km	2.42	1.59	2.30	1.62	2.38	1.55	2.23	1.51	2.16	1.35
Parking	km	0.19	0.09	0.19	0.09	0.19	0.09	0.20	0.10	0.20	0.08

Surfers Paradise	km	3.95	1.86	4.12	1.82	4.04	1.80	3.93	1.73	4.12	1.33
Southport	km	4.24	2.26	4.48	2.54	3.98	2.39	4.27	2.43	3.75	2.64
Heavy Rail 2011	km	0.00	0.00	0.00	0.00	0.00	0.00	10.31	3.48	0.00	0.00
Heavy Rail 2016	km	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	5.53

*AUD= Australian Dollars

5 Results

The estimation results of the DD model are presented in Table 3. Overall, the model fit is quite good with an adjusted R-square of 0.612 showing that 61.2% of the variation in the data is being explained. This study has required comparable data for each of five time periods: the unexplained variation is potentially due to data limitations leading to an inability to include many more amenity variables particular to the Gold Coast environment. The estimated parameters also have the expected signs as hypothesised. As this is a semi-log model, the estimated parameters may be interpreted as percentage change in the dependent variable for a unit change in the explanatory variable.

The quarterly seasonal time series variable is significant confirming that property prices increased on average 1.5% each quarter between 1996 and 2016. The catchment terms coefficients refer to the property price difference between the catchment and control areas relative to a base year of 1996. Table 3 shows these catchment coefficients are negative (and statistically significant) suggesting that in 1996 (before the Gold Coast Light Rail project had been announced), the average property price in the catchment area of 800m around actual light rail stations was lower than those in the control area (outside the 800m of light rail stations).

The particular variables of interest are the interaction terms between the catchment dummies and year as discussed above in the method section. The interaction terms capture the property price difference between the catchment and control area for the year identified in the interaction. These are the DD estimators and the coefficients are the estimated effects of light rail stations on property values for the specific year of the interaction term, relative to 1996 as the base. As identified above, 1996 as the base represents before the announcement of the GCLRT, 2002 is after the announcement but before the solid commitment period, represented by 2006 with 2011 representing the construction period and 2016 is the opening of the Stage One operation and Stage Two construction period. Table 3 shows that in general, property prices started to increase after the announcement (2002) and reached the highest increment after solid financial commitments were made (2006). Property prices then slowed in incremental percentage terms during construction and operation period.

Table 3: Estimation Results of DD model

ln_price	coefficient	t value	VIF
Constant	11.865	357.053	
Time variable			
SeasonalTimeSeries	0.015	77.427	2.616
Catchment variables			
C100m	-0.121	-4.428	4.259
C101-400m	-0.099	-7.577	4.672
C401-800m	-0.085	-5.895	4.152
Interaction terms			
CY2002_100m	-0.171	-4.642	1.885
CY2006_100m	0.391	10.795	1.978
CY2011_100m	0.221	4.388	1.741
CY2016_100m	0.170	3.274	2.158
CY2002_101-400m	0.119	9.617	1.962
CY2006_101-400m	0.383	28.844	1.644
CY2011_101-400m	0.142	5.509	3.391
CY2016_101-400m	0.173	5.533	5.840
CY2002_401m-800m	0.153	9.087	2.119
CY2006_401m-800m	0.334	18.423	1.680
CY2011_401m-800m	0.178	6.189	2.346
CY2016_401m-800m	0.187	5.385	3.002
Property attributes			
Property type	-0.410	-41.325	1.813
Bedrooms	0.114	16.990	1.972
Baths	0.115	11.481	1.983
Parking			
Sale Price Over 1 million	1.175	80.561	1.230
Neighbourhood variables			
% Older	0.171	4.463	1.492
% Unemployed	-3.864	-23.828	1.696
% College	0.769	7.294	1.268
Accessibility variables			
D_School	0.157	18.496	1.204
D_Beach	-0.136	-27.254	4.422
D_Park	-0.316	-8.159	1.106
D_CBD_Surfers	0.032	9.984	3.344
D_CBD_Southport	-0.010	-5.684	1.461
D_Heavy Rail_2011	-0.003	-1.524	4.294
D_Heavy Rail_2016	-0.019	-8.089	7.845

Number of obs	19561
F(30, 19530)	1029.020
P>F	0.000
R-squared	0.613
Adjusted R-squared	0.612

For example, taking the 101-400m catchment area as an example, the model results show a positive impact of 11.94% on house price for properties located within 101-400m of a light rail station after the GCLRT project was announced in 2002, relative to the baseline in 1996. Compared to the announcement, shown by the 2002 interaction term, a further 26.31% increase (= 38.25% -11.94%) is estimated for the commitment period in 2006. However, moving into the construction period, represented by the 2011 interaction term, only a further 2.3% increase on property price over the after announcement period of 2002 is achieved. The final period in this study is the Stage One operation and Stage Two construction period where there is a further 5.38% increase as compared to 2002. Also within the catchment area, but at different distances from the light rail stations (100m and 401-800m), properties show a similar pattern of price change but with slightly different amounts. Interestingly there is no evidence of property prices in close proximity to the stations suffering a negative impact, as shown in other studies (Mulley, 2016, Mulley and Tsai, 2016). This may well be due to the property type distribution in the Gold Coast, as discussed next.

Table 4 provides information on the property price differences between the different catchment areas and control area. In terms of the different catchment areas, generally speaking, the properties have the highest increment when it has the highest accessibility to stations (i.e., within 100m of stations). However, the actual amount of \$AUD increase tells a different story. The properties that have the highest amount of \$AUD increase are those properties with the lowest accessibility (i.e., 401-800m of stations) in catchment areas. This is explained by the residential property type mix. Table 5 shows the ratio of different residential property types across catchment areas. Most property types within 100m and 101-400m of stations are units with only the outermost of the catchment area of 401-800m from stations having a higher ratio of house to units. As can be seen, houses have a higher average price than units although the units close to stations are having a higher uplift in percentage but not absolute terms.

Table 4: Property price difference among catchment areas and control area.

Catchment area	Year	n	Average price*	% of increase	\$ increase*
100m	1996	136	215,044	-	-
	2002	225	216,123	-17.06	-36,872
	2006	279	463,533	39.06	181,054

	2011	125	628,208	22.09	138,765
	2016	298	379,542	17.05	64,695
	1996	1188	228,600	-	-
	2002	2640	313,151	11.94	37,400
101-400m	2006	1859	515,735	38.25	197,283
	2011	959	450,402	14.24	64,123
	2016	2390	467,882	17.32	81,014
	1996	833	248,837	-	-
	2002	1460	368,468	15.27	56,277
401-800m	2006	967	715,022	33.41	238,910
	2011	523	683,595	17.81	121,750
	2016	963	700,169	18.67	130,744

*Australian Dollars

Table 5: Property type ratio across catchment areas

Catchment distance	Unit			House		
	n	%	Average sale price*	n	%	Average sale price
0-100m	1073	98.2	365358.8	20	1.8	664150.0
101-400m	8711	96.4	384485.1	327	3.6	791779.3
401-800m	3280	69.1	437833.4	466	30.9	704203.6

*Australian Dollars

Most of the property attributes, including the number of bedrooms, bathroom and properties with the sale price over \$1 million Australian dollars have a positive impact on the property price as expected. The parameter of property type is negative and significant suggesting the average price of units are lower than average house price: this is observed in most Australian capital cities. The neighbourhood attributes also show expected signs with property prices being higher in neighbourhoods with a lower unemployed population, higher older age population and residents with college and higher qualifications.

Most of the accessibility variables are significant except for the distance to nearest heavy rail station for properties sold in 2011. The GCLRT Stage Two decision to go ahead was delivered in 2011 (see Figure 2) and this will impact, when built, on the accessibility to heavy rail: in 2011 the lack of significance suggests that the uplift due to this accessibility was not realised although by 2016 when Stage 2 building had started there is evidence of uplift (properties further from the heavy rail have lower uplift). On average, property prices are higher when the property is located closer to a beach, a park and the CBD (Southport). On the other hand, if the property is located closer to the school and major tourism site, Surfers Paradise, property prices are lower. However, the schools in this study area include all type of schools without

considering their quality and the presence of schools with lower quality rankings in this study area are likely to explain the negative impact on property prices. For Surfers Paradise, the effect may be due to the way in which Surfers Paradise is one of the best known Australian “tourist playgrounds” which may bring with it negative externalities for residents.

In summary, the impact of the LRT on property price in this study area is identified particularly for the period when solid financial commitment was made by the government.

6 Discussion and Conclusions

This paper uses a DD model to identify the impact of the LRT system on residential property prices in Gold Coast, Australia. While controlling for other price determinants including property attributes, neighbourhood characteristics and accessibility attributes, the DD model shows that the property price in the catchment areas starts to increase after the announcement with the highest increment being found after solid financial commitments have been made by government. Property prices then slow during construction and operation periods. The research findings confirm that property values in the study area do benefit from the accessibility offered by GCLRT as the effect of time and other impacts are controlled by the time dummies and catchment dummies (interaction terms) in the model. The model results also identify the uplift differences for different sections of the catchment areas with the highest increment being for properties with the greatest accessibility to the LRT stations.

It is worthy of note that from the accessibility attributes, the identification of properties sold in 2016 would have a higher price if located closer to the heavy rail station (i.e., Helensvale Station in this case). These variables could be the proxy for the GCLRT Stage Two that started being investigated in 2011 with construction starting in 2016. From the model results, it appears that the GCLRT Stage Two has created value uplift for property immediately after its construction began.

The proposed model in this study examines the timing of the land value uplift effect for the GCLRT and has implications for value capture schemes for infrastructure in this geographical area (see section 2 for a discussion on value capture mechanisms). For GCLRT, if Stage Three is planned to be funded via a value capture scheme, the model of this paper suggests that the value uplift effects could happen from the time of solid commitment so the value capture design should start early. Moreover, the model shows how different distances from the station give rise to uplift differences and this too needs to be taken account of in the design of a value capture policy. Perhaps more importantly, a value capture design not implemented until after operation starts may miss a significant portion of the uplift. The modelling of this paper demonstrates the importance of getting the timing right.

Future research should consider separating the different house and unit properties. The

dummy variable denoting property type unsurprisingly reveals this has an impact on property price but the Gold Coast area around the light rail stations are dominated by units. A model separating the types of property is worthy of further investigation as parameter estimates for other variables may be impacted by the dominance of unit properties and, subject to data availability, modelling uplift to existing commercial properties around stations could be of interest to compare with that of residential property uplift. The selection of the control area is another area for further development: this study followed previous studies to choose those properties within 801-1600m of stations as a control group. However, this could be argued to be somewhat subjective and other methods to identify the control area deserve further exploration (e.g., the propensity score approach). Finally, the literature identifies many different methods have been used in this research domain and further comparison with other methodologies for the same location is worthy of investigation to see how robust DD estimation is in this case.

Acknowledgements

Funding: This research was supported partially by the Australian Government through the Australian Research Council's Linkage Projects funding scheme (project LP150100078) and by the Queensland Department of Transport and Main Roads, Transport for NSW, Gold Coast City Council and Queensland Airports Limited. This research also contributes to the research program of the Institute of Transport and Logistics Studies, specifically the TfNSW program in ITLS associated with the Chair in Public Transport.

The views expressed are solely those of the authors, who are responsible for all errors and omissions. The views expressed herein are those of the authors and are not necessarily those of the Australian Government or the Australian Research Council or our funding partners.

References

- Alonso, W., 1964. Location and Land Use. Harvard University Press; Cambridge, Massachusetts, USA.
- Athey, S., Imbens, G., 2006. Identification and inference in nonlinear difference-indifferences models. *Econometrica* 74, 431–497.
<http://onlinelibrary.wiley.com/doi/10.1111/j.1468-0262.2006.00668.x/full>
- Australian Bureau of Statistics, 2011. Australian Statistical Geography Standard
<http://www.abs.gov.au/websitedbs/d3310114.nsf/home/asgs+fact+sheets>
- Banister, D., Thurstain-Goodwin, M., 2011. Quantification of the non-transport benefits resulting from rail investment. *Journal of Transport Geography* 19(2), 212-223.
<http://www.sciencedirect.com/science/article/pii/S0966692310000712>

- Bertrand, M., Duflo, E., Mullainathan, S., 2004. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics* 119, 249–275.
<https://academic.oup.com/qje/article/119/1/249/1876068/How-Much-Should-We-Trust-Differences-In>
- Billings, S., 2011. Estimating the value of a new transit option. *Regional Science and Urban Economics* 41: 525–536.
<http://www.sciencedirect.com/science/article/pii/S0166046211000500>
- Cao, X.J., Porter-Nelson, D., 2016. Real estate development in anticipation of the Green Line light rail transit in St. Paul. *Transport Policy*, in Press.
<http://www.sciencedirect.com/science/article/pii/S0967070X16300087>
- Cervero, R., Duncan, M., 2002. Transit's value-added effects: light and commuter rail services and commercial land values. *Transportation Research Record*, vol.1805, 8-15.
<http://trrjournalonline.trb.org/doi/abs/10.3141/1805-02>
- Cervero, R., Kang, C.D., 2011. Bus rapid transit impacts on land uses and land values in Seoul, Korea. *Transport Policy* 18, 102-116.
<http://www.sciencedirect.com/science/article/pii/S0967070X1000082X>
- Crocker S., Dabinett B., Gore T., Haywood R., Hennebury J., Kirkpatrick A., Lawless P. and Townroe P., 2000. Monitoring the Economic and Development Impact of South Yorkshire Supertram. Centre for Regional and Economic and Social Research, Sheffield. Sheffield Hallam University.
- Debrezion, G., Pels, E., Rietveld, P., 2007. The impact of railway stations on residential and commercial property values: A meta-analysis. *The Journal of Real Estate Finance and Economics* 35(2): 161–180. doi:10.1007/s11146-007-9032-z.
<https://link.springer.com/article/10.1007%2Fs11146-007-9032-z?LI=true>
- Deng, T., Nelson, J., 2013. Bus Rapid Transit implementation in Beijing: An evaluation of performance and impacts. *Research in Transportation Economics* 39(1): 108-113.
doi:http://dx.doi.org/10.1016/j.retrec.2012.06.002.
<http://www.sciencedirect.com/science/article/pii/S0739885912000741>
- Du, H., Mulley, C., 2006. Relationship Between Transport Accessibility and Land Value: Local Model Approach with Geographically Weighted Regression. *Transportation Research Record*, 197-205. <http://trrjournalonline.trb.org/doi/abs/10.3141/1977-25>
- Du, H., Mulley, C., 2007. The short-term land value impacts of urban rail transit: Quantitative evidence from Sunderland, UK. *Land Use Policy* 24, 223–233.
<http://www.sciencedirect.com/science/article/pii/S0264837706000020>
- El-Geneidy, van Lierop, A., D., Wasfi, R., 2014 Do people value bicycle sharing? A multilevel longitudinal analysis capturing the impact of bicycle sharing on residential

- sales in Montreal, Canada. Presented at the 2nd World Symposium on Transport and Land Use, Delft, the Netherlands, 24-27 June 2014.
<http://www.sciencedirect.com/science/article/pii/S0967070X16000032>
- Enoch, M., Potter, S., Ison, S., 2005. A Strategic approach to financing public transport through property values. *Public Money and Management* 25, 147–154.
<http://www.tandfonline.com/doi/abs/10.1111/j.1467-9302.2005.00467.x>
- Forrest, D., Glen, J., Ward, R., 1996. The impact of a light rail system on the structure of house prices: a hedonic longitudinal study. *Journal of Transport Economics and Policy*, 3(1), 15-29
- Guerra, E., Cervero, R., & Tischler, D., 2013. Half-Mile Circle: Does It Best Represent Transit Station Catchments? *Transportation Research Record*, 2276, 101-109.
- Goldling, Stage 2 overview, http://www.gclrstage2.com/stage2_overview, accessed 12 July 2017.
- Hensher, D., Li, Z., Mulley, C., 2012. The impact of high speed rail on land and property values: A review of market monitoring evidence from eight countries. *Road and Transport Research* 21(4): 3-14.
<https://search.informit.com.au/documentSummary;dn=145470162627643;res=IELENG>
- Hess, D., Almeida, T., 2007. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. *Urban Studies* 44(5-6), 1041-1068.
<http://journals.sagepub.com/doi/abs/10.1080/00420980701256005>
- Higgins, C. D., Kanaroglou, P. S., 2016. Forty years of modelling rapid transit's land value uplift in North America: moving beyond the tip of the iceberg. *Transport Reviews* 36(5), 610-634. doi:10.1080/01441647.2016.1174748.
<http://www.tandfonline.com/doi/abs/10.1080/01441647.2016.1174748>
- Iacono, M., Lari, A., Levinson, D., Zhao, Z., 2009. Value Capture for Transportation Finance: Report to the Minnesota Legislature, CTS 09-185. Center for Transportation Studies, University of Minnesota, Minneapolis, MN.
- Knowles R.D. and Ferbrache F., 2016 Evaluation of wider economic impacts of light rail investment in cities. *Journal of Transport Geography* 54, 430-439
- Lancaster, K.J., 1966. A new approach to consumer theory. *The journal of political economy*, 132-157. <http://www.journals.uchicago.edu/doi/abs/10.1086/259131?journalCode=jpe>
- Landis, J., Cervero, R., Guhathukurta, S., Loutzenheiser, D., Zhang, M. 1995 Rail transit investments, real estate values, and land use change: A comparative analysis of five California rail transit systems. Berkeley, USA: Institute of Urban and Regional Studies, University of California at Berkeley, Monograph 48.
<http://escholarship.org/uc/item/4hh7f652>

- Lechner, M., 2011. The estimation of causal effects by difference-in-difference methods. University of St. Gallen, Mimeograph.
<http://www.nowpublishers.com/article/Details/ECO-014>
- Lefebvre, H., 1991. *The Production of Space*. trans. D. Nicholson-Smith. First published in 1974 by Editions Anthropos, ed. Blackwell, Oxford, OX, UK; Cambridge, Mass., USA, 1991.
- Mathur, S., Ferrell, C., 2013. Measuring the impact of sub-urban transit-oriented developments on single-family home values. *Transportation Research Part A: Policy & Practice* 47, 42–55.
<http://www.sciencedirect.com/science/article/pii/S096585641200153X>
- Mathur S., 2014. *Innovation in Public Transport Finance: Property Value Capture*. Routledge, London and New York.
- Mathur S. and Smith A., 2013. Land value capture to fund public transportation infrastructure: examination of joint development projects' revenue yield and stability. *Transport Policy*, 30, 327-335.
- McDonald, J. F., Osuji, C. I., 1995. The effect of anticipated transportation improvement on residential land values. *Regional science and urban economics* 25(3), 261-278.
<http://www.sciencedirect.com/science/article/pii/016604629402085U>
- McIntosh, J., Trubka, R., Newman, P., 2014. Can value capture work in a car dependent city? Willingness to pay for transit access in Perth, Western Australia. *Transportation Research Part A: Policy & Practice* 67, 320-339.
<http://www.sciencedirect.com/science/article/pii/S0965856414001736>
- McMillen, D. P., McDonald, J., 2004. Reaction of house prices to a new rapid transit line: Chicago's midway line, 1983–1999. *Real Estate Economics* 32(3), 463-486.
<http://onlinelibrary.wiley.com/doi/10.1111/j.1080-8620.2004.00099.x/full>
- Medda, F., 2012. Land value capture finance for transport accessibility: a review. *Journal of Transport Geography* 25, 154-161.
<http://www.sciencedirect.com/science/article/pii/S0966692312002116>
- Mohammad, S., D. Graham, P. Melo, R. Anderson, 2013. A meta-analysis of the impact of rail projects on land and property values. *Transportation Research Part A: Policy & Practice* 50, 158–170. doi:<http://dx.doi.org/10.1016/j.tra.2013.01.013>.
<http://www.sciencedirect.com/science/article/pii/S0965856413000207>
- Mohammad, S., Graham, D., Melo, P., 2015. The effect of the Dubai Metro on the value of residential and commercial properties. *Journal of Transport and Land Use* 10(2), 1-25. doi:10.5198/jtlu.2015.750. <https://conservancy.umn.edu/handle/11299/187841>

- Mulley, C., 2014. Accessibility and residential land value uplift: Identifying spatial variations in the accessibility impacts of a bus transitway. *Urban Studies* 51(8), 1707-1724.
<http://journals.sagepub.com/doi/abs/10.1177/0042098013499082>
- Mulley, C., Ma, L., Clifton, G., Yen, B.T.H. and Burke, M., 2016. Residential property value impacts of proximity to transport infrastructure: An investigation of bus rapid transit and heavy rail networks in Brisbane, Australia. *Journal of Transport Geography* 54, 41-52. <http://www.sciencedirect.com/science/article/pii/S0966692316302691>
- Mulley, C., Tsai, C.H.P., 2016. When and how much does new transport infrastructure add to property values? Evidence from the bus rapid transit system in Sydney, Australia. *Transport Policy* 51, 15–23.
<http://www.sciencedirect.com/science/article/pii/S0967070X16300105>
- Murray, Cameron K., Land Value Uplift from Light Rail (September 5, 2016). Available at SSRN: <http://ssrn.com/abstract=2834855> or <http://dx.doi.org/10.2139/ssrn.2834855>
- Muth, R., 1969. *Cities and Housing*. University of Chicago Press; Chicago, USA.
- New York City Economic Development Corporation, Waterfront Vision & Enhancement Group, and Steer Davies Gleave, 2013. *CityWide Ferry Study 2013: Preliminary Report*. New York: NYCEDC.
- Pagliara, F., Papa, E., 2011. Urban rail systems investments: an analysis of the impacts on property values and residents' location. *Journal of Transport Geography* 19(2): 200-211.
doi:<http://dx.doi.org/10.1016/j.jtrangeo.2010.02.006>.
<http://www.sciencedirect.com/science/article/pii/S0966692310000153>
- Puhani, P.A., 2012. The treatment effect, the cross difference, and the interaction term in nonlinear "difference-in-differences" models. *Economics Letters* 115, 85-87.
<http://www.sciencedirect.com/science/article/pii/S0165176511004769>
- Rodriguez, D.A., Mojica, C.H., 2009. Capitalization of BRT network expansions effects into price of non-expansion area. *Transportation Research Part A* 43, 560-571.
<http://www.sciencedirect.com/science/article/pii/S0965856409000299>
- Rosen, S., 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy* 82, 34-55.
<http://www.journals.uchicago.edu/doi/abs/10.1086/260169?journalCode=jpe>
- Salon, D. and Shewmake, S., 2011, Opportunities for Value Capture to Fund Public Transport: A Comprehensive Review of the Literature with a Focus on East Asia (February 1, 2011). Available at SSRN: <https://ssrn.com/abstract=1753302> Downloaded 1 December 2017)

- Senior, M.L., 2009. Impacts on travel behaviour of Greater Manchester's light rail investment(Metrolink Phase 1): evidence from household surveys and census data. *Journal of Transport Geography*, 17, 187-197
- Smith, J.J., Gihring, T.A., 2006. Financing transit system through value capture: an annotated bibliography. *American Journal of Economics and Sociology* 65, 751-786.
<http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.532.1746>
- Stokenberga, A., 2014. Does Bus Rapid Transit influence urban land development and property values: a review of the literature. *Transport Reviews* 34(3): 276-296.
<http://www.tandfonline.com/doi/abs/10.1080/01441647.2014.902404>
- Tsai, C.H.P., Mulley, C., Burke, M., Yen, B.T.H., 2017. Exploring property value effects of ferry terminals: evidence from Brisbane, Australia. *The Journal of Transport and Land Use* 10, 1-19. <https://www.jtlu.org/index.php/jtlu/article/view/562>
- Transport for London (2017) Land Value Capture, Final Report. Available at https://www.london.gov.uk/sites/default/files/land_value_capture_report_transport_for_london.pdf Accessed 18 May 2017
- Zhang, M. and Y. Liu (2015) An exploratory analysis of Bus Rapid Transit on property values: A case study of Brisbane's South East Busway. Presented at the State of Australian Cities Conference, Gold Coast, Australia, 9-11 December 2015.
<http://soacconference.com.au/wp-content/uploads/2016/02/Zhang.pdf>
- Zhao, Z., Saunoi-Sandgren, E., Barnea, A., 2011. Advancing public interest in public private partnership of state highway development, Center for Transportation Studies, University of Minnesota, Minneapolis, MN.
<https://conservancy.umn.edu/handle/11299/149401>
- Zhao, Z.J., Das, K.V., Larson, K., 2012. Joint development as a value capture strategy for public transit finance. *The Journal of Transport and Land Use* 5, 5-17.
<https://jtlu.org/index.php/jtlu/article/view/142>

Data References

- Australian Bureau of Statistics, 2011, 1259.0.30.002 - Statistical Geography - Australian Standard Geographical Classification (ASGC), Digital Boundaries , 2006.
<http://www.abs.gov.au/ausstats/abs@.nsf/DetailsPage/1259.0.30.0022006?OpenDocument>
- City of Gold Coast, Points of interest (various), 2017,
<https://data.gov.au/organization/city-of-gold-coast>
- City of Gold Coast, Beach Towers, 2017, <https://www.goldcoast.qld.gov.au/%2Fdocuments%2FBeachTowers.kml&usg=AFQjCNHQeKDbfHjBCQIkuj5xGFMi4rFZOA>

Corelogic RP Data, 2017, Property Sales Price Gold Coast City Council, 1996 to 2016

OpenStreetMap contributors, Amenity Categories, Gold Coast Local Government Area, 2017,
<http://download.geofabrik.de/australia-oceania/australia.html>

Queensland Department of Natural Resources and Mines (DNRM), Cadastral data -
 Queensland series, 2016,
<https://data.qld.gov.au/en/dataset/cadastral-data-queensland-series>, Identifier:
 B7BCD0C6-56A9-42FE-A35D-36FB775A819A

Queensland Department of Transport and Main Roads, 2016. General transit feed
 specification (GTFS)—South East Queensland (28/7/2016)
<https://data.qld.gov.au/dataset/general-transit-feed-specification-gtfs-seq/resource/be7f19e5-3ee8-4396-b9eb-46f6b4ce8039> Accessed May 18th 2017

Queensland Government, 2017. Queensland Spatial Data Catalogue, Baseline roads and
 tracks - Queensland (13/03/2017)
<http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={67B61562-A329-4119-929B-1D400EBE4E7F}> Accessed May 18th 2017.