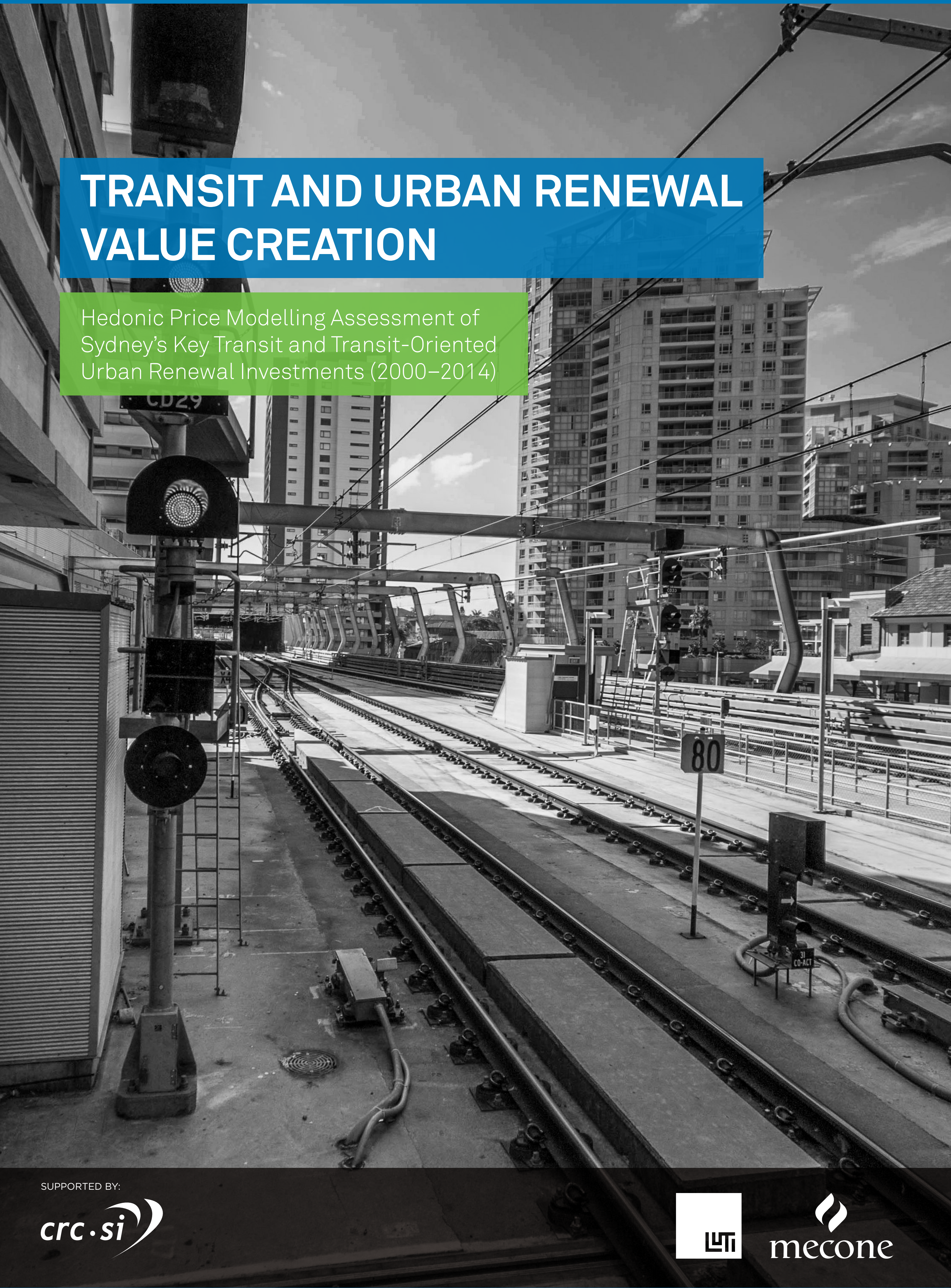
TRANSIT AND URBAN RENEWAL VALUE CREATION

Hedonic Price Modelling Assessment of Sydney's Key Transit and Transit-Oriented Urban Renewal Investments (2000–2014)



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i.

ACKNOWLEDGEMENTS

i. ACKNOWLEDGEMENTS

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ii.

GLOSSARY

ii. GLOSSARY

400m Catchment

This is the 400metre pedestrian walking catchment surrounding a station calculated using road centreline and road network distance based modelling, illustrating how far a person can walk in 5 minutes

800m Catchment

This is the 800metre pedestrian walking catchment surrounding a station calculated using road centreline and road network distance based modelling, illustrating how far a person can walk in 10 minutes

1600m Catchment

This is the 1600metre pedestrian walking catchment surrounding a station calculated using road centreline and road network distance based modelling, illustrating how far a person can walk in 20 minutes

Activity Centre Level 1

Global City specified centres

Activity Centre Level 2

Strategic and regional centres

Activity Centre Level 3

Town centres

Activity Centre Level 4

Standalone shopping centres and lower order centres

Any CBD

The 'Any CBD' includes Sydney CBD or centre designated as Global City, whichever is nearer

Area

The area of the cadastral parcel in m2

BRT

This refers to the rapid bus based transport infrastructure (the T-Ways) operated by Sydney Buses for Transport for NSW

http://www.sydneybuses.info/

Effective Job Density

Distance-weighted sum of employment numbers

Ferry

This refers to the ferry based transport infrastructure operated by Sydney Ferries for Transport for NSW

http://www.transport.nsw.gov.au/customers/ferries/sydney-ferries

FSR

Floor Space Ratio

Heavy Rail

This refers to the rail based transport infrastructure operated by Sydney Trains for Transport for NSW

http://www.sydneytrains.info/

ii. GLOSSARY

Heritage

This refers to whether the lot is located within a heritage conservation area, as specified by a heritage zoning layer

High School Catchment Rating

High School Location feed in catchment and Myschool Ratings

http://www.myschool.edu.au/

HPM

Hedonic Price Modelling

Ln_ULV

The Natural Log of the Unimproved Land Value

Ln_ULVpsm

The Natural Log of the Unimproved Land Value per square metre

LRT

This refers to the surface based rail transport infrastructure operated by Sydney Light Rail for Transport for NSW

http://www.sydneylightrail.transport.nsw.gov.au/

Main Road

Road management between Roads and Maritime Services and councils in NSW provides for three categories of road: State, Regional and Local. For a road to be classified as a main road it must be a State, or regional road, as specified by RMS.

http://www.rms.nsw.gov.au/business-industry/partners-suppliers/lgr/arrangements-councils/road-classification.html

SEIFA Score

The SEIFA index of relative advantage and disadvantage

http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100042011

SNAMUTS (2011)

Spatial Network Analysis for Multi-Modal Urban Transport Systems

http://www.snamuts.com/

Strata

The strata specification indicates whether a land parcel is strata-titled

ULV

Unimproved Land Value

ULVpsm

Unimproved Land Value per square metre

Water Body / Coast

Digitised coastline of NSW

WTP

Willingness to Pay

iii.

SYNOPSIS

iii. SYNOPSIS

This report presents the findings of research undertaken to analyse the value created in the land markets surrounding transportation and urban renewal projects within the Sydney metropolitan area from the year 2000 to 2014. Econometric techniques were applied to cross-sectional data for the year 2014 to determine near present-day impacts of land-related attributes on land values, while panel data spanning the years 2000 to 2014 were used to determine the impacts of projects on land values over time.

The research analysis highlights that the value created by investment in transportation projects can be characterised into three consecutive phases: the monetisation of improved accessibility benefits, the rezoning of land parcels to their highest and best use, and the increase in development capacity by the increase in floor space ratios (FSR). This three-phase approach to understanding the value creation process is presented in Figure 1.

The central focus of this report is to quantify these three value creation phases to enable the forecasting of land market benefits that accrue to transportation infrastructure and urban regeneration catchments and to demonstrate that they are created through the integration of transportation, land use, and land development planning. The results of the 2014 cross-sectional metropolitan-wide model for the transport accessibility, zoning, and FSR control variables are presented in Table 1.

Table 1 – Metropolitan Transport Accessibility, Zoning, and Floor Space Ratio Outputs of the 2014 Cross-sectional Hedonic Price Model

		% Uplift in Land Value	Standard Error (Sig. Level)
Dummy Catchment Variables (% Value Premium)	**Phase 1 – Accessibility**		
	Heavy Rail 0–400 m	4.5%	0.002 (***)
	Heavy Rail 400–800 m	1.3%	0.001 (***)
	Heavy Rail 800–1600 m	0.3%	0.001 (**)
	Main Road 0–100 m	-7.6%	0.001 (***)
	Main Road 100–200 m	-0.6%	0.001 (***)
	Phase 2 – Zoning		
	Zoning – Residential (Base comparison zone)	—	—
	Zoning – Business (++)	-3.8%	0.002 (***)
	Zoning – Sydney CBD (++)	27.2%	0.034 (***)
	Zoning – Industrial (++)	-38.9%	0.004 (***)
	Zoning – Mixed Use (++)	11.8%	0.003 (***)
		Elasticity	**Standard Error (Sig. Level)**
Continuous Variables (Elasticity)	**Phase 3 – Development Density**		
	log(FSR)	0.239	0.001 (***)

Notes:
(++) Compared to the Residential zoning
Adjusted R-squared: 0.912 with 920,549 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

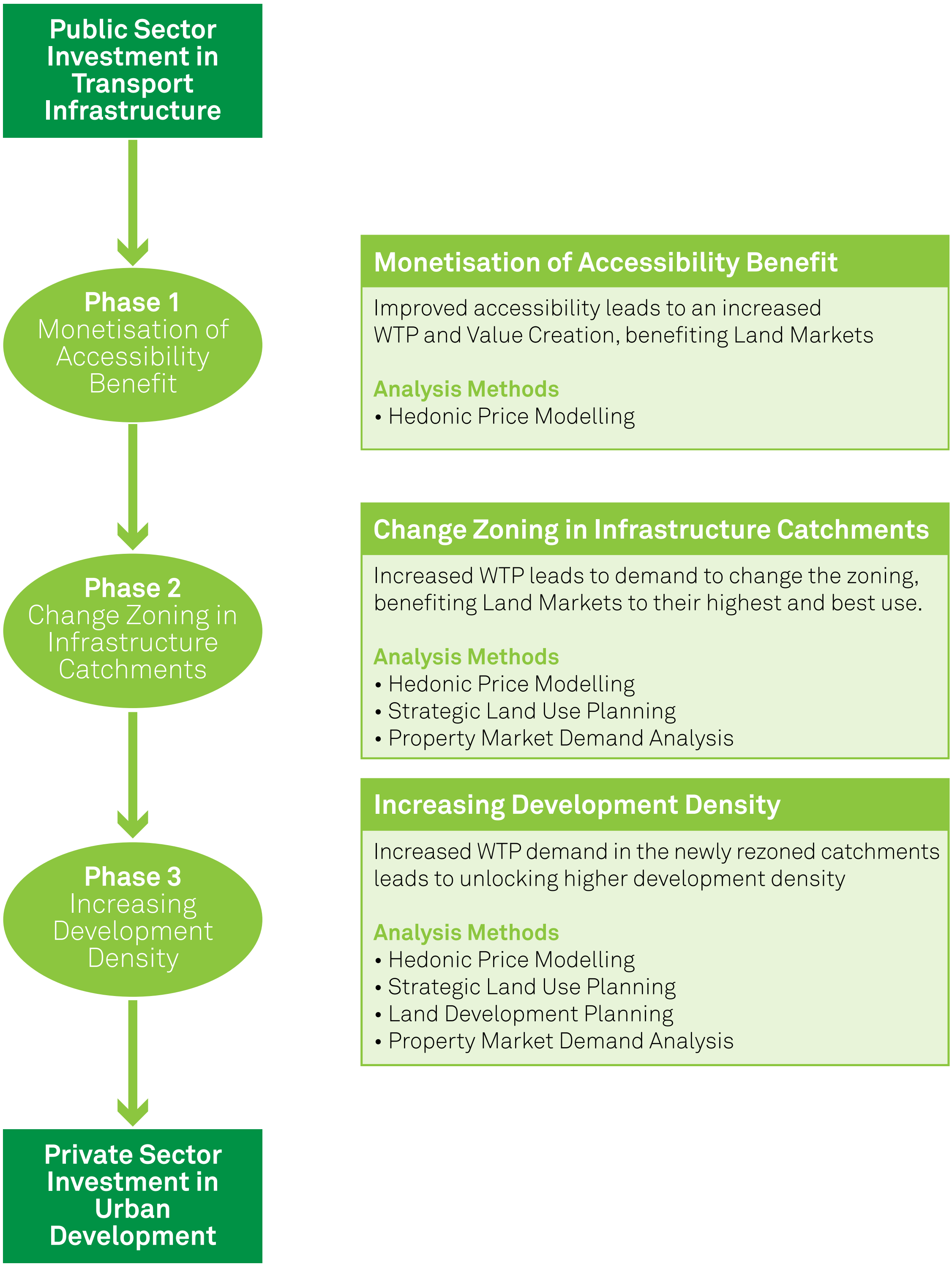

Figure 1 – Phases in the Transportation Infrastructure Investment-induced Land Market Value-creation Process

iii. SYNOPSIS

The results from 2014 in Table 1 highlight the following:

- Phase 1 – The heavy rail public transport accessibility benefit across the Sydney Metropolitan Region is an average of 4.5% within a 400 m walking catchment, and the effect of being within 100 m of a main road is -7.6%.
- Phase 2 – The change in zoning benefits illustrated in Table 1 demonstrates that in terms of land use planning zones, the Sydney CBD-zoned land has the highest proportional benefit, followed by the Mixed Use zone and Residential-zoned land, with the Business and Industrial-zoned land valued below Residential. Therefore, significant value can be created for projects if land catchments surrounding new infrastructure are rezoned to their highest and best use for the specific mode and corridor.
- Phase 3 – The increase in development density benefit across the metropolitan region is explained by the Floor Space Ratio (FSR) elasticity presented in Table 1, where every 1:1

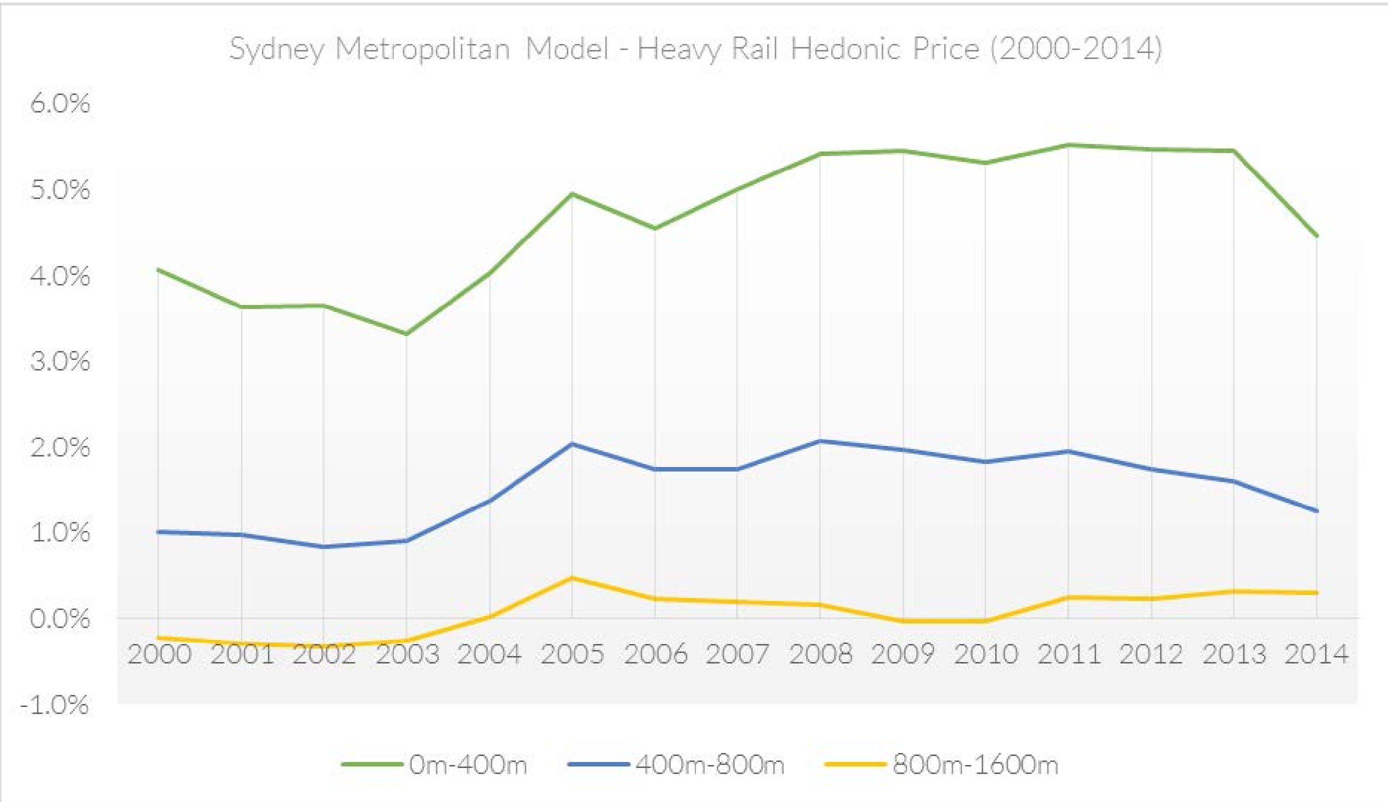

Figure 2 – Heavy Rail Catchment Panel Data Hedonic Price Model Results for the Metropolitan Region for the Period 2000–2014

iii. SYNOPSIS

increase in FSR equates to a marginal 23.9% increase in land value. The change in FSR across a corridor to take advantage of an increase in accessibility can induce significant increase in land value as developers, new residents, and businesses seek to locate themselves near the transit infrastructure.

The cross-sectional hedonic price models are effective in illustrating the willingness to pay (WTP) for specific land market attributes at a specific time, and for the change in zoning and FSR this is entirely appropriate as the corridor forecasts will be best conducted from the most recent analysis period.

However, when analysing the change in accessibility induced by a specific project, it is important to analyse the monetisation of accessibility over time using comparable projects for forecasting changes in other corridors.

The panel data hedonic price analysis results presented in Figure 2 illustrate that across the metropolitan region for the period of 2000–2014, the WTP for proximity to heavy rail stations remained relatively stable over time for the 400m, 800m, and 1600m catchments.

The accessibility impact of the investment in transit is not actually perceived across the entire transit network but is localised within the subregion around the transit corridor, and it is also perceived predominately in the land uses that are considered to value proximity to transit the most; namely, Residential and Mixed Use zoned land.

This localised Residential and Mixed Use land market response to the investment in transit is illustrated in Figure 3, using the panel data analysis of the catchments surrounding the new stations (North Ryde, Macquarie Park, and Macquarie University) along the Epping to Chatswood Rail Line. Construction of the line commenced in November 2002 and operations commenced in February 2009.

When analysing the panel data hedonic price models presented in this report, it is worth noting that government-assessed land value tends to lag behind the actual land market value by approximately one year owing to the NSW Government's annual assessment periods, and this can be detected in the panel data analysis of the infrastructure catchments. The timing of the assessed land value response to land market change is analysed in detail in this report.

The model of the Epping to Chatswood Rail Line demonstrates the land market monetisation of accessibility into the 400m pedestrian walking catchments started from around the time of commencement of operations and continued over the first four years of operations (when the assessment time lag is taken into consideration). After the initial four years, there was a minor market correction. Experience from other projects and jurisdictions, however, tells that this correction is minor and will be regained over the coming years.

iii. SYNOPSIS

One of the most interesting aspects of the monetisation of accessibility illustrated in Figure 3 is that, in general, it mainly occurs in the 400 m pedestrian catchments surrounding the stations, and in the case of the Epping to Chatswood rail line, it occurs from the commencement of operation of the line.

This analysis enables a quantification of the value created by transport infrastructure investment and can be used to inform the financial value-sharing modelling to determine how a portion of the value created can be shared to defray the cost of government investment. Together, a comprehensive assessment of the value-sharing mechanisms available in NSW (provided in a separate study for the NSW Government) and the findings in this report form part of the broad analysis of land market value creation and the opportunities to share the value induced by transit investments in NSW.

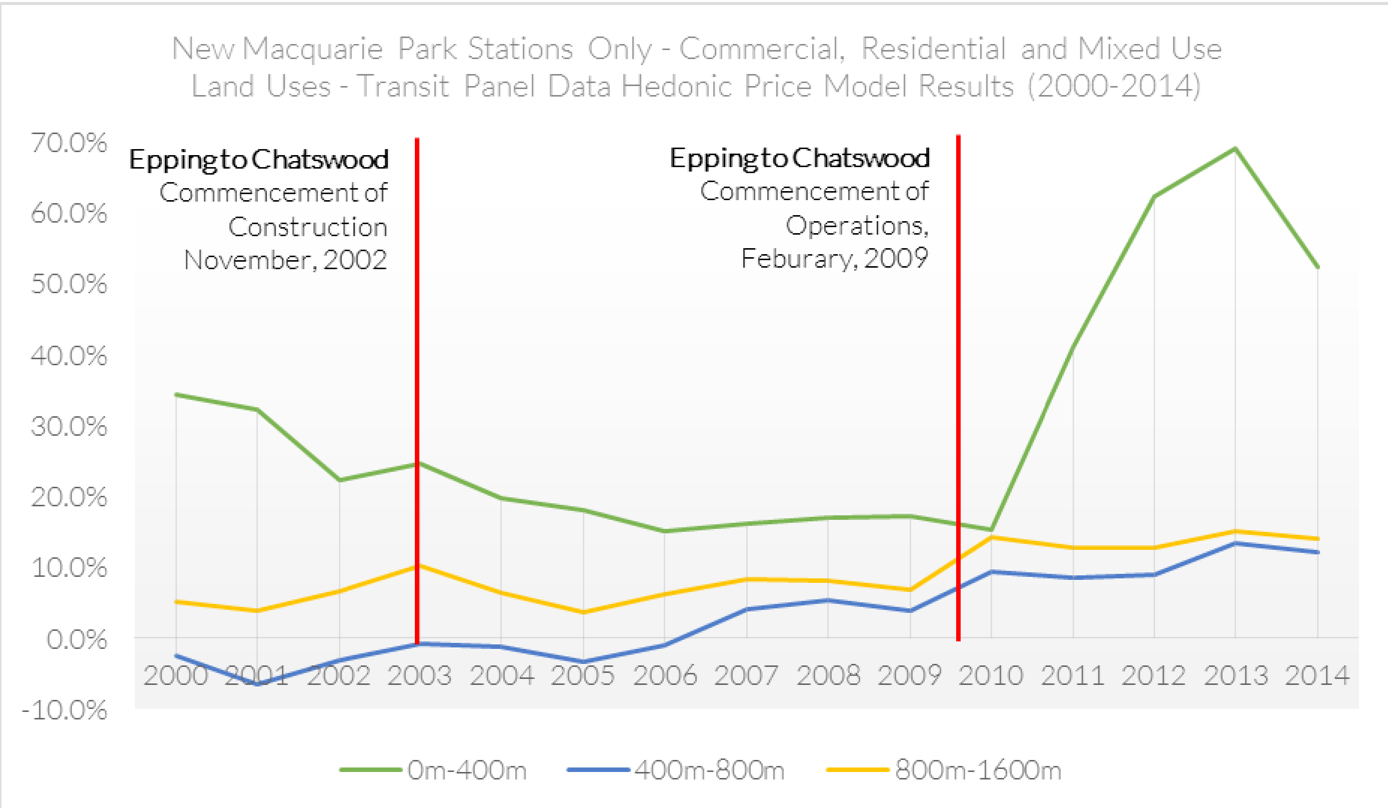

Figure 3 – Heavy Rail Catchment Panel Data Hedonic Price Model Results for the New Macquarie Park Stations (2000–2014)

1.

INTRODUCTION

1. INTRODUCTION

The Sydney Metropolitan area has a total area of approximately 12,000 km^2 and contains 38 Local Government Areas. The city is developed around a hierarchy of centres. Sydney CBD has the highest concentration of jobs and services along with the Global Economic Corridor, which extends from Macquarie Park through the Sydney CBD to Port Botany and Sydney Airport. This economic cluster generates 41% of the NSW Gross State Product (GSP) and accommodates a diverse range of services and knowledge-based jobs.

The metropolitan area includes a hierarchy of primary and second-order centres as follows: Sydney CBD and Parramatta CBD, Regional City Centres (Liverpool and Penrith), strategic centres, and transport gateways. This hierarchy is presented in Figure 4.

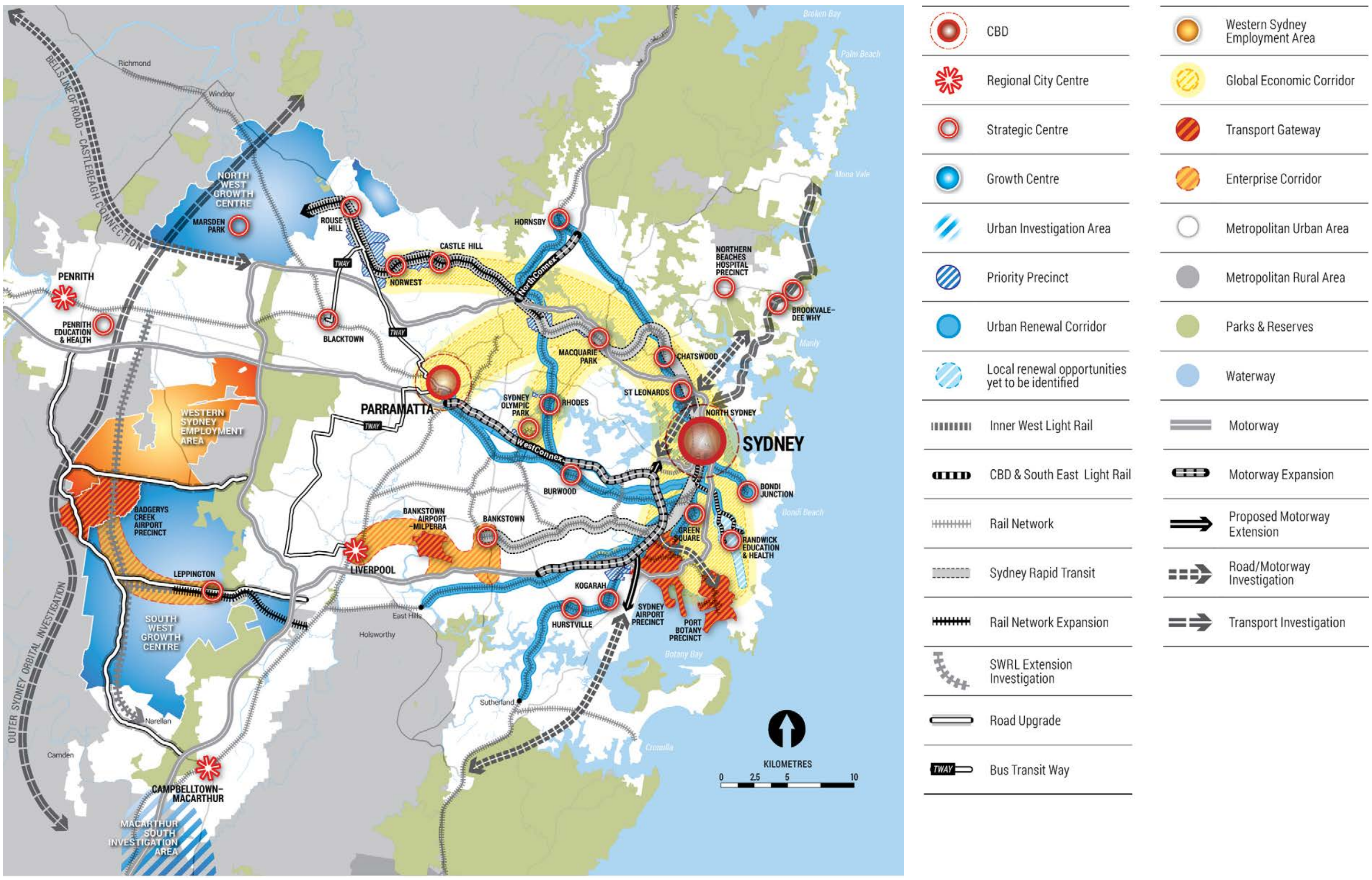

Figure 4 – Sydney Metropolitan Strategy 2014: 'A Plan for Growing Sydney' (Department of Planning and Environment)

1. INTRODUCTION

1.1 MODAL SHARE OF THE JOURNEY TO WORK IN SYDNEY

Sydney's public transport system features a network of trains, buses, light rail lines, and ferries. According to the Bureau of Transport Statistics Journey to Work figures, about 20% of Sydney's population uses public transport to travel to work and services, while 73% use private vehicles.

These mode shares for Global Sydney (City East, North Sydney, Redfern–Central Sydney, Sydney CBD, Ultimo–Pyrmont) are depicted in Figure 5. It can be seen that rail has the highest modal share, followed by private vehicles marginally ahead of bus and walking; therefore, the demand for these services is evident.

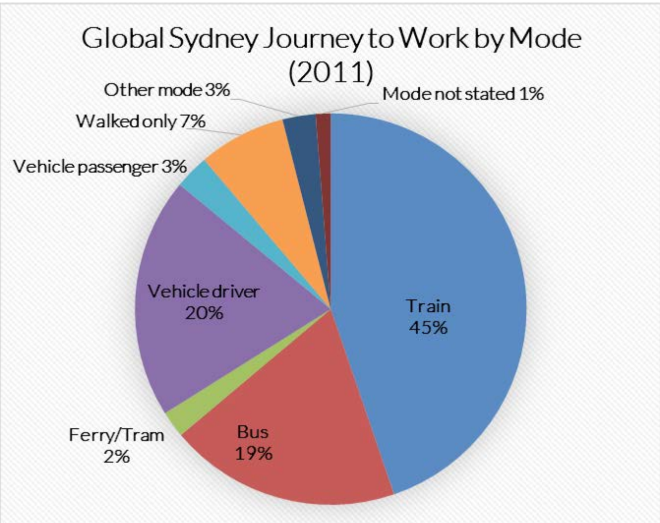

Figure 5 – Global Sydney Journey-to-Work Mode shares in Sydney (BTS, 2016)[1]

1 http://www.bts.nsw.gov.au/Statistics/Journey-to-Work/default.aspx?FolderID=217#top

In Sydney, primary access to the public transit network is through the pedestrian walking catchments surrounding the stations, stops, and wharves. The 400 m, 800 m, and 1600 m pedestrian catchments to Sydney's transit modes of ferry, bus rapid transit, light rail transit and heavy rail are presented in Figure 6. The catchments were calculated in ArcGIS using the routable Sydney road network dataset, thereby enabling the calculation of the pedestrian walking distances on existing roadways from station exits to the surrounding land and property catchments.

These transit infrastructure pedestrian catchments are the locations where transit proximity is most highly valued in the city's land markets, with an increased WTP resulting from the increased level of accessibility that is enabled by residing within these catchments. The analysis of the increased WTP for locational proximity to the transit infrastructure impact on NSW Government-assessed land value is the focus of this report.

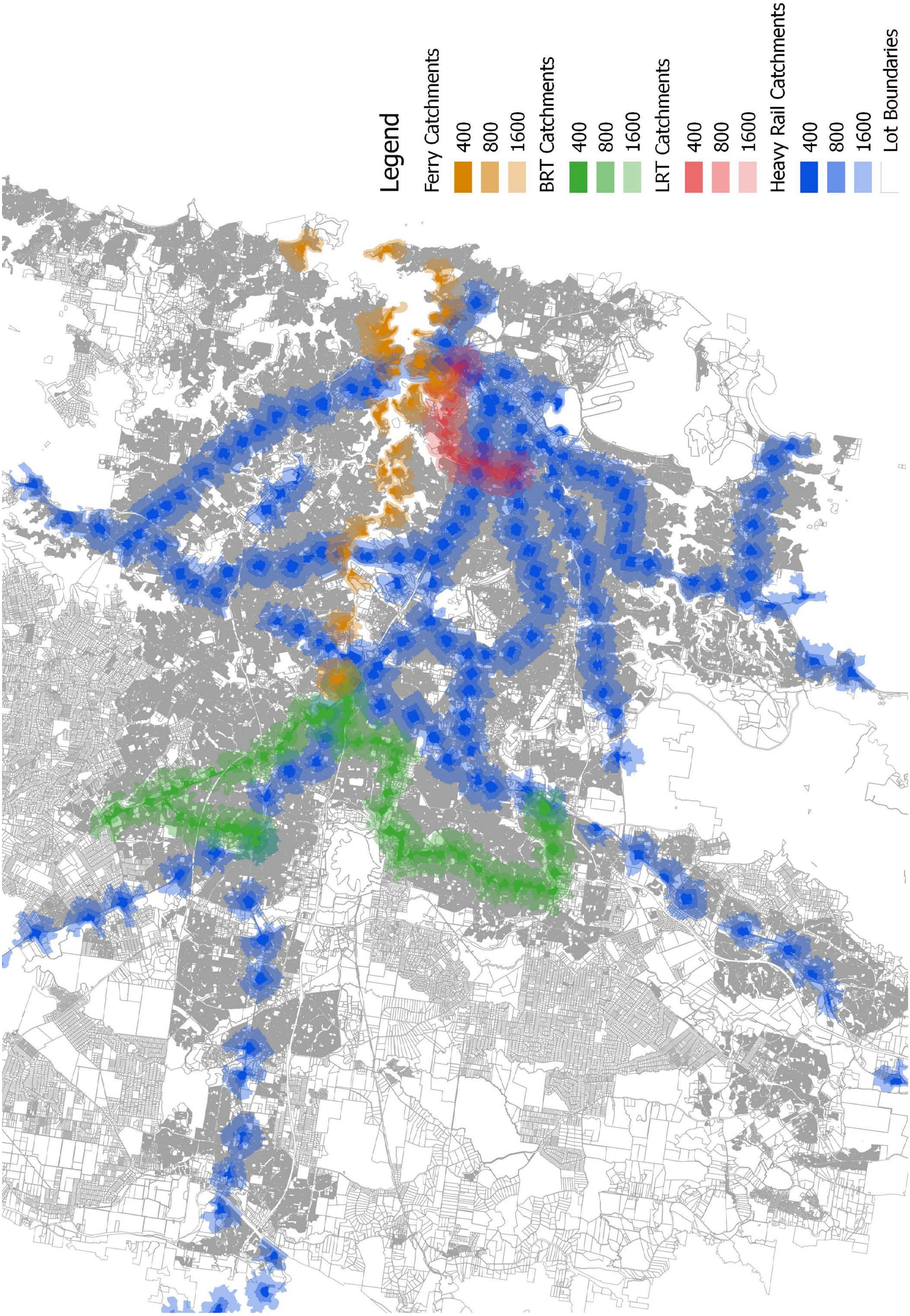

Figure 6 – Metropolitan Sydney's Mass Transit Pedestrian Walking Catchments

1. INTRODUCTION

1.2 MODELLING OF THE 'WILLINGNESS TO PAY' FOR THE INVESTMENT IN TRANSIT AND URBAN RENEWAL IN METROPOLITAN SYDNEY

LUTI Consulting and Mecone Planning have undertaken an in-depth analysis of a number of projects in the Sydney Metropolitan area, looking at the WTP for access to transit infrastructure. The WTP analysis used hedonic price modelling to understand the value attributable to catchments with access to transit infrastructure, where the key dependent variable used for the analysis was the NSW Government-assessed land value. The analysis used the following spatial and land attribute datasets:

- Metropolitan Sydney Land Valuations (2000–2014)
- Property Sales Values (2000–2014)
- Lot boundaries/cadastre
- Heritage Conservation Area Controls
- Zoning
- Floor Space Ratio (site development capacity)
- Road centreline data (for calculating network-based distances to transit stops and stations)
- ABS Socio Economic Index for Areas (SEIFA)
- ABS Suburbs
- Digitised coastline
- Parks
- Activity Centres
- Transit stops (Rail, LRT, BRT, Ferry Wharves)
- High school ratings based on HSC scores
- SNAMUTS public transit accessibility metric

The hedonic price analysis employed all these input datasets to determine the land value impacts of proximity to all transportation modes (excluding standard bus services) and relevant urban renewal precincts. The hedonic price models estimated include the following:

- Metropolitan-wide model for all modes of transport (2000–2014)
  - Heavy rail
  - Light Rail
  - Bus rapid transit
  - Ferry
  - Roads
- Heavy rail project (2000–2014)
  - Epping to Chatswood Line
- LRT project (2000–2014)
  - Inner West LRT and the Dulwich Hill Extension
- BRT projects (2000–2014)
  - Parramatta to Liverpool T-Way
  - Parramatta to Rouse Hill T-Way
- Urban renewal projects (2000–2014)
  - Airport link transit-oriented urban renewal

This report documents the theory and methodology used for the analysis, provides the results of the hedonic price models, and discusses the potential application of the analysis outputs to new project business cases and value-capture strategies as well as strategic land use and transportation planning and policy.

2.

BACKGROUND

2. BACKGROUND

Economically, land is the most basic resource and a heterogeneous good that differs in terms of its characteristics and location. Although land markets are imperfect (owing to the non-standardised commodities they trade), they perform four important functions, which include[2, 3]:

- bringing buyers and sellers together to facilitate transactions,
- setting prices for land parcels,
- allocating land by setting land prices that clear at the quantity of land demanded, and
- fulfilling an important role in ensuring that land is efficiently used.

Improved urban accessibility is one of the most significant drivers of economic activity and growth in cities. It has also been acknowledged that the reduction in transport externalities, such as congestion and pollution, increases growth in the NSW economy. There is an increased awareness at all levels of the government and the community that investment in urban transportation infrastructure leads to a range of economic, social, and environmental benefits that would otherwise not be achieved. In particular, the investment in transit brings a range of direct and indirect benefits, including:

- direct transport benefits such as travel time saving, reduced frequency of accidents, and enhanced reliability:
- economic benefits such as agglomeration impacts and enhanced productivity;
- environmental benefits, including reduced fuel consumption, pollution, and emissions; and
- social benefits, including enhanced liveability and accessibility to jobs and centres.

Hence, there is a clear and ongoing trend in Australian capital cities of higher population growth and higher rates of land value growth in the inner areas that are well serviced by transportation infrastructure and that have a higher intensity and mix of land uses. The cyclical relationship between land market activity and transportation accessibility (and relevant transportation and land use policy frameworks and modelling tools) is illustrated in Figure 7.

The purpose of this study is to improve the understanding of the land market impact of transit investments and land use zoning changes in Sydney with a view to applying them in value-capture strategies to help defray the costs of infrastructure projects and also to aid in strategic land use and transport planning and policy generally, whereby overall project benefits can be increased when transport and land

2 Hannonen, M. (2009) Hedonic Modelling in Land Markets – A Modern Approach VDM Verlag Dr. Müller, pp. 159–160.

3 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 Vol. 67, September 2014, pp. 320–339 http://www.sciencedirect.com/science/journal/09658564/67.

2. BACKGROUND

development impacts are considered in combination. The current approach to transit project funding in Australia is such that capital costs are subject to 100% government subsidy and operating costs are subject to approximately 80% government subsidy, leading to projects being priced (in the eyes of the consumer) far below the marginal cost. This approach not only limits the number of projects that can be invested in at any time owing to budget limitations but also leads to equality issues as it is the land owners that stand to benefit the most, and it can be reasonably expected that the average property owner is wealthier than the average tax payer. Thus, value-capture strategies can potentially be employed to ensure sharing of the costs and benefits of a project to free up funds for other important projects that stand to generate net social benefits and also address equality issues to an extent as well.

The case for value capture is not premised on being a new welfare benefit stream to contribute to the appraisal of transport economic benefits, as it can be expected that the land market impacts of a transport infrastructure investment are already accounted for in the estimation of traditional economic benefits and including both in an economic assessment would lead to a double-counting of the benefits. Rather, the land market impacts can be seen as a monetisation of the traditional transport benefits into existing land values. For instance, an increased level of accessibility to the CBD is a welfare benefit that is quantified in transport project business cases (in the form of a reduction in the generalised cost of travel), and consequently, this benefit is monetised into land values as there is a WTP for access to high-quality transit (up to the amount of benefit generated). Similarly, a reduction in a negative externality such as noise pollution can also be expected to be monetised into land values as the social cost of occupying a site is reduced.

The investment in transport infrastructure and the rezoning of land create value in the impacted land and property markets as the actions are economically generative, with the actual value placed on these actions being determined by the market demand and WTP. While in the context of fixed population size, the impacts of creating development capacity in a transit corridor may be considered economically redistributive, but in reality, Australian capital cities are growing rapidly and they fundamentally cannot accommodate this growth unless land market development capacity is unlocked. Whether the capacity for growth is created in the urban fringe or in inner urban areas, growth is simply not feasible without the presence of basic hard and soft infrastructure and services (such as potable water, power, transport, schools, hospitals, etc.) to enable land to be rezoned and developed to its highest and best use.

2. BACKGROUND

The social benefits of well-designed transport infrastructure can be experienced over a broader network, but owing to the complexity of property markets metropolitan wide, it can be difficult to estimate the land value impacts of a project at a great distance from the infrastructure asset. It is reasonable to assume, however, that the majority of the land market impacts resulting from a project will be experienced in close proximity to the infrastructure asset, as that is where the perceived and experienced value of the investment will be greatest, and this point forms the foundation of the analysis in this study.

2.1 THE VIRTUOUS CYCLE

Public investment in urban renewal and transport infrastructure creates a number of economic, social and environmental benefits that improve public health and safety and the economic environment for employment, whilst reducing urban development externalities (urban sprawl) and transport externalities (congestion, pollution, etc.). Investment in urban renewal and transport infrastructure also financially benefits the land and property markets that it serves. This public sector financial value creation leads to further private sector investment, facilitating a public and private sector value reinvestment cycle. This relationship is illustrated by a conceptual urban renewal and transportation investment financial value 'Virtuous Cycle' (see Figure 8).

The six-step Virtuous Cycle is the theoretical basis for discussing investment in urban renewal/regeneration and transportation infrastructure. The Virtuous Cycle enables:

- an understanding of the net costs and benefits of the investment accrued to the public and private sectors,
- the development of options to defray the public sector cost of the project,
- an open discussion on value-sharing arrangements between public and private sector stakeholders,
- long-term planning and integrated urban renewal and transportation infrastructure investment policy,
- the development of a project affordability and funding analysis framework, and
- the development of a comprehensive integrated urban renewal and transportation project value proposition.

The analysis undertaken as part of this report focuses on Step 2 of the Virtuous Cycle, where the value created from the investment in transit is analysed.

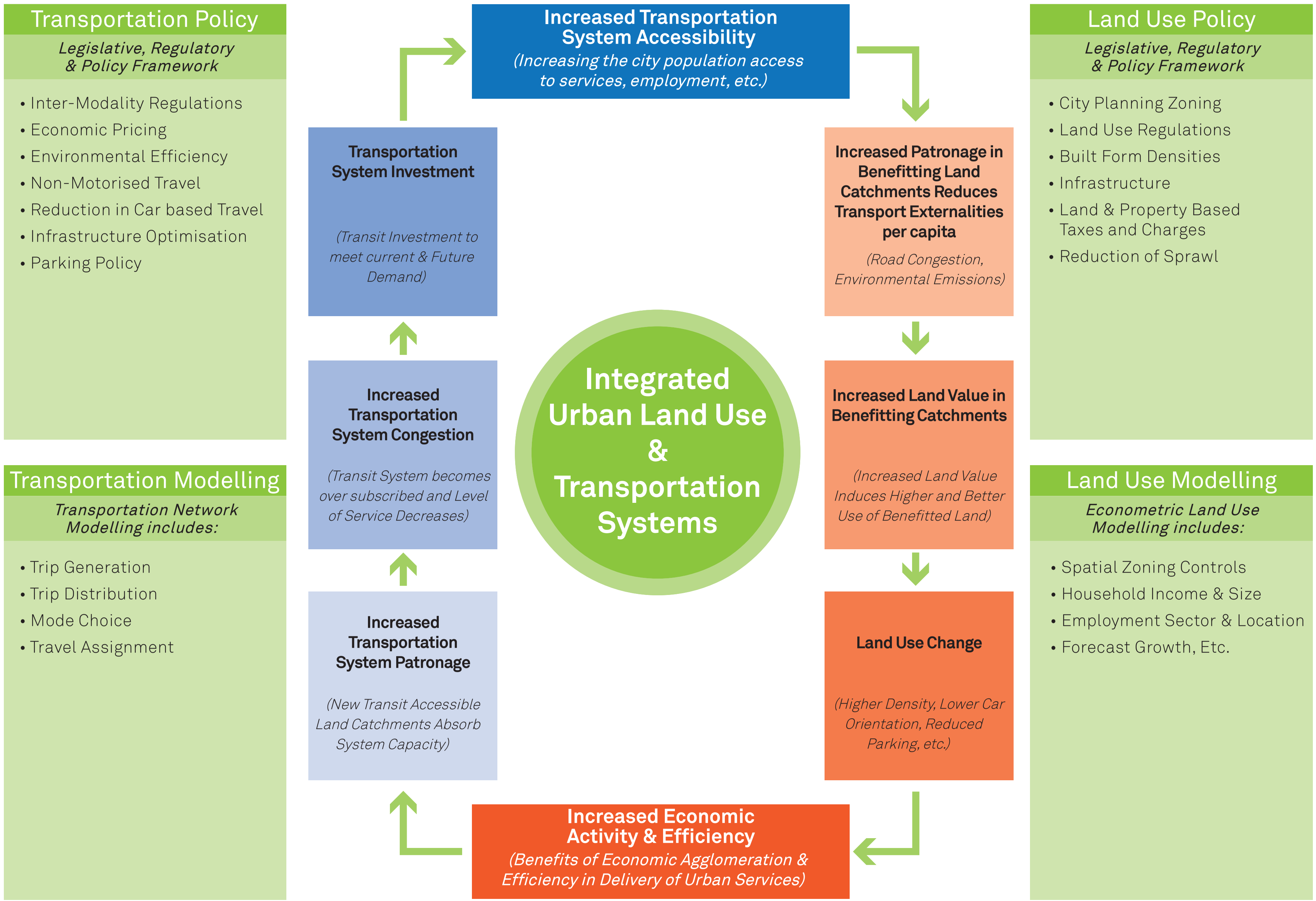

Figure 7 – Cyclical Relationship between Land Market Activity and Transportation Accessibility (and the Relevant Transportation and Land Use Policy Frameworks and Modelling Tools)

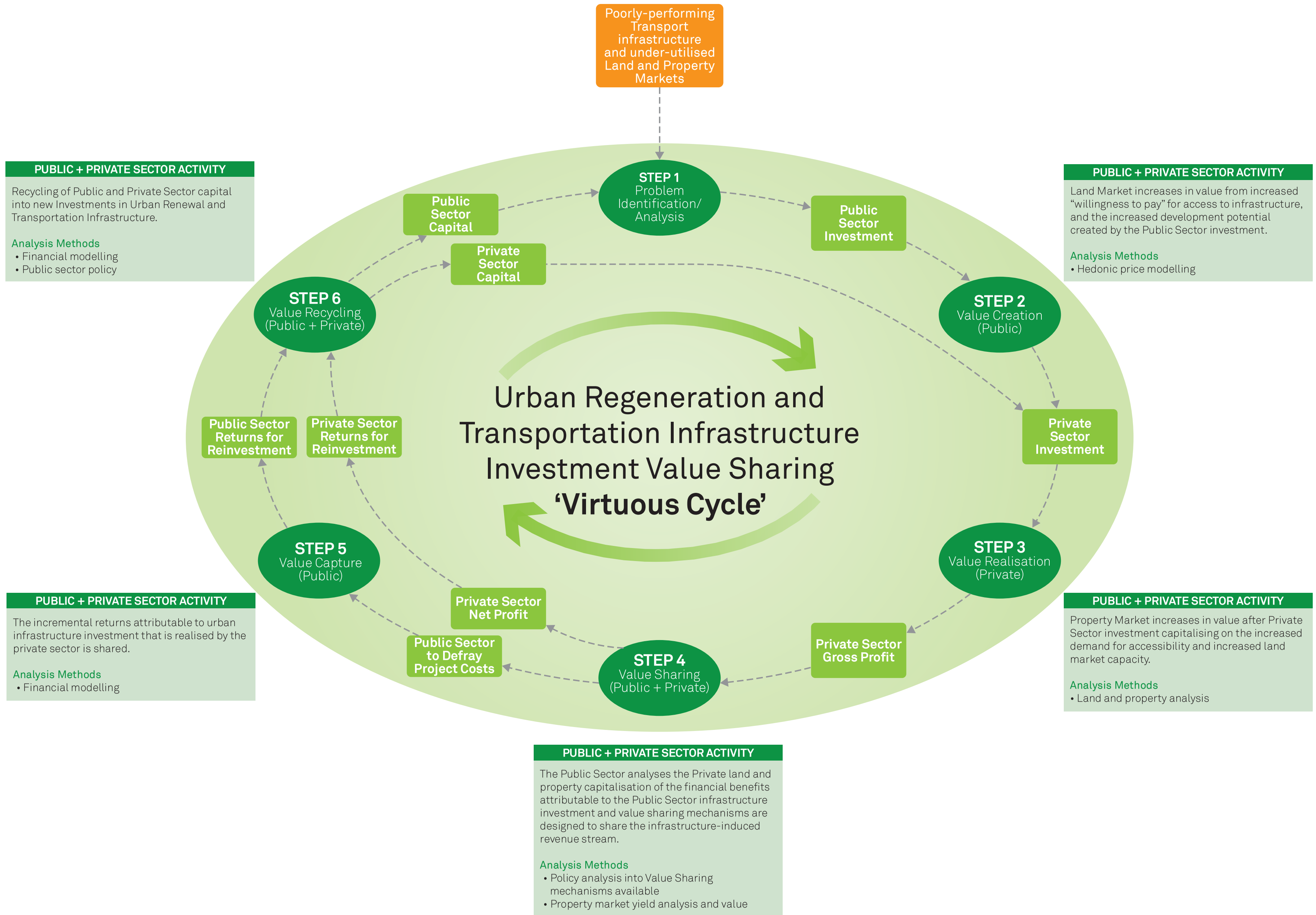

Figure 8 – The Financial Value 'Virtuous Cycle' Resulting from the Investment in Urban Regeneration and Transportation Infrastructure (LUTI & Mecone, 2015)

2.2 HOW DOES INTEGRATING URBAN RENEWAL AND TRANSPORTATION PROJECTS CREATE VALUE?

As illustrated in the urban regeneration and transportation infrastructure 'Virtuous Cycle' in Figure 8, it is well understood that public investment in urban infrastructure creates value in the land and property markets it serves. Investment in transportation infrastructure is generally undertaken to reduce travel times and increase levels of accessibility. The transportation business case justifies this investment by calculating the net economic benefits generated (e.g. reduction in travel time, congestion, environmental emissions, and number of accidents).

However, in addition to the economic value assessed for the project investment business case, the investment in transportation infrastructure creates financial value in the land and property markets in the benefiting land catchments. Step 2 of the Virtuous Cycle focuses on transportation infrastructure investment for value creation. This value creation in the markets can be described in three separate and sequential phases:

- Phase 1: Monetisation of Accessibility Benefits into Infrastructure Catchments – Improved accessibility leads to an increased WTP for access to the infrastructure in the land and property markets in the benefiting land catchments, resulting in value creation in the land and property markets.
- Phase 2: Change of Zoning in Infrastructure Catchments to their Highest and Best Use – The increased WTP for access to transportation infrastructure leads to a demand to change the zoning of the land market capability for land parcels to achieve their highest and best use, over and above their existing use.
- Phase 3: Increasing Development Density of Infrastructure Catchments – The WTP for access to transportation infrastructure leads to greater demand in the rezoned infrastructure catchments, unlocking higher development density (Floor Space Ratios) commensurate with the market-led WTP.

The sequential nature of each of the phases of the value-creation process is illustrated in Figure 9, and the theory for each of the three infrastructure value-creation phases is introduced next and subsequently analysed in each of the hedonic price modelling case studies.

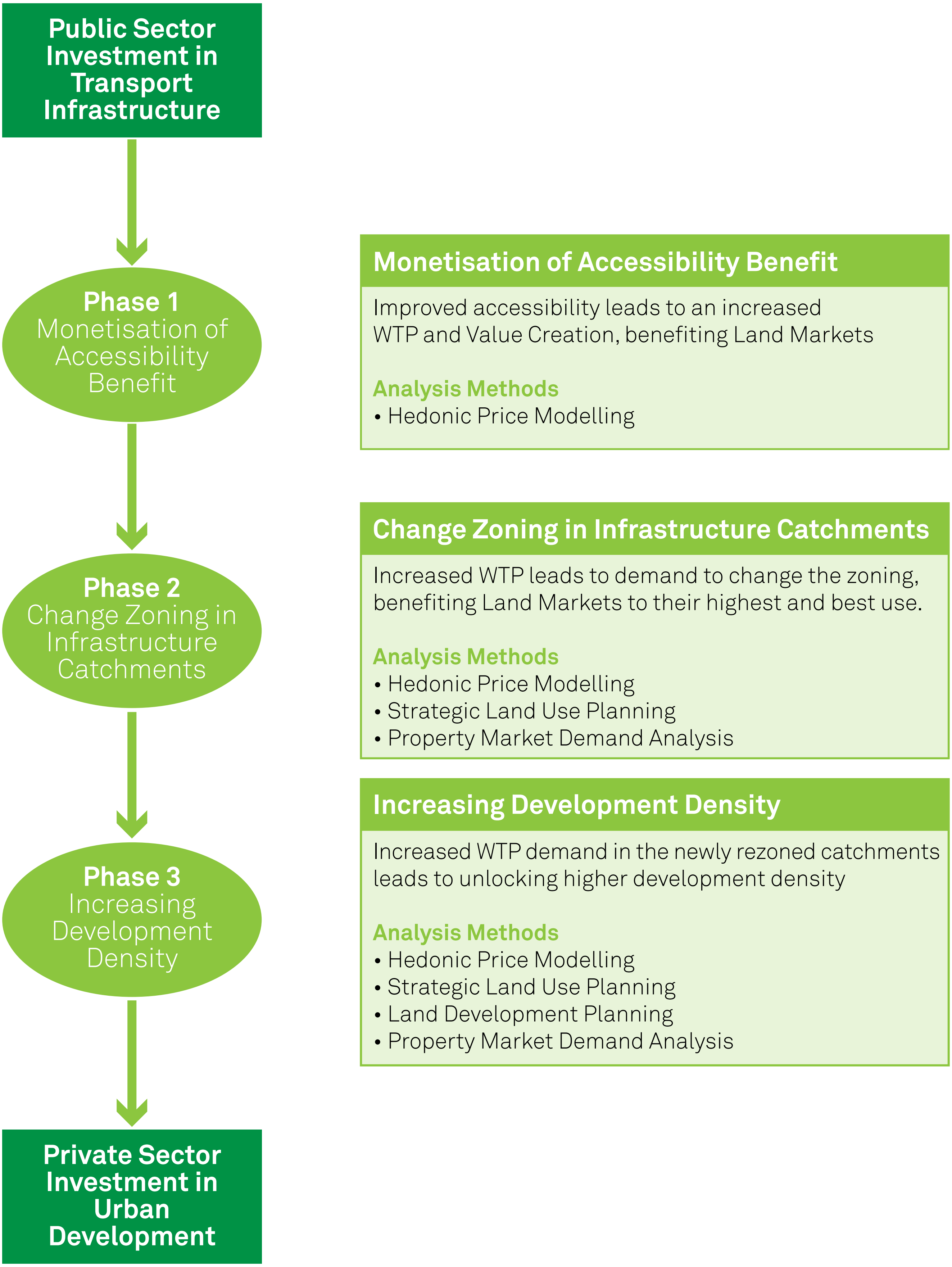

Figure 9 – Phases of the Transportation Infrastructure Investment-induced Land Market Value-creation Process (LUTI Consulting)

2.2.1 PHASE 1: MONETISATION OF ACCESSIBILITY BENEFIT INTO INFRASTRUCTURE CATCHMENTS

Increase in accessibility and subsequent reduction in transportation externalities produced by the investment in transportation infrastructure are financially monetised into the infrastructure's land market values and this represents a WTP for a reduction in economic cost.

The increase in the WTP for transportation accessibility is a land market response that reflects that residents, businesses, and developers are willing to pay increased land and property costs for a commensurate reduction in transportation costs. Figure 10 illustrates this conceptual increase in the WTP, as the investment in transportation infrastructure effectively moves the property closer to employment and other services, in terms of time, and up the land market bid-rent curve.

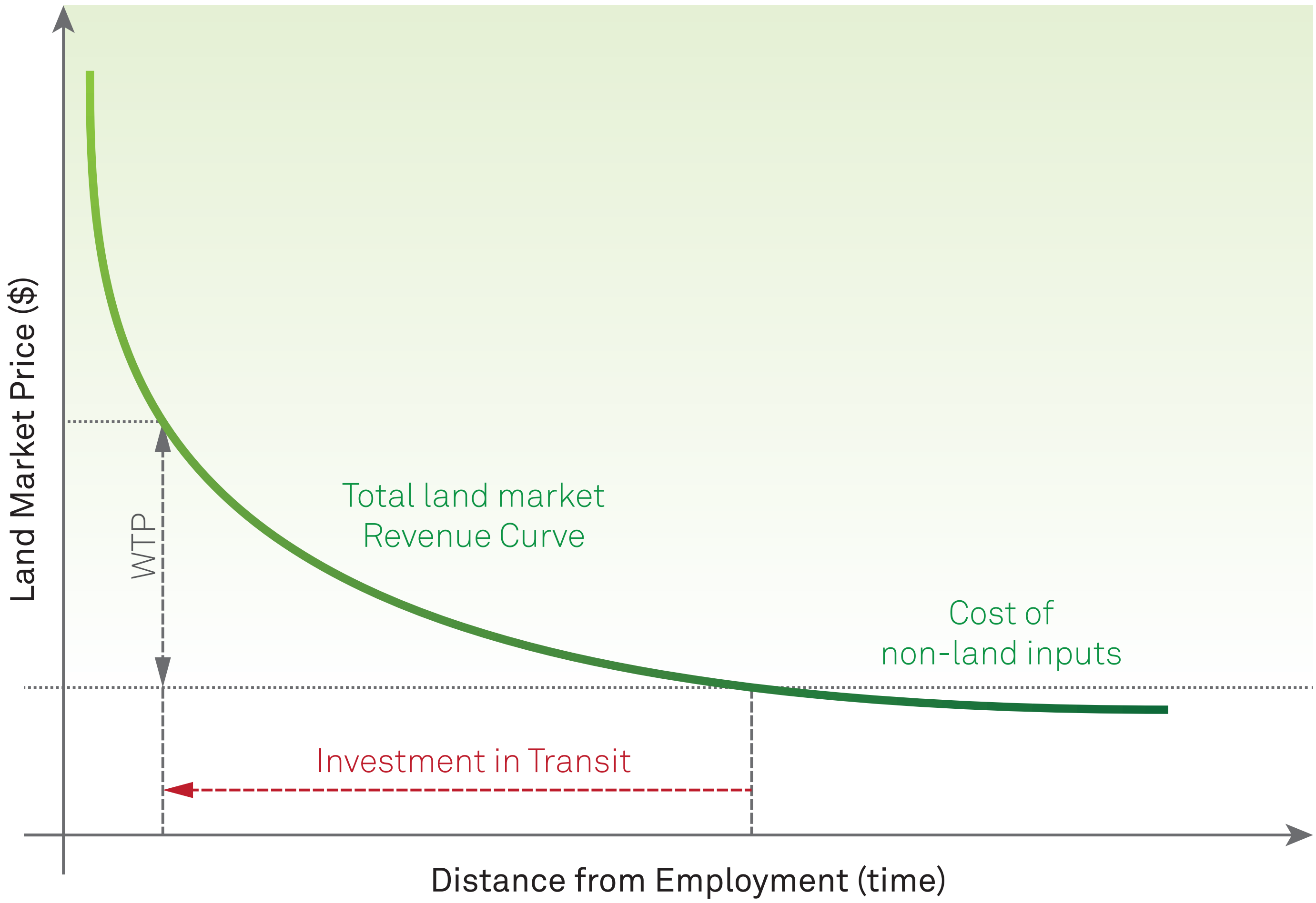

Figure 10 – Land Market Bid-Rent Curve (Land Bid-Rent = Total Revenue – Cost of non-land inputs)

2. BACKGROUND

Although studies on property market response to investments in transportation infrastructure tend to agree that proximity and accessibility to urban transit deliver a value premium, the observed magnitude of uplift can vary depending on a number of factors related to both the specific projects being investigated and the study design. For instance, the WTP for access to transportation infrastructure can vary according to a range of locational, transport system, and socio-economic factors as well as the level of land use integration in the project. Additionally, study design can also impact the derived estimates of the accessibility premiums, where methods designed to capture the change in land and property market value from an investment are preferred to those that simply analyse the current post-investment value compared to locations without the same levels of accessibility.

Land market prices reflect the interaction between buyers and sellers, as costs (such as travel) are traded-off against land rents (and population densities) in a bid-rent curve[4,5,6]. The theoretical value WTP premium curve for the monetisation of access to transit infrastructure is presented in Figure 11. The figure illustrates how the accessibility benefit is economically monetised into the catchment's land markets. The financial impact on the benefiting land markets is an increase in value commensurate with the WTP for the city's residents and businesses for access to the infrastructure.

A theoretical value WTP premium curve for the monetisation of access to transit infrastructure presented in Figure 11[7,8] illustrates the effect of transit accessibility in different stages of a project's development and life-cycle. In Australia, according to the findings of McIntosh et al. (2014), the accessibility benefit is monetised into the surrounding land markets from the funding commitment, through the construction period, and to operations as has been found in traditional transit corridors in other global cities.

This report estimates the land value uplift in Sydney from investments in transit infrastructure projects while considering the metropolitan area as a whole and also while looking at discrete transit project subregions.

4 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 Vol. 67, September 2014, pp. 320–339 http://www.sciencedirect.com/science/journal/09658564/67.
5 Alonso, W. (1964) Location and Land-use: Towards a General Theory of Land Rent. Harvard University Press, Cambridge, pp. 204.
6 Muth, R. (1969) Cities and Housing: The spatial pattern of urban residential land use. Chicago, IL: University of Chicago Press pp. 355.
7 Center for Transit-Oriented Development. (2008) Capturing the value of transit. Oakland, CA. Downloaded from: http://www.reconnectingamerica.org/public/display_asset/ctodvalcapture110508v2.
8 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 Vol. 67, September 2014, pp. 320–339 http://www.sciencedirect.com/science/journal/09658564/67.

2. BACKGROUND

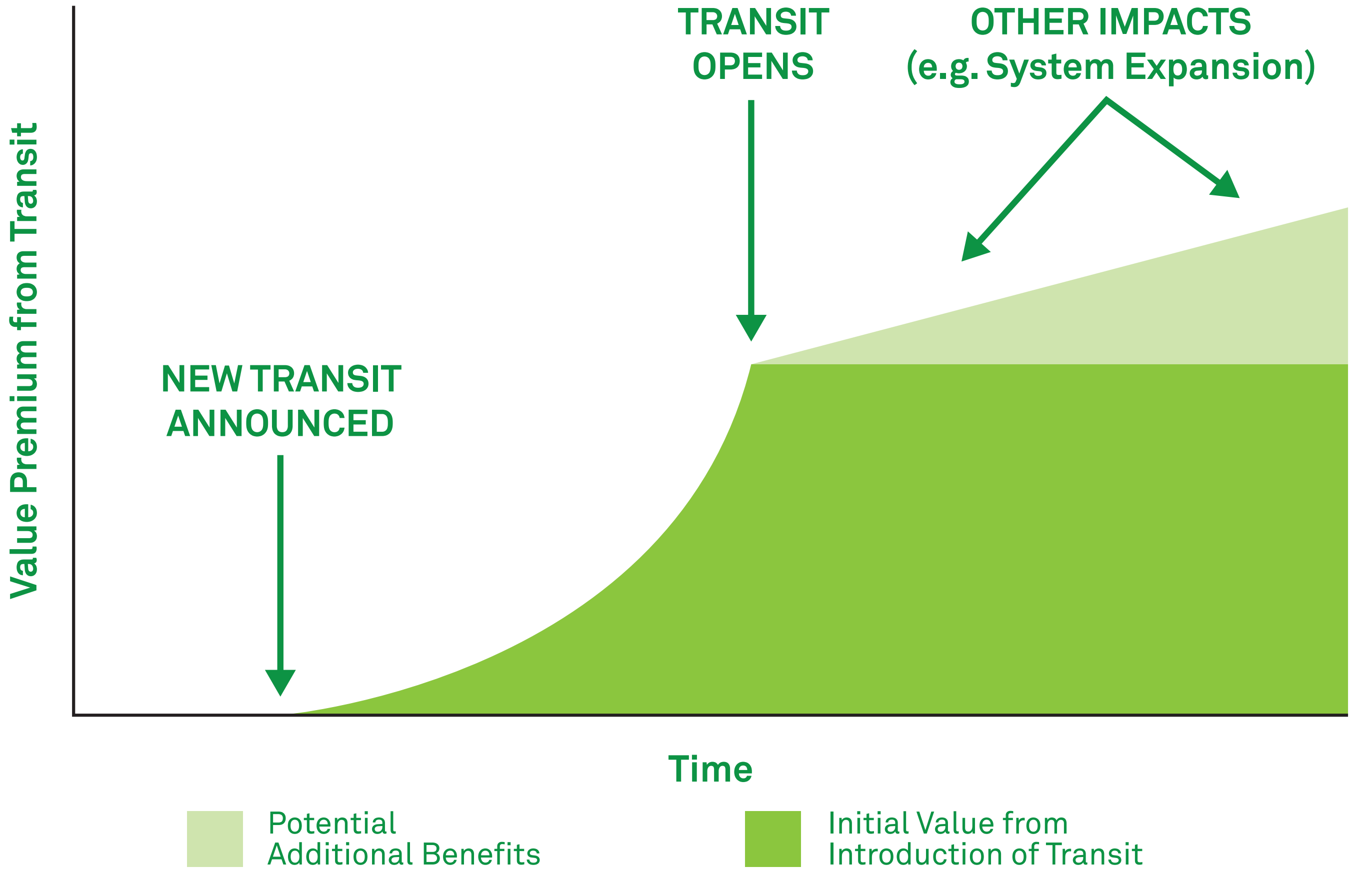

Figure 11 – Theoretical Land Market Value Creation Curve of the Monetisation of Accessibility from the Investment in Transit Infrastructure[9]

9 LUTI Consulting and Mecone Planning, (2015) Transportation and Urban Renewal Value Creation and Sharing – A Review and Assessment of the Non-Monetised Benefits of Value Sharing Mechanisms available in NSW, 2015 (Report undertaken for the NSW Department of Premier and Cabinet – Delivered, July 2015).

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2.2.2 PHASE 2: CHANGE OF LAND MARKET ZONING IN THE INFRASTRUCTURE CATCHMENTS TO THEIR HIGHEST AND BEST USE

The land markets that surround an investment in transit infrastructure are the critical catchments that create the economic return to the business for initial investment, and it is these catchments that gain the most benefit. The demand for access to the catchments drives land use change to capitalise on the benefits that the investment has created. The value in the land markets is therefore commensurate with the specific market WTP for access.

As an example, underutilised light industrial or low-density residential development is not the highest and best use of the catchments surrounding a new metro line, as high-density residential/commercial/mixed use development is best suited to take advantage of the increased transport network capacity and related benefits that lead to an increase in the willingness to pay for the land parcels. Another example would be a new freight line and hub that would not be suited to land uses that do not value proximity to freight infrastructure (such as residential, commercial, etc.), but would be highly valued by those seeking to exploit the access to a large scale freight and logistics facility, such as businesses requiring an industrial zoning.

Therefore, a critical aspect of investing in infrastructure is to ensure that land use planning and transportation planning are aligned and integrated. This is important to not only resolve the issue of land use conflicting with the infrastructure (to reduce unnecessary externalities such as noise and other emissions) but also to ensure that the infrastructure catchments are structured in a way to maximise their value for those who either currently reside in them or for those who will want to relocate to the catchments to maximise the infrastructure utilisation and experience a reduction in negative externalities (thus avoiding the economic costs of road-based congestion, urban sprawl, etc.).

The differential values of land uses are analysed at a metropolitan and project catchment level in detail in subsequent sections of this report.

2.2.3 PHASE 3: INCREASING DEVELOPMENT DENSITY OF INFRASTRUCTURE CATCHMENTS

The different levels of WTP for accessibility to different forms of transportation infrastructure in surrounding land catchments are also reflected in the development density demand. The property market demand for development density in surrounding (appropriately zoned) land catchments increases the value of the land parcels, where land capable of a more intensive use is designated by larger floor space ratio (FSR) values. The market-derived demand for development intensity induced by an infrastructure investment creates value and can be viewed in terms of the incremental impact of FSR increases in different catchments for differently zoned land uses. For example, a low-frequency, low-capacity suburban transit service is unlikely to induce a significant level of WTP to locate either residential or

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commercial land uses within its benefitting catchment when compared to a high-frequency, high-capacity service to the CBD. These different levels of accessibility will impact the WTP for access to the infrastructure and the subsequent development density of appropriate land uses required to meet this demand.

It is understood that there may be a market demand for development density away from an infrastructure investment, but the demand for infrastructure and services created from intense land uses can create significant urban externalities (such as road-based congestion and under-supply of services). To avoid these externalities and take advantage of the benefits created by infrastructure investment, there is a market demand premium (value uplift) for developing in the benefitting catchments, which subsequently creates greater demand for density in these locations over other areas without access to the increased amenities that effectively reduces travel costs.

In this report, all estimated models feature controls for FSR to determine the land value impacts of increasing the allowable development intensity of land. The FSR coefficients produced by the models can be used to determine the marginal effects of increasing (or decreasing) FSR on land values, and they can be considered average marginal effects across the modelled subregions. Owing to the relatively large subregion sizes, the coefficient estimates can be considered conservative, especially as the subregions will contain vast numbers of lots with low FSR (e.g. 0.10 to 0.65), where generally only separate dwellings will be allowed and hence dramatic land value differences across them will not be observed. Also, the FSR coefficients will be much more reliable if applied to FSR changes within the spectrum of what has previously been seen in the subregion. For instance, if a subregion only contains lots with FSR values between 0.50 and 3.0, then the model will not be able to accurately predict the land value impacts associated with an FSR increase to 10.0 or 20.0. Also, in the case of large scale urban renewal, there will likely be uplift effects beyond simple rezoning effects that will be associated with a complete re-visioning of an area, and the last case study in this report based on the Mascot and Green Square urban renewal precincts investigates this effect closely.

An alternative approach to estimating the land value impacts of increasing FSR, typical of the development industry, involves residual land value calculation. Using this approach, it is likely that one will estimate greater land value uplift effects associated with increasing FSR. Generally speaking, the approach involves determining the type of development one would like to construct and estimating a market price for the sale of all the units, and then working backwards from there by subtracting various costs and fees to determine what the land is worth. Using this approach, the type of development desired for construction can be used to determine the required FSR, and the difference between the existing land value and the residual land value can be deemed the uplift associated with rezoning. Although this approach is considered conventional, it is much more involved and requires a keen understanding of local market conditions. In this report, we base our FSR uplift examples on the application of hedonic price model coefficients as they closely reflect the relationship between unimproved land value per square metre and FSR in the valuations data, which can be more easily applied to large project areas and are more conservative in nature.

The land market impact of varying the FSR is analysed using the hedonic price modelling method at a metropolitan and project catchment level in detail in subsequent sections of this report.

2.3 ASSESSMENT OF LAND VALUE IN NEW SOUTH WALES

2.3.1 NSW GOVERNMENT LAND VALUATION ASSESSMENT METHOD

In NSW, the government assesses the land value of each land parcel in accordance with provisions of the Valuation of Land Act, 1916. The methodology used to assess land value by the NSW Government is illustrated in Figure 12 below.

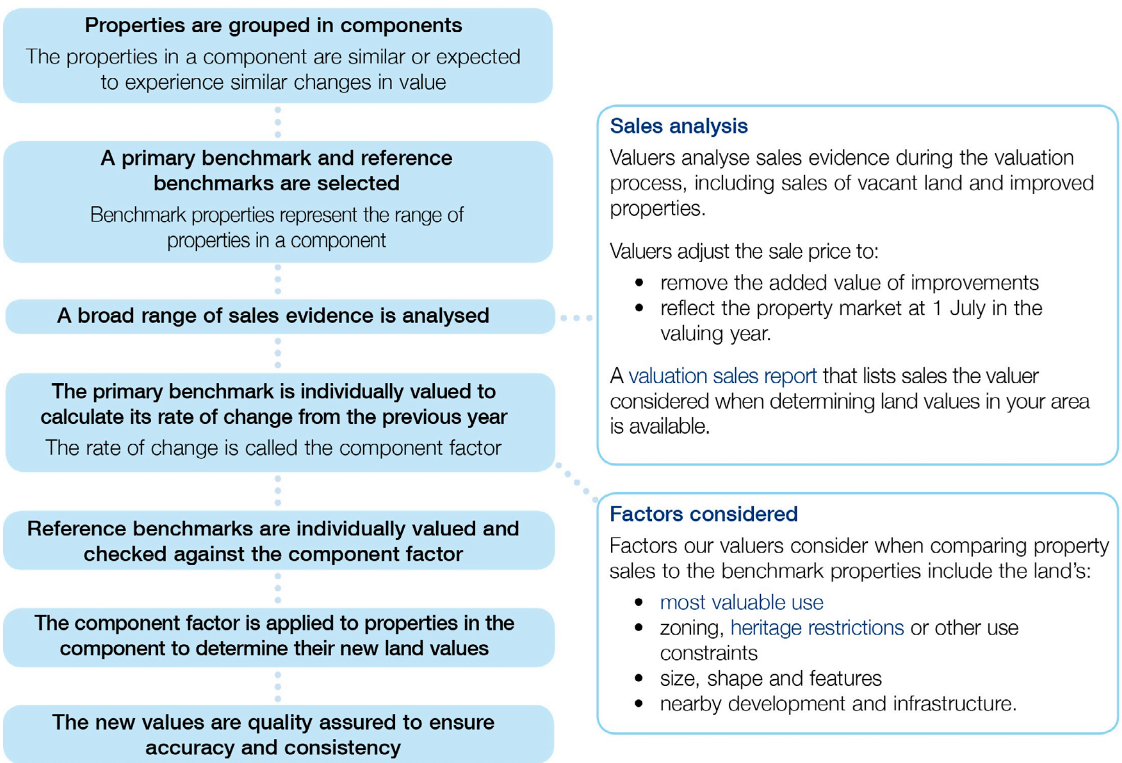

Figure 12 – NSW Mass Valuation Approach (http://www.valuergeneral.nsw.gov.au/land_values/valuation_method)

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To explain the mass valuation method presented in Figure 12, the NSW Government provides the following details[10]:

- **Mass Valuation Process** – The mass valuation method used in NSW is the component method. Valuation methods, such as the direct comparison method and the hypothetical development method are used to value a sample of individual properties within the component. In the component method analysis, the group of properties used for mass valuation is called as a component. These properties have similar attributes, such as location, size and amenities, and are expected to experience similar changes in market value. For example, high-density residential land components contain land zoned for high-density residential development.
- **Component Method** – When using the component method, you must select properties from each component as the primary benchmark and reference benchmark. The primary benchmark is individually valued each year based on real estate market sales evidence to determine how much the land value has changed from the previous year. The rate of change recorded for the primary benchmark is then applied to the other properties in the component. Reference benchmarks are selected from within the component and used to check the quality of the proposed valuations. Reference benchmarks are important for checking the accuracy of the mass valuation process. Benchmarks must represent the range of properties in a component, and their valuations must be supported by market evidence.
- **Primary Benchmark** – The valuation primary benchmark is based on a property that is within 5% of the component's median land value, enabling a direct comparison to value it at 1st July each year. It is calculated as the rate of change from the prior year's 1st July land value. The rate of change is called the component factor.
- **Reference Benchmark** – Reference benchmarks with values further away from the median land value (upper and lower quartiles) are chosen. Then, these are valued at 1st July and the valuations are checked against the primary benchmark's rate of change to determine if subgroups of properties have had changes in value inconsistent with the majority of the component. Inconsistencies with the reference benchmarks either require individual valuations for some properties or the creation of a component sub factor.

10 Valuer General's Policy – Valuation of high-density residential land (2014) http://www.valuergeneral.nsw.gov.au/__data/assets/pdf_file/0010/198622/Valuation_of_high_density_residential_land_20-08-14.pdf

- **Component Factor** – The component factor derived from the primary benchmark is used to value other properties in the component. This is applied to each property in the component, except for handcrafted valuations or valuations which have been valued using a component sub-factor. Handcrafted and sub-factor values override component factor values.

To determine the assessed land valuation response to land market WTP for discrete land market impacts (infrastructure investment, change in zone, increase in development capacity on a site) as well as the timing of the response, a comparison between assessed land value and property market sales data was undertaken to determine whether government-assessed land value lagged behind the property sales, and if so, by how much.

2.3.2 TIMING COMPARISON OF SALES RESULTS AND ASSESSED LAND VALUES

A comparison between assessed land value and property market sales values was carried out to determine the presence and duration of a lag between them. The assessment of this lag is useful to understand when the property market response began in the panel data models that are based on land valuations data. Two subregions were investigated in the examination of the lag effect: Epping to Chatswood and the Dulwich Hill Extension to the Inner West LRT.

Both the average and median assessed land values and property sales values for both the Epping to Chatswood Rail Line and the Dulwich Hill extension to the Inner West LRT are presented in Figures 13, 14, 15 and 16. All the graphs for the two lines demonstrate that assessed land value historically lags behind the property sales values by 1 year up to around 2010, where after that date, the changes in the assessed land value appear to directly correlate with the market trends in the corridor in the median and average values in the catchment property sales.

The importance of comparison between assessed land value and sales data is that it enables the interpretation of the panel data results for the analysis of each of the catchments and facilitates a comparison between documented key project milestones (funding commitment, commencement of construction, and commencement of operations) and changes in the land market WTP for access to the infrastructure. This land market response analysis enables the determination of the actual response to the investment in all other land market activity.

Figure 13 – Dulwich Hill Extension to the Inner West LRT Catchment: Average Assessed Land Values and Catchment Sales Values (Red Circles – 1 year lag) (Blue Circles – Apparent Direct Correlation)

Figure 14 – Dulwich Hill Extension to the Inner West LRT Catchment: Median Assessed Land Values and Catchment Sales Values (Red Circles – 1 year lag) (Blue Circles – Apparent Direct Correlation)

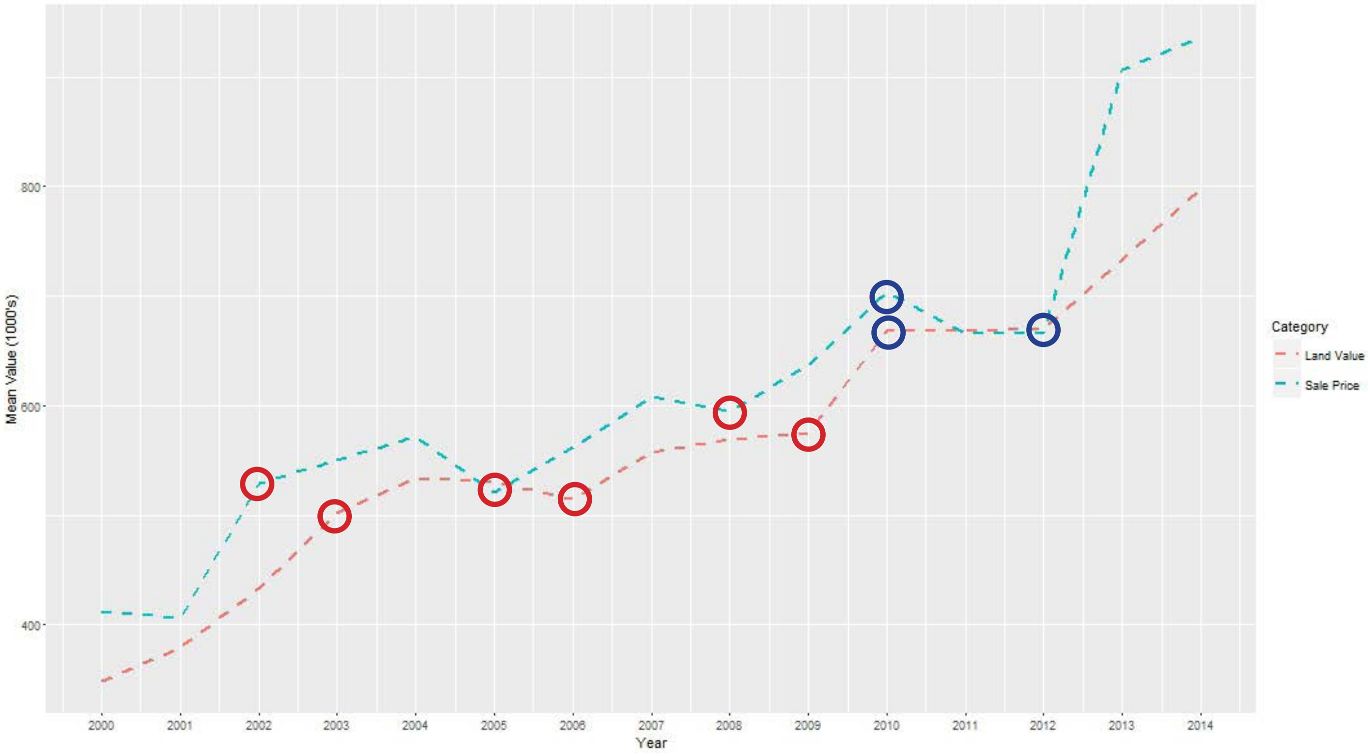

Figure 15 – Epping to Chatswood Rail Line Catchment: Average Assessed Land Values and Catchment Sales Values (Red Circles – 1 year lag) (Blue Circles – Apparent Direct Correlation)

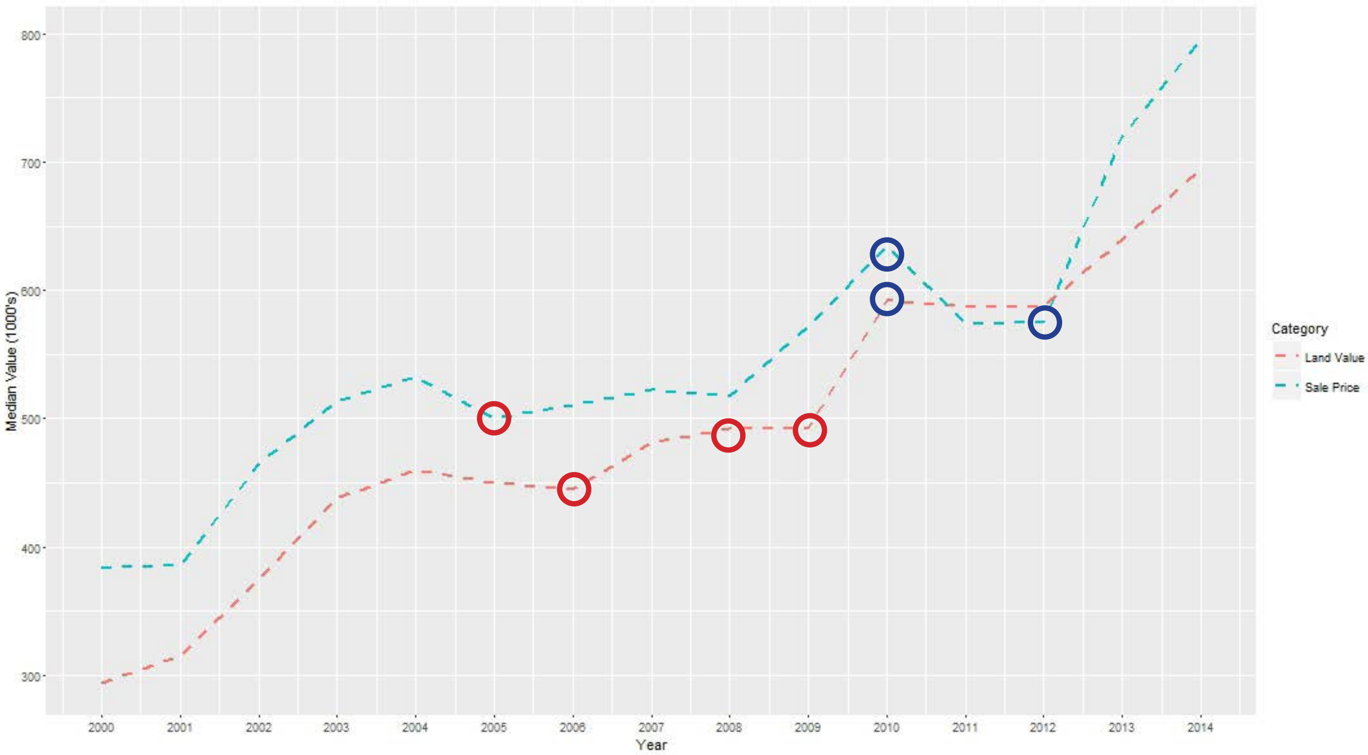

Figure 16 – Epping to Chatswood Rail Line Catchment: Median Assessed Land Values and Catchment Sales Values (Red Circles – 1 year lag) (Blue Circles – Apparent Direct Correlation)

3.

METHODOLOGY

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The purpose of this study was to determine the impact of investment in transportation infrastructure and urban renewal projects on land values in benefitting catchments in the context of Sydney, NSW. To analyse how land markets in Sydney value access to transit infrastructure as well as other land and property-based attributes, hedonic price modelling (HPM) was applied. HPM is a regression-based statistical method that can be applied to land or property data to develop a model to either predict land or property prices (the dependent variable) and the marginal effects of land or property attributes (the independent variables) on land or property prices. This section discusses the HPM methodology used to assess the land value impacts of various transit and urban renewal projects in Sydney using data spanning the years 2000 to 2014.

3.1 HEDONIC PRICE MODELLING

McIntosh et al. (2014) note that the term "hedonics" is derived from the Greek word "hedonikos", which simply means pleasure and in an economic context refers to the utility or satisfaction one derives from the consumption of goods and services[11]. HPM has been employed extensively in land and property research and is a widely accepted approach for conducting empirical studies of housing markets. There are five key assumptions in the economic analysis of land markets that are particularly important for HPM analysis[12]:

1. Land market homogeneity
2. Perfect competition in the market
3. Buyers and sellers have freedom to enter and exit the market
4. Buyers and sellers have perfect information concerning the product and price
5. Market equilibrium has no interrelationship with price and attributes

Hedonic price modelling (HPM) involves the utilisation of regression techniques to predict land or property values while using a set of land or property attributes as predictors or controls. For this study, assessed land valuation data were chosen over property sales data as they could be sourced for all parcels in the metropolitan area, for all years, leading to large sample sizes that in turn could produce more efficiently estimated models. Metro-wide data were also required for estimating models for the various project subregions, so the sample sizes would remain adequately large.

An additional benefit of using land valuation data as opposed to property sales data is that controls for capital improvements (such as building age, number of bedrooms, number of bathrooms, etc.) do not have to be controlled for in the models, as capital improvements are not of particular interest to this study and they can introduce a great deal of variation into models.

11 Chin, T.L. and Chau, K.W., (2003) A Critical Review of Literature on the Hedonic Price Model. International Journal for Housing Science and its Applications, 27(2) pp. 145-165

12 McIntosh J., Trubka R. and 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 Vol. 67, September 2014, 320–339 http://www.sciencedirect.com/science/journal/09658564/67

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A regression-based HPM seeking to establish a relationship between land value and land attributes takes on the general form in Equation 1:

Equation 1 – General Hedonic Price Modelling Equation

$$Y=\alpha+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n$$

Where:

- Y is the independent variable (i.e. land value),
- x_n represents an independent variable, or predictor (i.e. property attribute), and
- β_n represents a regression coefficient (i.e. marginal effect)

In this study, both cross-sectional models using 2014 data and panel data models using data spanning the years 2000 to 2014 were estimated. While cross-sectional models can typically be relied upon to give a snapshot of the marginal effects of land attributes on land prices, they do not show how these effects may have changed over time. Panel data models, on the other hand, have the benefit of allowing for interactions between land attributes and time, which is particularly useful for seeing how transit benefits are monetised into land values from the time of announcement, through construction, and until operation. Additionally, panel data models can be used to determine how the marginal effects of some control variables have changed over time (such as zoning controls or proximity to activity centres).

As part of the modelling process, appropriate data transformations were determined by plotting the dependent variable (unimproved land value per square metre) against each independent variable to observe their relationship and deduce appropriate variable transformations. Numerous model specifications and functional forms were then trialled while reviewing standard errors, residual plots, and model fit indicators in an iterative process to determine the best performing models. Eventually, a hybrid log-log/log-linear functional form was selected, where the dependent variable (natural log of unimproved land value per square metre) was regressed against logged continuous independent variables and an untransformed set of dichotomous independent variables.

Continuous variables included land attributes such as lot area, distance to CBD, and FSR, while dichotomous (or dummy) variables included mainly qualitative indicators such as land use and whether a land parcel was in or out of a particular transit catchment. Coefficients of logged independent variables were interpreted as elasticities (i.e. a percent change in the dependent variable given a percent change in the independent variable) while coefficients of dichotomous variables were interpreted as approximations of percentage uplifts. The theoretical model below in Equation 2 represents the specification of the cross-sectional models while the panel data models are represented in Equation 3. Note that the panel data models only differ from the cross-sectional models by their inclusion of controls for time (i.e. year) fixed effects and time-transit mode interactions.

Equation 2 – Parametric Land Price Equation

$$ln(ulvpsm) = \alpha+\beta_a lnA_a + \beta_t T_t + \beta_l L_l + \beta_s S_s + \mu$$

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Equation 3 – Parametric Land Price Equation with Year and Year-Transit Catchment Interactions

$$ln(ulvpsm) = \alpha + \beta_a lnA_a + \beta_t T_t + \beta_l L_l + \beta_s S_s + \beta_y Y_y + \beta_{ty} TY + \mu$$

Where:

- A is a vector of continuous variable land attributes (e.g. distance to CBD and FSR),
- T is a vector of transport and transit-related dichotomous variables (e.g. within 400 m of a heavy rail station and 100 m of a major road corridor),
- L is a vector of dichotomous land use variables (e.g. A – Residential or M – Mixed Use),
- S is a vector of dichotomous variables indicating the land parcel's suburb,
- Y is a vector of dichotomous year variables spanning 2001 to 2014 with the year 2000 providing the base year for comparison, and
- TY represents a vector of interaction terms between valuation year and transit mode.

The effects of changing model geographic boundaries were also tested to determine how the reference cases for the dichotomous variables would respond. This involved digitising project boundaries for clipping the sample data and occasionally adjusting these boundaries to include more or less of adjacent areas. The sample data for each model were also mapped and filtered for each year for a visual inspection of any issues in the data that may be impacting the results. This proved to be a valuable step in the modelling process as instances of missing valuations data for some properties and years as well as the change in land uses could be identified and the modelling approach could be adjusted to take these occurrences into account. Also, when running models for individual land uses it was found that the rezoning of a valuable lot near a train station from residential to some other land use (such as mixed use), meaning the lot would not appear in a residential hedonic model from the year of rezoning onwards. As a result, the residential model would report a drop in land values near the train station that might mistakenly be construed as a reduced WTP for access to transit, when in reality, it was because the record was essentially removed from the sample because of the rezoning. Because of this, it was decided to run models for all land uses combined while controlling for simplified land use classification instead of running models for each simplified land use separately.

The general workflow entailed a process of preparing a base spatial and land attribute dataset using geographic information system (GIS) applications (ESRI ArcGIS and Postgres/PostGIS), identifying and digitising project subregions in the Sydney Metropolitan Area for clipping sample subsets; merging the land attribute data with the tabular valuations data to export a series of modelling datasets for subregion analysis; estimating a series of hedonic price models in the R statistical computing environment; and exporting results for review, tabulation, and reporting.

This process is illustrated in Figure 17, and Table 2 presents the source and brief description of each of the input datasets into the hedonic price modelling workflow.

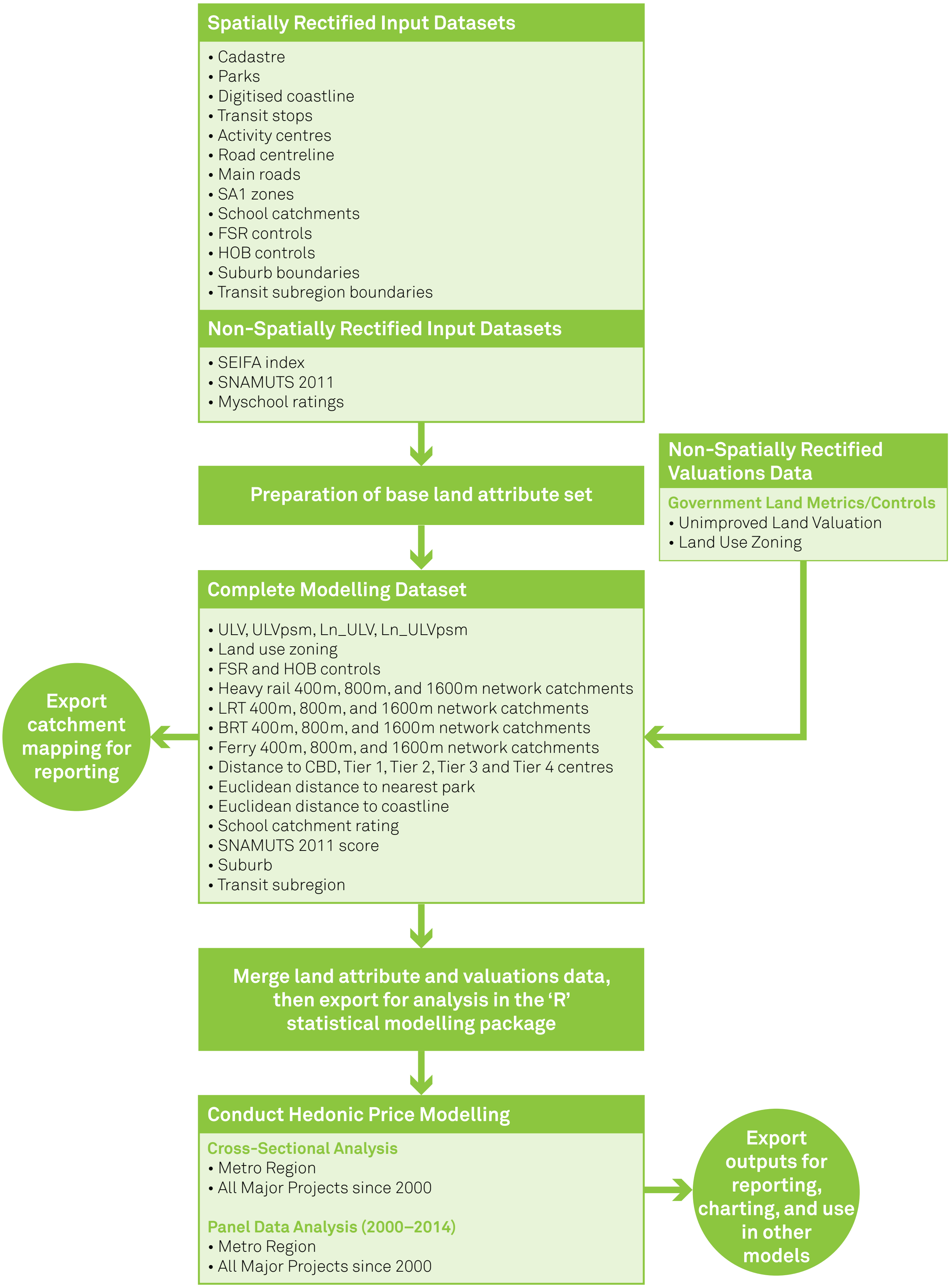

Figure 17 – Hedonic Price Modelling Workflow Utilised for this Project (LUTI Consulting)

3.2 PREPARING THE INPUTS TO THE HEDONIC PRICE MODEL

Prior to extracting datasets and beginning the modelling process, a great deal of work had to be done to prepare a base spatial and land attribute dataset consisting of lot boundaries and land attributes. The lot boundary spatial layer used as the foundation dataset for appending all other indicators was the 'property' Shapefile sourced from the LPI, as this had a PROPID field that could be uniquely matched with records in the tabular historical valuations data. The property layer was split into 3 files that had a significant number of records overlapping with each other so the three files had to be merged and then cleaned to avoid the double counting of some records. Once ready, the process of adding land attribute indicators to the spatial and land attribute dataset could begin.

While some indicators could be populated directly from some datasets via spatial join, such as FSR from the SILEP_FSR and SEPP_FSR datasets, others required more work. The road network-based distance calculations, such as those carried out for the activity centre proximity indicators, required the base spatial layer to be converted from a polygon layer to a point layer and then imported into ArcGIS for use with the Network Analyst extension. The proximity to the coastline indicator required the entire NSW coastline to be digitised prior to calculating the linear distance from each lot to the coast, and transit catchment indicators for the 4 modes (heavy rail, light rail, bus rapid transit, and ferry) were created by first manually plotting station entry points for every station and mode and then generating 400 m, 800 m and 1600 m road network-based service areas (i.e. pedestrian catchments) before running spatial queries to demarcate those lots that are in and out of the catchment. The land use zoning data also had to be processed prior to being joined with the base spatial layer, as the land use categories had to be simplified owing to the updated LEP zoning categories being adopted by only some LGAs and in different years.

One of the most important and valuable steps in the hedonic modelling process was the preparation of the accessibility bands around transit stations, so a great deal of time was spent for making these as accurate as possible. An alternative to using road distance-based calculations for the derivation of pedestrian catchments is the application of Euclidean (i.e. linear) distances. However, while using linear distances to demarcate bands of accessibility may be a quicker and simpler process, they can lead to a drastic misrepresentation of the shapes and sizes of catchments as they ignore the street layout and presence of obstructions impeding direct paths like water bodies and freeways. In some cases, a 400m catchment measured by Euclidean distance may exaggerate the area of accessibility by 2 or 3 times, and this can have a drastic effect on the

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estimated coefficients of the models. The effects can become pronounced over larger distances as there are more opportunities for obstructions to straight-line travel to occur. While road network-based distances are still imperfect, as they cannot account for all potential pedestrian pathways, they are considered to be far superior to Euclidean-based approaches.

In addition to the preparation of the spatial and land attribute dataset, various subregions of Sydney were digitised to represent the extents of various transit interventions and urban renewal areas. These digitised subregions were used at the time modelling datasets were being exported in order to clip records from the metropolitan data that fell within certain boundaries of investigation. During the process of preparing the base spatial layer and the digitised subregions, the tabular valuations data were kept separate and joined only at the time of extraction when modelling datasets were being created, as the format of the modelling datasets would vary depending on the type of model being estimated. Only records with a simplified land use zoning of residential, business, mixed use, industrial or Sydney CBD were exported for analysis as land designated for environmental conservation, public recreation, infrastructure and so on cannot be expected to monetise the benefits of transit accessibility like the other land uses.

During the data preparation and modelling process, various challenges and issues became apparent. Some of these issues could be overcome, but others could not and required some adaptation. These issues are outlined below:

- **Issues with data completeness** – Some of the input datasets did not cover the entire metropolitan area and, in effect, had many gaps. For example, the SILEP_FSR and SEPP_FSR datasets did not have FSR controls for many areas of the city, even in areas where SILEP and SEPP zoning data were available. The result was that many lots across the Sydney metropolitan area initially had no FSR controls applied to them, meaning they could not be included in the estimation of any hedonic model that included FSR as a control. To remedy this, FSR controls were estimated based on heuristics derived from neighbouring areas and a tacit knowledge of the areas affected.
- **Land zoning systems change and application over the analysis period** – Prior to the standardisation of the Local Environmental Plans (LEPs) in NSW, councils would adopt their own categorisation of zoning depending on the nature of land use in their Local Government Area (LGA). The Standard Instrument for LEPs was gazetted in 2006, providing a template for LEPs and

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mandating the use of standardised definitions and zones. The standardisation process took many years to complete. At the time of writing this report, Campbelltown is the only LGA in the Sydney Metropolitan Area that has not adopted the standard instrument. The inconsistent use of zoning controls over the study period and the delay in the councils' application of the standard definitions presented a challenge in the analysis, meaning that zoning classifications had to be grouped and simplified for consistency across space and time.

- **Land valuation data availability** – The project team initially intended to undertake the analysis for the period between 1990 and 2014. Within this period, the team could undertake the hedonic price assessment for the catchments of various new transport infrastructure projects, including the Airport Link, Epping to Chatswood and Sydney Light Rail from the project announcement stage to commencement of operation. However, there were significantly fewer records available for the years prior to 2000 as the Valuer Generals Office was not obliged to prepare annual valuations for all properties within NSW. Further, the archiving system used in the 1990s had significant technical limitations, making it impossible to spatially join the annual valuations data to the current cadastre in an effective and reliable manner that would be suitable for assessment. As such, the study period was limited to the 15-year period spanning 2000 to 2014.
- **Multiple valuations for the same lot** – During the modelling process, it became evident that in a number of cases, multiple instances of the same geometry in the "property" Shapefile with unique PROPID values would be stacked on top of one another, and each would have its own unique matching valuation record. The effect of joining the spatial and valuations data as provided would be that these records would have their land values per square metre drastically underrepresented (as the values of stacked records would be additive) and yet they would be included in the analysis multiple times. Inspection of these locations identified them as government-owned, such as Central Station and the train yards, so rather than aggregating the land values and removing duplicate geometries, they were simply excluded from the sample.

A full list of the datasets used in the hedonic price modelling process is presented in Table 2 that includes a brief description of the data and their source.

Table 2 – Spatial and Hedonic Price Modelling Input Datasets

Data Set	Description	Data Source
Property Shapefile	The spatial data that the parcel-based data are joined for using the Property Identifier	NSW Government – Land and Property Information
CBD & Major Activity Centres	The following hierarchy of centres was used for the purpose of this analysis: • CBD, including Sydney CBD, North Sydney and Redfern-Newtown • Strategic and Regional Centres, including all major centres, specialised centres, regional centres and planned regional and major centres as identified under the 2005 Metropolitan Strategy (City of Cities – A Plan for Sydney's Future) • Town Centres and Standalone Shopping Centres • Lower Order Centres, including neighbourhood centres, villages and small villages	NSW Government – Department of Planning and Environment
Coastline	Digitised coastline for the NSW coast	Custom made using ABS digital boundary data
Zoning used for valuation	Land parcel land use zoning	NSW Government – Land and Property Information NSW Government – Department of Planning
Unimproved Land Value	The NSW Valuer Generals Office assessment of the unimproved land value, and forms the dependent variable in the hedonic model.	NSW Government – Land and Property Information
Strata Count	Number of strata titles on a lot, otherwise NULL if no strata.	NSW Government – Land and Property Information
Heritage Controls	State and local heritage items and heritage conservation areas as listed under the Local Environmental Plans	NSW Government – Department of Planning and Environment
Height of Building	The height of the building that is allowed to be built on the parcel of land	NSW Government – Department of Planning and Environment
Floor Space Ratio (FSR) Controls	The maximum allowable floor space ratio for the land parcel	NSW Government – Department of Planning and Environment
Strata Indicator and Strata Counts	Indicator of whether a lot is strata titled and counts of stratas	NSW Government – Land and Property Information
Parks	All land zoned RE1 Public Recreation under the Local Environmental Plans.	NSW Government – Department of Planning and Environment
Employment density	Number of employee's by travel zone	NSW Government – Department of Planning and Environment
Transportation Infrastructure	Station locations, station entry points, transit routes, major roads and freeways	NSW Government – Department of Planning and Environment, Custom made (station entry points)
School Catchments	High School catchment and Myschool Ratings	NSW Government – Department of Education MySchool – http://www.myschool.edu.au/
Socio-Economic Indexes for Areas (SEIFA), 2011	The SEIFA advantage and disadvantage index http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100042011	Australian Bureau of Statistics (ABS) – Census data
Suburbs	Suburb digital boundaries for allocating suburb names to properties	Australian Bureau of Statistics (ABS)
LGAs	LGA digital boundaries	Australian Bureau of Statistics (ABS)
Spatial Network Analysis for Multi-Modal Urban Transport Systems	The SNAMUTS accessibility score for the PT system in Sydney. http://www.snamuts.com/	RMIT/Curtin University

4.

SYDNEY METROPOLITAN-WIDE HEDONIC PRICE MODELS

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

Prior to estimating a series of hedonic price models for the selected subregions of the Sydney metropolitan area, a number of metropolitan-wide models were estimated. These models helped guide decisions on model specification and functional form and helped establish a base level of understanding of how the included land attribute control variables are impacting land values across the metropolitan area on average.

Owing to the diverse nature of the metropolitan region and the scale of its geographic extent, it can be expected that relationships between the dependent variable (i.e. log of unimproved land value per square metre) and the independent variables would be subdued, but estimating these models can produce outputs useful for deriving conservative estimates of land attribute hedonic prices for value capture modelling purposes. A metropolitan-wide model also has the benefit normalising local disturbances and generating highly significant outputs owing to its large sample size although the downside is that the model coefficients are fixed for all locations of the study area, making them less suitable for value capture assessment of targeted projects. This section discusses the results of the metropolitan-wide WTP analysis as a precursor to the subregion models.

4.1 METROPOLITAN REGION CROSS-SECTIONAL HEDONIC PRICE MODEL EQUATION

The first model estimated included records for the entire Sydney metropolitan area. As a metropolitan-wide model, many localised disturbances are normalised, generating modelling outputs that represent the average marginal effects of land attributes on land values for the entire metro region. The model can be useful for establishing baseline parameter estimates for comparison with those generated by more localised, subregional models. The equation for the Metropolitan Region hedonic price cross-sectional model for 2014 is presented below in Equation 4.

It is important to note that the model controls for land use zoning and suburb fixed effects in the equation below are summarised by the variables 'zoning' and 'suburb' for brevity.

Equation 4 – Metropolitan Region Hedonic Price Modelling Equation

$$log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) + log(distanycbd) + log(distctr2) + log(distctr3) + hrail\_0\_400 + hrail\_4\_800 + hrail\_8\_1600 + lrt\_0\_400 + lrt\_4\_800 + lrt\_8\_1600 + brt\_0\_400 + brt\_4\_800 + brt\_8\_1600 + ferry\_0\_400 + ferry\_4\_800 + ferry\_8\_1600 + main\_road\_0\_100 + main\_road\_1\_200 + log(snamuts11) + log(seifa\_per) + log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

The metropolitan-wide land value-based hedonic price model was designed to model the metropolitan-wide average effects of proximity to transit (Heavy Rail, LRT, BRT, and Ferry) in Sydney. The catchments (depicted in Figure 18) used were the network walking distance catchments from all the various transit stations, with the 400m, 800m, and 1600m catchments corresponding to 5-, 10- and 20-minute walking distances. All land parcels beyond 1600 m from transit stations were used to establish the reference case for comparison with the three designated walking catchments.

The importance of the metropolitan-wide model is that it analyses the performance of the transit modes across the whole region and reduces the impact of localised market fluctuations on the broader analysis of the WTP for access to infrastructure and different forms of accessibility across the region. In effect, the metropolitan model averages the effects of the modelled independent variables and reduces the effects of spurious local noise that could distort model results, as well as the effects of unobserved or omitted variables that cannot be controlled for by the included suburb fixed effects. The size and geographic coverage of the model also ensures considerable variation in control variable values, so parameters can be estimated more reliably and efficiently. Thus, whilst the model is more conservative than the individual project models, it provides a very robust base for analysing future projects owing to its strength (high R2 value) and scale (over 920,000 records).

4.1.1 METROPOLITAN REGION HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The Metropolitan Region hedonic price model contained 920,121 land parcels accounting for land use categories falling into the broad categories of Residential, Business, Mixed Use, Industrial and Sydney CBD. The model's input variables and dataset's descriptive statistics are presented in Table 3.

Table 3 – Metropolitan Region – Hedonic Price Model Descriptive Statistics (2014)

Continuous Variables	Average Values
Unimproved land value (ulv)	$696,097
ln_ulv	13.13
Unimproved land value per sqm (ulvpsm)	$1,220
ln_ulvpsm	6.76
Land area (m^2)	793.9
Floor Space Ratio (fsr)	0.65
Distance to any CBD	21.74
Distance to Activity Centre Level 1	21.85
Distance to Activity Centre Level 2	5.06
Distance to Activity Centre Level 3	3.6
Distance to Activity Centre Level 4	1.06
Distance to Coast	8.92
SNAMUTS (2011)	6.71
Effective Job Density	165,509
SEIFA Score	60.19
High School Catchment Myschool Rating	95.11
Dummy Variables	**% of Metro Region within the Catchment**
Heavy Rail 0–400 m	4%
Heavy Rail 400–800 m	11%
Heavy Rail 800–1600 m	23%
LRT 0–400 m	1%
LRT 400–800 m	1%
LRT 800–1600 m	2%
BRT 0–400 m	1%
BRT 400–800 m	2%
BRT 800–1600 m	5%
Ferry 0–400 m	< 1%
Ferry 400–800 m	1%
Ferry 800–1600 m	2%
Main Road 0–100 m	19%
Main Road 0–200 m	34%

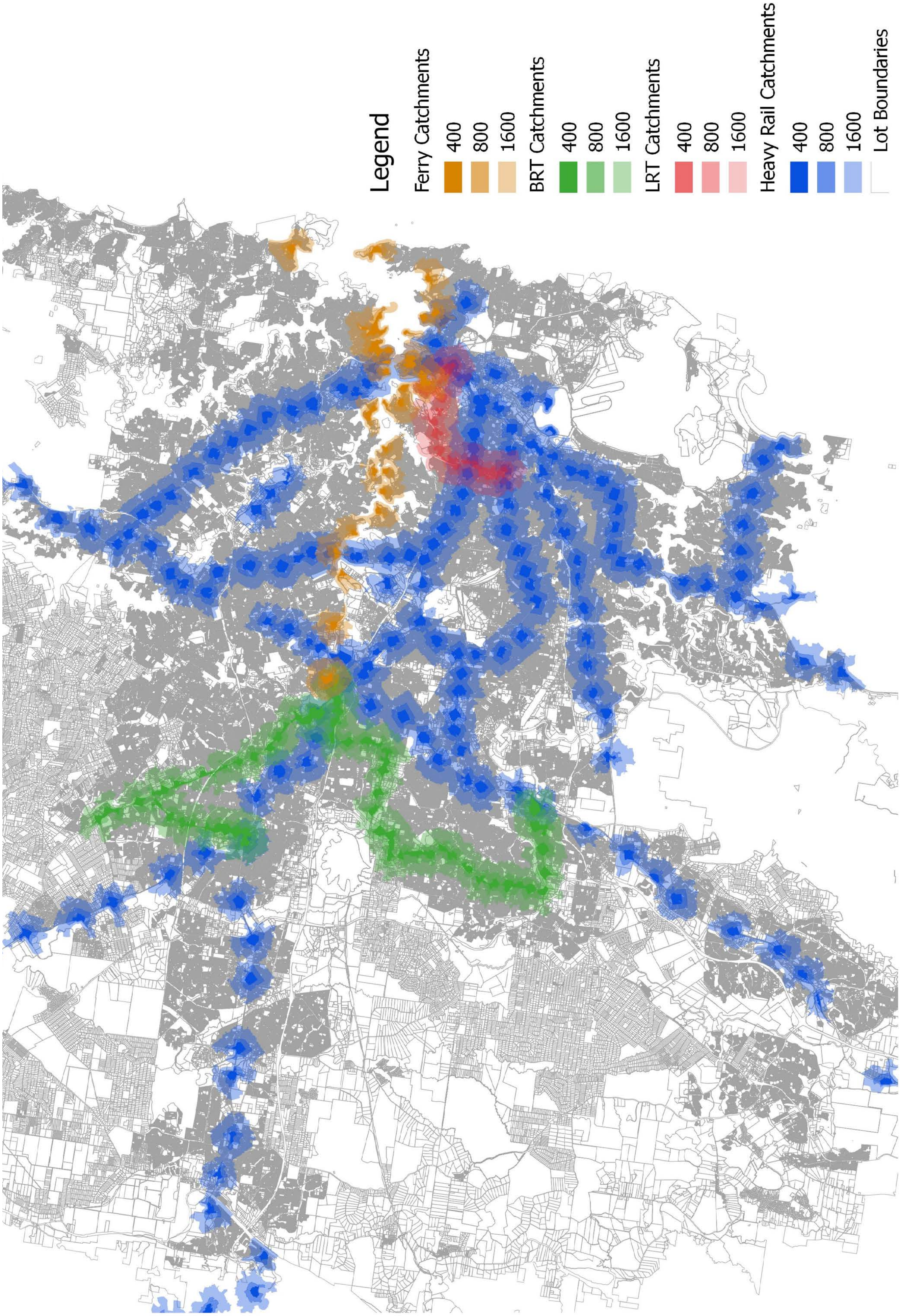

Figure 18 – Metropolitan Sydney Transit Catchment Map

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

4.1.2 METROPOLITAN REGION CROSS-SECTIONAL 2014 HEDONIC PRICE MODEL RESULTS

The results of the 2014 Metropolitan Region Hedonic Price Model focus on the non-transit accessibility based indicators as they are addressed in the panel data analysis (2000–2014) where the focus is on accessibility change.

Improving the accessibility of transport-constrained land can enable a change of zoning to occur and an increase in the FSR for land markets to be developed to their highest and best use. Thus, the value of investing in transit infrastructure is not only derived from the infrastructure itself but also derived from the urban renewal opportunities it creates as well. The key explanatory variables that guide the calculation of the potential land value impacts from the cross-sectional analysis include:

- the rezoning of land parcels within the land markets surrounding a station to capitalise on the increase in land market development capability to ensure land is utilised for its highest and best use and
- the potential future FSR values in the land markets surrounding a station to capitalise on the increase in land market development capacity unlocked by the investment in transit.

Table 4 shows the results for the non-transit related explanatory variables. The hedonic prices for each of the land use zonings when compared to the Residential zone are of particular interest as they show very

Table 4 – Metropolitan Region, 2014 Cross-Sectional Hedonic Price Modelling results for Non-Transit Catchment Explanatory Variables

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heritage	3.8%	0.001 (***)	log(Area)	-0.323	0.001 (***)
Strata	23.0%	0.001 (***)	log(FSR)	0.239	0.001 (***)
Zoning B – Business (+)	-3.8%	0.002 (***)	log(Dist. to coast)	-0.075	0.001 (***)
Zoning C – Sydney CBD (+)	27.2%	0.034 (***)	log(Dist. to any CBD)	-0.050	0.003 (***)
Zoning I – Industrial (+)	-38.9%	0.004 (***)	log(Dist. to 2nd tier centre)	-0.027	0.001 (***)
Zoning M – Mixed Use (+)	11.8%	0.003 (***)	log(Dist. to 3rd tier centre)	-0.016	0.001 (***)
Main Road 0 m–100 m	-7.6%	0.001 (***)	log(SNAMUTS11)	0.0003	0.0001 (***)
Main Road 100 m–200 m	-0.1%	0.001 (***)	log(SEIFA index)	0.031	0.001 (***)
			log(MySchool rating)	-0.002	0.0001 (***)

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.912 with 920,549 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

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significant differences in land value associated with land use in the metropolitan region with the Sydney CBD zone being the most in demand, followed by the Mixed Use, Residential and Business zones with Industrial land being valued the least.

The demand for these zones is not surprising, as Sydney has had a significant amount of urban growth in recent years, with these zones reflecting the leading drivers for employment in the CBD as well as inner urban regeneration-based zones. The reduced demand for non-CBD based business zoned land when compared to the Residential zoning is not surprising given the strength of the CBD zone.

The Industrial zoned land is significantly less valued than the other zones, and the reasons behind this could potentially be that as Sydney transitions even further to a services-based economy and away from its manufacturing based past, the demand for industrial zoned land is reducing when compared to that for the other land uses. This also provides evidence of agglomeration economies, mainly as service-orientated industries experience greater productivity benefits from urban density and accessibility than industrial activities, they will be more willing to endure higher rents and hence bid up the value of land. Also, as the city continues to grow, the value placed on residential land can be expected to increase, especially in locations closer to the city. The metropolitan demand for urban density is reflected in the strong FSR elasticity, and this is discussed later.

In terms of road-based based transport coefficients produced by the metropolitan-wide model, the land parcels in close proximity to main roads have a 7.6% disadvantage when compared to the other land markets owing to road-based noise and other emissions, though it is noticeable that this disadvantage is reduced over a very short distance. This result is not unexpected as noise impacts land markets on an exponential scale, and as such, the traffic noise impacts dissipate over short distances in an urban built environment. The magnitude of these impacts will not be applicable to all roads in all areas and local coefficients will need to be developed to capture the local context of the impact of roads on the surrounding land catchments.

The distance away from the coastline has a negative impact on the metropolitan region's land markets and is two to three times more important to the value of land than the distance to activity centres. The value placed on proximity to activity centres, however, cascades as expected with proximity to the CBD being valued the most, followed by second- and third-tier centres.

The Australian Bureau of Statistics Index of Relative Socio-Economic Advantage and Disadvantage (ISRAD)[13] elasticity has a relatively strong and significant impact on the land value of the catchments analysed, reflecting the impact of the city's social sectors and the potential impact of gentrification on land value. The index also acts as a spatial lag in the model as land values will be determined not only by the attributes of the parcel itself but also by the land values of neighbouring properties

13 The SEIFA advantage and disadvantage index – http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100042011

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that in aggregate can dictate the attractiveness of a neighbourhood, and a strong correlation between socio-economic standing and land values can be expected.

In addition to the discrete attributes presented in Table 4, the hedonic price of being within one of the 523 individual suburbs within the Metropolitan Sydney model was analysed to determine the premium for being located in an individual suburb. Figure 19 illustrates the hedonic price for each of the suburbs compared to the Sydney CBD, so the results can be interpreted as an approximation of the percentage difference relative to the Sydney CBD, keeping all other variables in the model constant (e.g. 0.98 equates to 98%).

The suburb values presented in Figure 14 can be interpreted as responding to local variances that are not captured by any of the other metrics, such as those pertaining to zoning and transit accessibility. However, it is clear that the broad trend is that as the distance from the CBD and the river or ocean increases, the hedonic price for the suburbs decreases. This trend is not uniform and some suburbs have higher or lower hedonic prices depending on historical factors and uncontrolled local attributes in addition to those presented in Table 4.

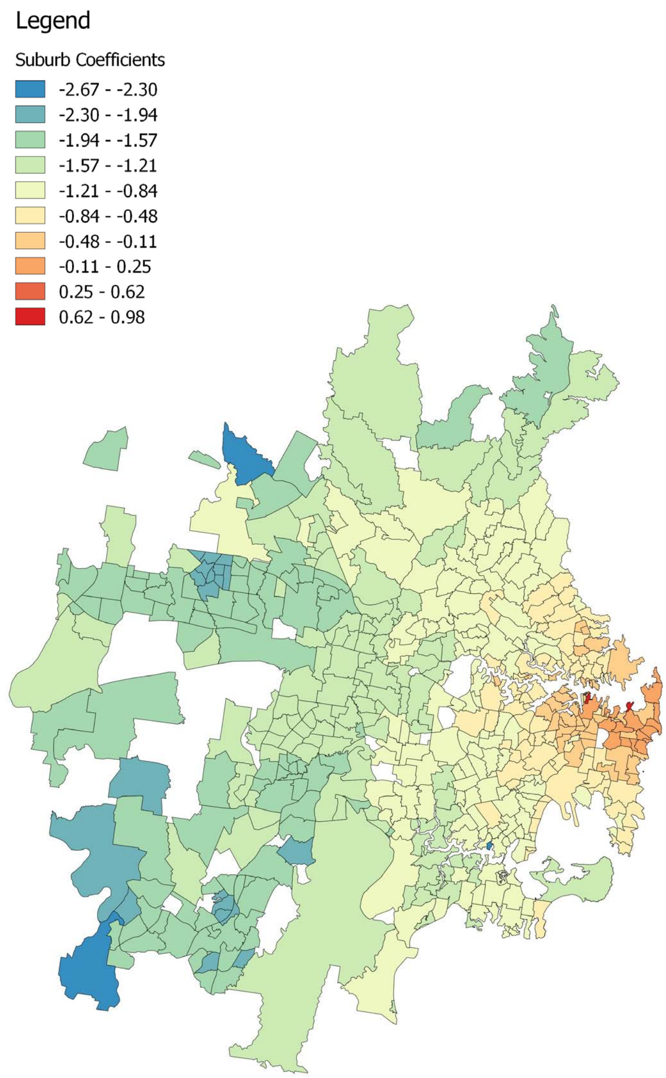

Figure 19 – Hedonic Price for Each of the Suburbs within the Metropolitan Model (compared to the Suburb of Sydney)

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

4.2 METROPOLITAN REGION PANEL DATA HEDONIC PRICE MODELLING ANALYSIS (2000–2014)

This section presents a temporal analysis of the Sydney metropolitan land markets, looking at how the hedonic prices of the 4 transit modes and other key parameters in the model performed between the years 2000 and 2014. Originally, the intention was to run the Sydney metropolitan region model as a panel data model, but owing to the size of the datasets with nearly a million records per year, it was not possible to run a model with all 15 years of data combined. To get around this problem, the model was run as individual cross-sectional models for every year from 2000 to 2014. As such, the equation presented below in Equation 5 is the same as the one presented above in Equation 4 for the Sydney metropolitan cross-sectional model.

Equation 5 – Metropolitan Region Hedonic Price Modelling Equation

$$\log(ulvpsm) \sim \log(area) + \log(fsr) + \log(distcoast) + \log(distanycbd) + \log(distctr2) + \log(distctr3) + hrail\_0\_400 + hrail\_4\_800 + hrail\_8\_1600 + lrt\_0\_400 + lrt\_4\_800 + lrt\_8\_1600 + brt\_0\_400 + brt\_4\_800 + brt\_8\_1600 + ferry\_0\_400 + ferry\_4\_800 + ferry\_8\_1600 + main\_road\_0\_100 + main\_road\_1\_200 + \log(snamuts11) + \log(seifa\_per) + \log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

4.2.1 METROPOLITAN REGION HEDONIC PRICE MODELLING ANALYSIS (2000–2014) RESULTS

As with the metropolitan cross-sectional model for 2014, the results for these individual year models spanning the years 2000 to 2014 tend to be more muted than those of the subregional models presented in subsequent chapters.

The change in each of the hedonic prices and their impact on the unimproved land value per square metre provide an extraordinary view of not only how the transit catchments performed over time but also of how the importance of the different land use zones varied over time and how the importance of floor space ratio has continued to climb since the early 2000s. The annual results analysed in the hedonic price model are presented in Table 5. A temporal analysis of each of the metrics is illustrated and discussed individually to draw out the importance of each metric over the analysis period. The subsequent sections of this chapter break down the metropolitan-wide temporal model and discuss its components in greater detail.

Table 5 – Metropolitan Region Hedonic Price Model Results for the Years 2000–2014

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Heavy Rail 0–400 m	4.1%	3.6%	3.6%	3.3%	4.0%	4.9%	4.6%	5.0%	5.4%	5.4%	5.3%	5.5%	5.5%	5.5%	4.5%
Heavy Rail 400–800 m	1.0%	1.0%	0.8%	0.9%	1.4%	2.0%	1.7%	1.7%	2.1%	2.0%	1.8%	1.9%	1.7%	1.6%	1.3%
Heavy Rail 800–1600 m	-0.2%	-0.3%	-0.3%	-0.3%	0.0%	0.5%	0.2%	0.2%	0.2%	0.0%	0.0%	0.2%	0.2%	0.3%	0.3%
LRT 0–400 m	-5.3%	-3.7%	-2.6%	-2.2%	-2.3%	-3.4%	-3.7%	-2.9%	-4.3%	-3.5%	-3.1%	-3.5%	-2.5%	-2.0%	-0.6%
LRT 400–800 m	-1.5%	-1.1%	-0.5%	-0.3%	-0.1%	-1.2%	-2.0%	-0.9%	-3.0%	-1.9%	-1.7%	-2.3%	-1.8%	-1.1%	-0.3%
LRT 800–1600 m	-2.3%	-2.0%	-1.7%	-1.0%	-0.6%	-2.0%	-2.9%	-1.5%	-2.1%	-1.3%	-1.2%	-1.8%	-1.5%	-1.3%	-0.8%
BRT 0–400 m	3.2%	2.5%	2.5%	2.6%	0.8%	0.1%	1.8%	1.3%	3.1%	2.5%	1.9%	2.3%	2.3%	2.8%	3.0%
BRT 400–800 m	1.5%	1.3%	1.6%	2.0%	0.5%	-0.2%	0.6%	-0.1%	1.2%	1.1%	0.6%	1.0%	1.2%	1.3%	1.2%
BRT 800–1600 m	-0.3%	-0.3%	-0.4%	0.0%	-1.1%	-1.7%	-1.5%	-1.7%	-1.0%	-1.0%	-1.3%	-1.1%	-0.7%	-0.2%	-0.2%
Ferry 0–400 m	12.6%	12.2%	11.7%	10.2%	11.4%	11.6%	10.1%	6.6%	6.2%	5.2%	5.3%	5.3%	6.9%	7.5%	8.0%
Ferry 400–800 m	3.0%	2.7%	2.8%	2.0%	4.3%	4.5%	1.8%	-0.5%	-0.8%	-1.2%	-0.4%	0.3%	2.0%	1.7%	2.1%
Ferry 800–1600 m	-2.8%	-3.3%	-3.6%	-4.2%	-2.4%	-1.1%	-2.4%	-3.8%	-4.0%	-3.9%	-3.4%	-3.3%	-2.6%	-2.8%	-2.1%
Main Road 0–100 m	-9.0%	-9.1%	-8.9%	-8.8%	-8.5%	-8.7%	-8.3%	-8.2%	-8.2%	-8.0%	-8.0%	-8.1%	-8.0%	-7.9%	-7.6%
Main Road 100–200 m	-0.9%	-0.9%	-0.8%	-0.9%	-0.6%	-0.8%	-0.7%	-0.6%	-0.7%	-0.7%	-0.5%	-0.6%	-0.5%	-0.5%	-0.6%
log(area)	-0.339	-0.332	-0.338	-0.342	-0.344	-0.344	-0.341	-0.335	-0.333	-0.331	-0.335	-0.334	-0.334	-0.328	-0.323
log(fsr)	0.179	0.178	0.166	0.159	0.153	0.159	0.164	0.167	0.167	0.174	0.175	0.185	0.197	0.228	0.239
log(distcoast + 0.001)	-0.075	-0.076	-0.075	-0.077	-0.085	-0.095	-0.102	-0.106	-0.109	-0.108	-0.101	-0.097	-0.093	-0.085	-0.075
log(distanycbd + 0.001)	0.005	-0.012	-0.023	-0.026	-0.030	-0.012	-0.010	0.005	-0.001	-0.005	-0.005	0.003	-0.006	-0.039	-0.050
log(distctr2 + 0.001)	-0.020	-0.020	-0.018	-0.019	-0.010	-0.004	-0.004	-0.017	-0.017	-0.019	-0.027	-0.030	-0.025	-0.020	-0.027
log(distctr3 + 0.001)	-0.010	-0.012	-0.011	-0.011	-0.007	-0.014	-0.015	-0.013	-0.011	-0.007	-0.008	-0.008	-0.011	-0.015	-0.016
log(snamuts11 + 0.001)	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000
log(seifa_per + 0.001)	0.039	0.038	0.041	0.040	0.041	0.039	0.037	0.038	0.040	0.040	0.040	0.041	0.040	0.036	0.031
log(schl_per + 0.001)	-0.002	-0.002	-0.002	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.002
Heritage	0.070	0.051	0.043	0.046	0.050	0.052	0.051	0.050	0.052	0.049	0.053	0.052	0.051	0.045	0.038
Strata	0.321	0.321	0.303	0.300	0.296	0.278	0.282	0.276	0.267	0.266	0.242	0.235	0.240	0.236	0.230
Zoning B – Business (+)	6.8%	5.6%	5.8%	6.7%	8.1%	17.0%	23.4%	26.1%	27.4%	25.3%	19.6%	16.1%	13.1%	3.3%	-3.8%
Zoning C – Sydney CBD (+)	0.2%	-1.8%	-2.1%	-7.3%	-7.7%	9.0%	9.4%	6.6%	19.8%	12.8%	11.0%	18.2%	22.6%	17.3%	27.2%
Zoning I – Industrial (+)	-16.3%	-17.8%	-23.8%	-20.7%	-20.1%	-10.0%	-2.8%	0.0%	3.0%	-1.4%	-9.2%	-14.2%	-15.7%	-25.1%	-38.9%
Zoning M – Mixed Use (+)	3.4%	4.6%	2.1%	3.3%	1.0%	2.7%	4.1%	6.2%	7.0%	5.6%	8.6%	8.2%	10.6%	11.4%	11.8%
Model Adjusted R-Squared	89.6%	89.8%	89.9%	89.7%	89.1%	90.1%	90.4%	91.1%	91.8%	91.8%	92.2%	92.1%	91.8%	91.4%	91.2%

Note: (+) Compared to the Residential zoning

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

4.2.1.1 THE SYDNEY HEAVY RAIL CATCHMENT HEDONIC PRICE, 2000–2014

Sydney's passenger rail network is generally oriented towards the CBD with four main lines radiating from the CBD:

- West (Western Line from Central to Strathfield, Blacktown, Penrith, Blue Mountains and Western NSW)
- North (Main North Line from Strathfield to Hornsby through to northern NSW)
- Southwest (Main South Line from Lidcombe through Regents Park and Cabramatta to southern NSW)
- South (Illawarra Line from Redfern to Sutherland, Wollongong and the South Coast).

Additional passenger lines branch from these four lines, forming a network of integrated lines as shown in Figure 20.

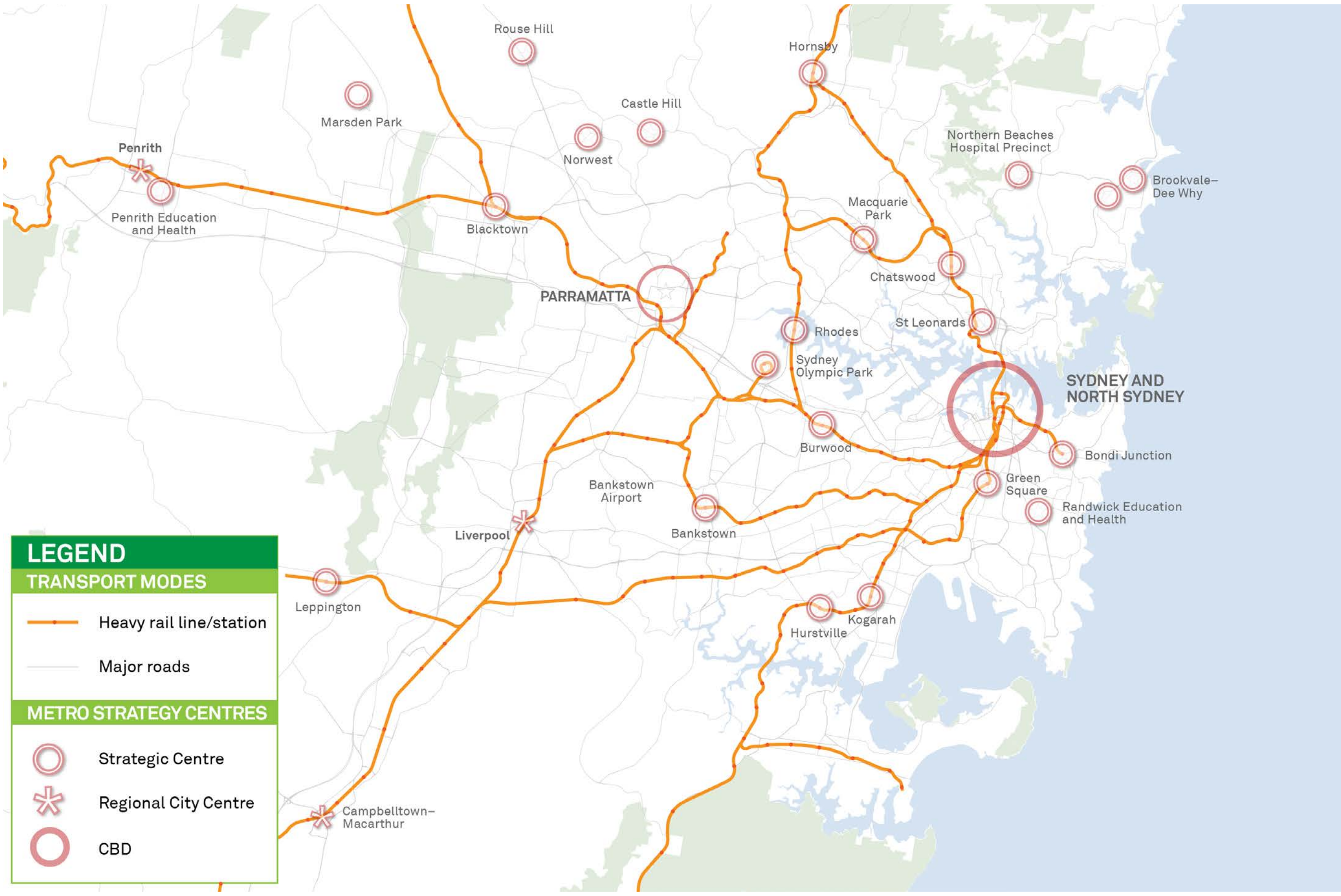

Figure 20 – Sydney's Heavy Rail Network (LUTI Consulting, Mecone Planning)

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

The Sydney to Parramatta rail line commenced operation for the first time in 1855, with the rest of the network developed over the course of the 19th and 20th centuries. During the analysis period (2000–2014), the only new rail link developed was the Epping to Chatswood link through Macquarie Park, which commenced operation on 23rd February 2009. The South West Rail Link connecting Glenfield to Leppington in Sydney's southwest was proposed in 2005. The construction of the rail line commenced in 2009 with commencement of operations in 2015.

The spatial distribution of the Sydney rail network with respect to the other modes of transit is presented in the Metropolitan Sydney Transit Catchment Map above in Figure 18.

Figure 21 illustrates that the Sydney heavy rail catchment hedonic price has stayed relatively constant over the analysis period with the 400m catchment 3–4% higher than the 800m catchment, and the 800m catchment valued only slightly higher than the 1600m catchment. The benefit of being close to transit

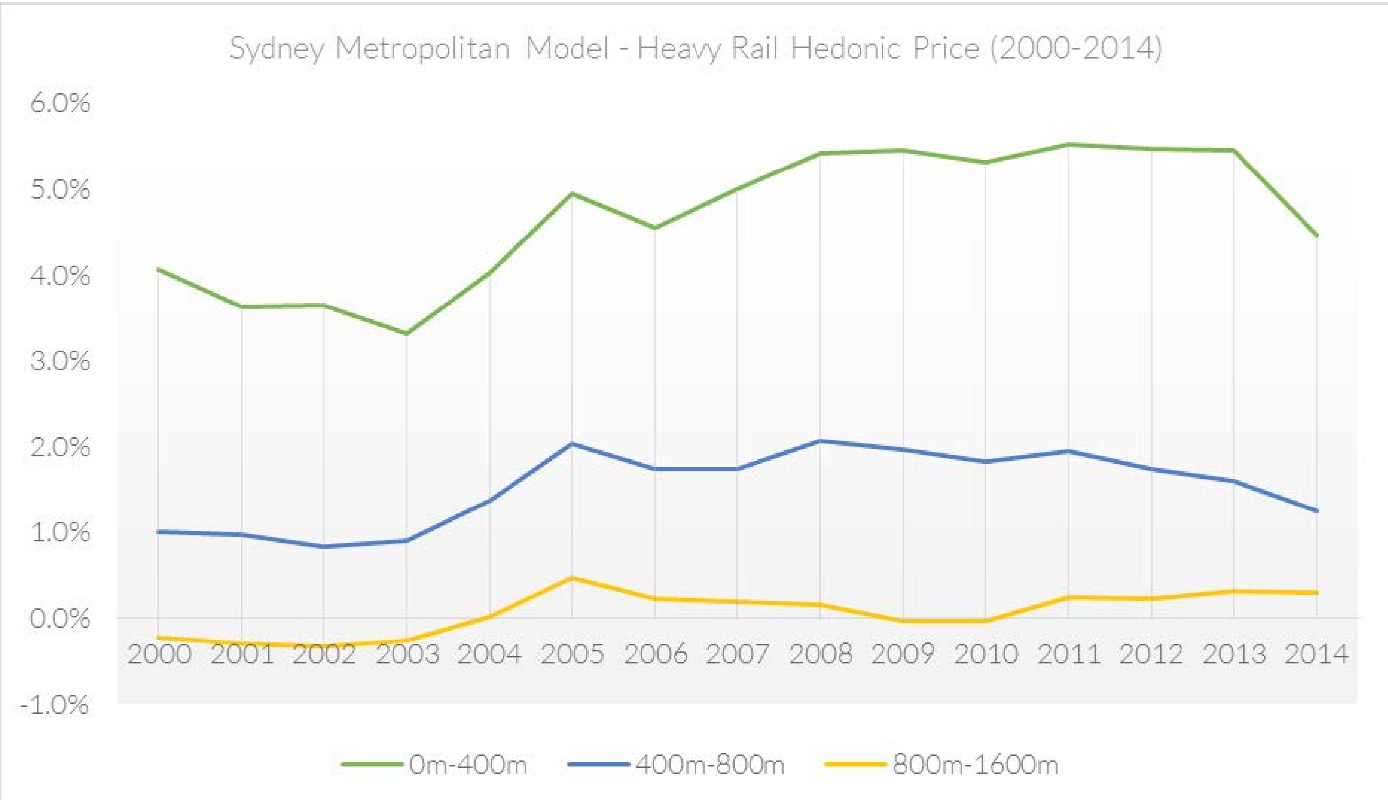

Figure 21 – Metropolitan Region Panel Data Hedonic Price Model Results for Heavy Rail Catchments (2000–2014)

illustrates that, on average, land markets within 400 m of a heavy rail station experience a premium of approximately 4.5% when compared to all land parcels farther than 1600m from a heavy rail station.

As stated previously, the level of the hedonic price benefit of being within the heavy rail catchments over the assessment period is relatively muted for all land uses and socio-economic regions in the metropolitan-wide model.

The land markets surrounding the majority of Sydney's heavy rail stations are well established and yet to undergo integrated land use and transportation planning to ensure that the most appropriate land uses are located next to each of the stations. As such, there are areas of the city that have more recently undergone integrated planning and are being undervalued in the model owing to the significant number of stations that have existing and potentially non-supporting land uses and, in some cases, even conflicting land uses (e.g. Industrial and Commercial zonings with poor urban amenity) such as in the case of the Epping to Chatswood rail line.

The hedonic modelling of the Epping to Chatswood rail line is analysed in full detail in subsequent sections of this report. Whilst the metropolitan model may be conservative, it is also a very strong model and can be viewed as a baseline indicating transit-induced value creation from infrastructure investment in Sydney.

4.2.1.2 THE SYDNEY FERRY CATCHMENT HEDONIC PRICE, 2000–2014

The Sydney ferry system can trace its roots back to as far as the arrival of the first fleet at Sydney Cove in 1789, when the first service between the harbour and Parramatta. Sydney ferries now has seven services around the harbour and up the Parramatta River. Figure 22 illustrates the current extent of the Sydney Ferry network.

Over the analysis period, the premium for being within the 400m Sydney Ferry catchments seems to have become reduced with respect to the other land markets in Sydney. This reduction in value illustrated in Figure 23 over the analysis period could be related to the changing nature of ferry operations or the ferries' generalised cost of travel compared to other modes, such as the heavy and light rail line services competing for trips in those catchments.

As with the other transportation modes, the hedonic price of the Sydney ferries catchments presented in Figure 23 is conservative when compared to the individual subregion analyses conducted in subsequent sections of this report. Whilst the metropolitan model may be conservative, it is also a very strong model and can be viewed as a baseline for transit induced value creation from infrastructure investment in Sydney. The Sydney ferries are a unique transit mode in a Sydney (and a national) context in that they tend to serve some of the most affluent areas of Sydney and, generally, have competing rail or bus services that have more services and shorter travel times. The change in use of ferries from previously considered a commuting mode to more of a leisure mode would also impact the WTP for access to ferry wharves over coastal areas without access to ferries. The premium may have reduced over time because they service more established areas that have not had the growth or renewal of other locations.

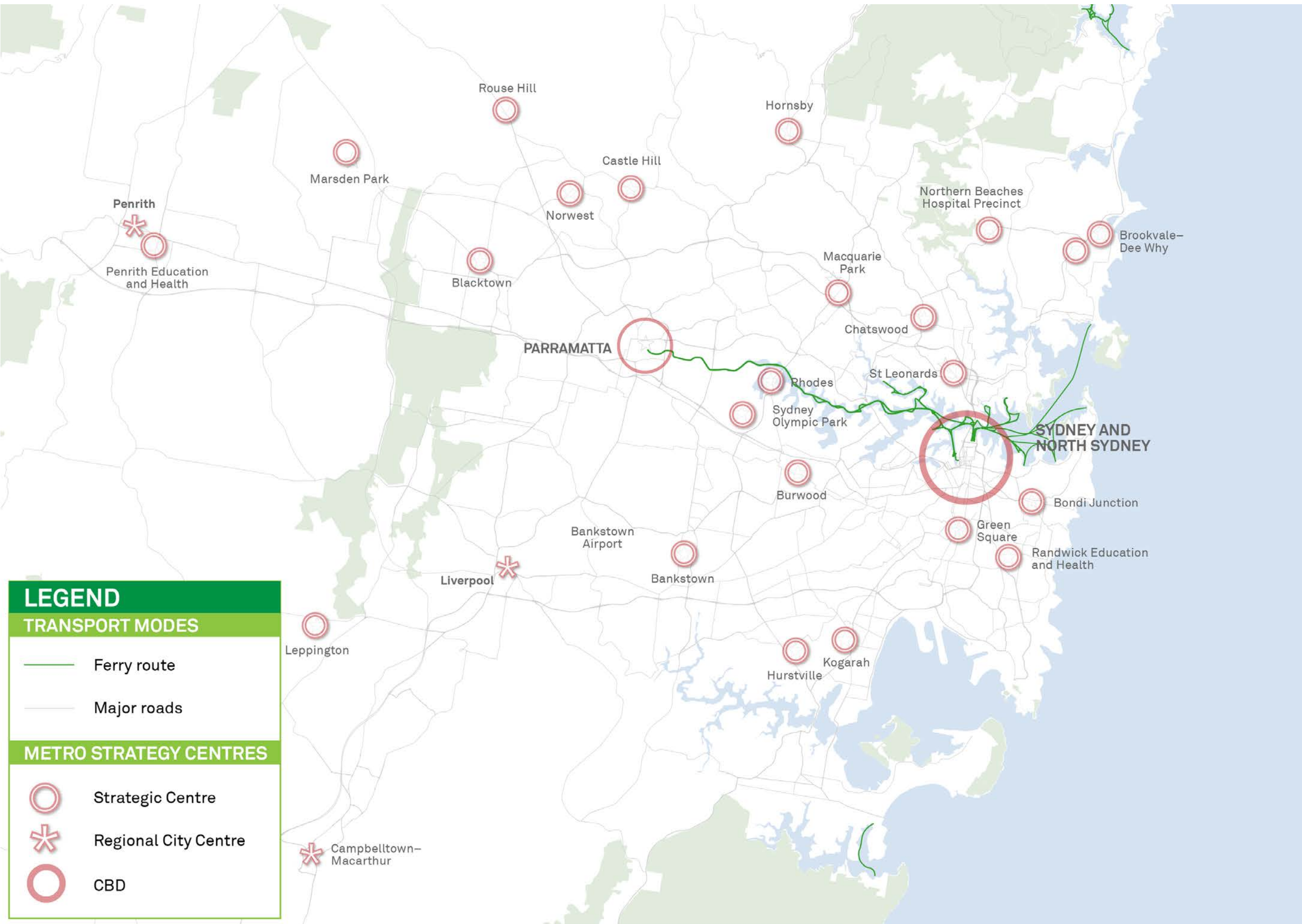

Figure 22 – Sydney's Ferry Network (LUTI Consulting, Mecone Planning)

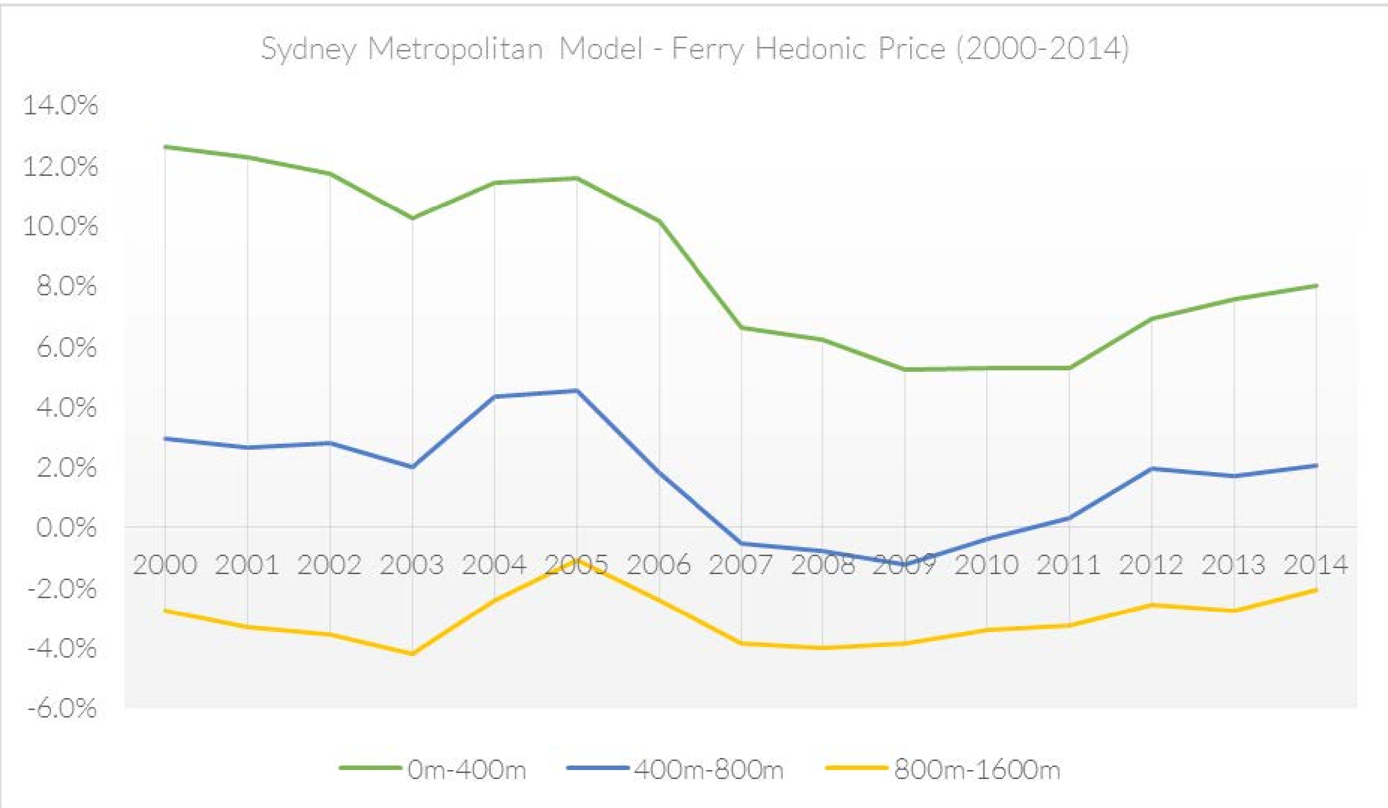

Figure 23 – Metropolitan Region Panel Data Hedonic Price Model Results for the Sydney Ferry Catchments (2000–2014)

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

4.2.1.3 THE SYDNEY MAIN ROADS CATCHMENT HEDONIC PRICE, 2000–2014

The proximity to transit infrastructure is well known to carry a value premium in Sydney, mainly on those living within the five- and ten-minute walking catchments of the stations who have access to the services. This accessibility benefit is recognised by those who live there and want to move to the area to take advantage of increased accessibility and reduced travel costs.

The same cannot generally be said for proximity to roads. The provision of road-based infrastructure is seen as a right in Australian cities, and as such, it is generally not perceived as having a value premium for proximity to it. In addition to this, the nature of car-based travel is that having the benefit of access to major road infrastructure that is dispersed over much larger distances (where the ten-minute driving catchment would be over five kilometres) is such that the road-based accessibility benefit, if it were to be perceived, would be virtually undetectable. With that said, as the focus of this study is on transit infrastructure, it is possible that restructuring the study to look specifically at road projects may produce some different results.

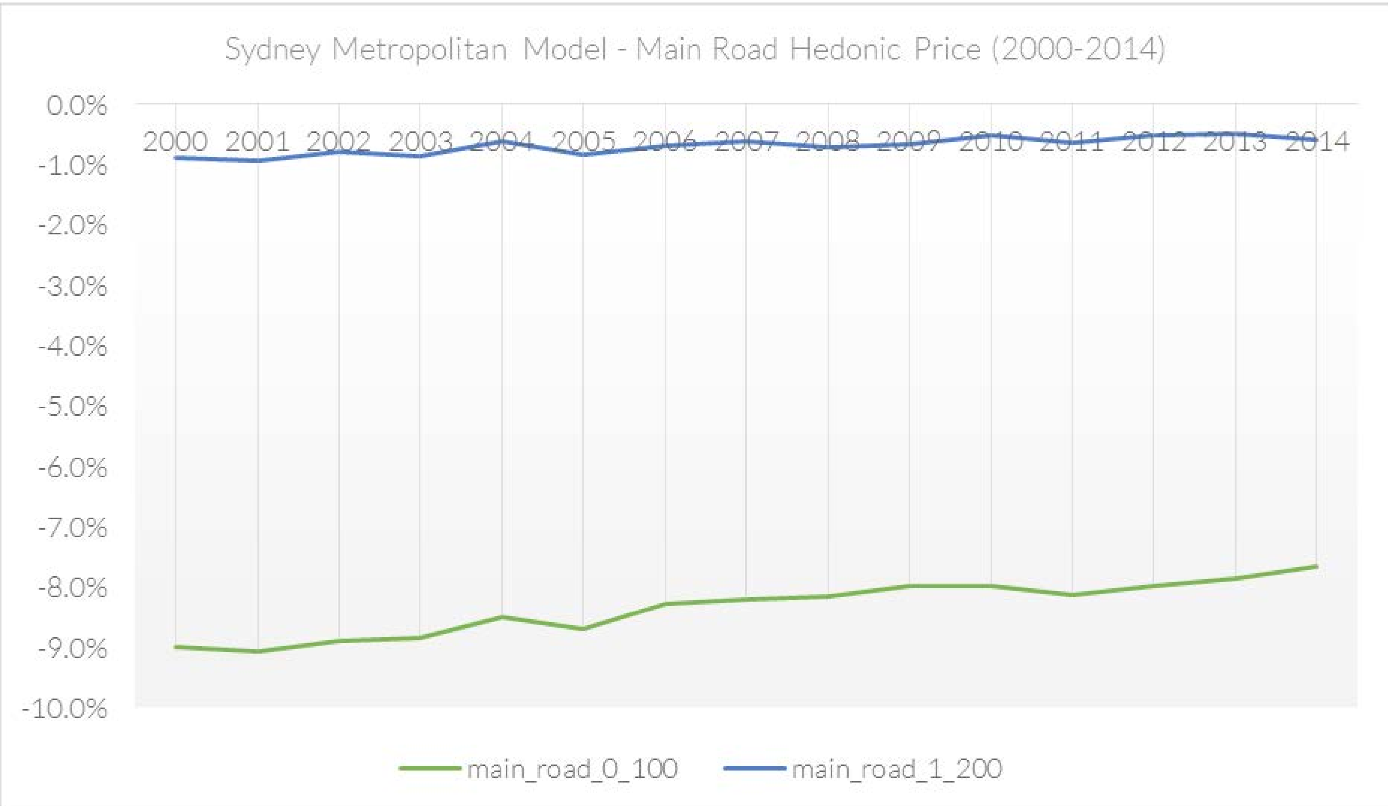

Figure 24 – Metropolitan Region Panel Data Hedonic Price Model Results for Sydney Main Roads Catchment Hedonic Price (2000–2014)

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

The negative externalities of being near a busy road are monetised into land and property values. Figure 24 illustrates that the land parcels within 100-m of a main road in Metropolitan Sydney have had a negative value of between -10% and -8% over the analysis period. As noise attenuates over a relatively short distance, the disadvantage of being in the 100-m to 200-m catchment is significantly reduced when compared to the 0-m to 100-m catchment.

The minor reduction in the negative value for proximity to a main road could be attributed to the intensive levels of urban regeneration in the inner urban areas occurring in Sydney over this period, thus bringing more properties within proximity to the main roads and also reducing the relative disadvantage of proximity to the externalities such as noise.

This reduction in the disadvantage of proximity to the main roads may also reflect greater levels of apartment-based living and improved soundproofing in apartments in these catchments, and limited outdoor space that could be impacted by the externalities of proximity to the main roads.

4.2.1.4 THE SYDNEY METROPOLITAN DISTANCE TO CBD, SECONDARY CENTRES AND COAST HEDONIC PRICE (2000–2014)

The access to transportation infrastructure is just part of what drives the value of land within cities. The distance to the CBD as well as the distance to secondary centres can be key contributing factors to the value of land, with respect to proximity to employment, shopping, and other amenities.

Figure 25 illustrates that increasing the distance to secondary centres has had a stable and negative impact on land values. Figure 25 shows that 1% change in the distance factor will lead to the distance attribute multiplied by land value. For example, an increase in the distance from the coast of 1% will lead to a reduction in land value by 0.08%.

The distance to the CBD was for a long period seen as a fluctuating. This was probably due to Sydney being the 'City of Cities' where secondary centres play an important role in metropolitan employment and other activities. However, this trend changed in 2010/11 where a negative trend showed the increasing importance of the CBD in determining land values. This time has also been a period of increasing urban renewal and regeneration within the areas close to the CBD, and this has been increasing the importance of the CBD as the economic centre of Sydney. Also, as congestion levels increase, it takes longer to travel a given length of road, and this may be another reason for an increasing negative relationship between land values and distance to the CBD in recent years.

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

As with all Australian cities, access to the coast is highly valued, and Figure 25 illustrates the long-term importance of the coast, with distance away from the coast being one of the most important negative drivers for land markets, and this reinforces the suburb hedonic model results presented in Figure 19.

4.2.1.5 THE SYDNEY LAND PLANNING ZONES HEDONIC PRICE, 2000–2014

The zoning of Sydney's land markets is controlled by Local Government (Councils) and the NSW Department of Planning and Environment. Whilst there have been many changes to the zones applied in Sydney over the analysis period, the core overarching planning zones have been present throughout the assessment period.

As mentioned earlier in this report, inconsistencies in the land use zoning among the various council areas was an important limitation of this study and imposed challenges in interpreting the data. In order to achieve consistent zoning classifications suitable for the analysis, all zoning information at the time of property valuation was aggregated under the following core planning zone groups:

- **Residential:** Including low, medium, and high density

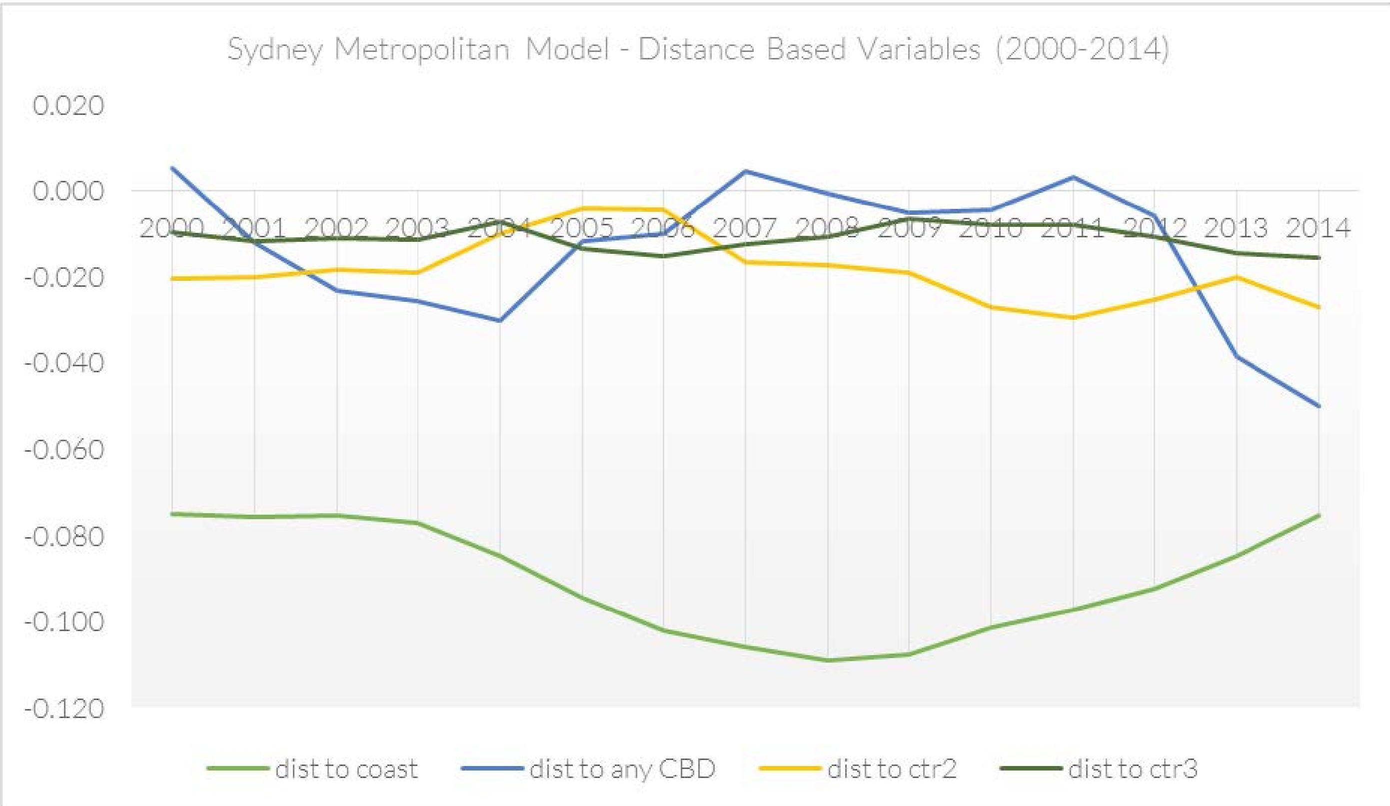

Figure 25 – Metropolitan Region Panel Data Hedonic Price Model Results for Distance to Coast & Centres Elasticities

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

- **Business:** Including all land zoned B1 Neighbourhood Centre, B2 Local Centre, B3 Commercial Core, B5 Business Development, B6 Enterprise Corridor, B7 Business Park as well as land zoned B-Business under the old LEPs.
- **Industrial:** Including all lane zoned IN1 General Industrial, IN2 Light Industrial, IN3 Heavy Industrial, IN4 Working Waterfront as well as land zoned I – Industrial and E – Employment under the old LEPs
- **Mixed Use:** Including all land zoned B4 Mixed Use as well as land zoned M – Mixed Residential Business or Mixed Use Development under the old LEPs
- **Sydney CBD:** Including all land zoned B8 Metropolitan Centre as well as land zoned C – Sydney Commercial/Business under the old Sydney LEP

Figure 26 illustrates how each of the core planning zones changed in terms of their impact on land value when compared to the Residential zone. Notably, the Mixed Use and Sydney CBD zonings have increased slightly over time relative to Residential while the Industrial and Business zonings have dropped relative to Residential in recent years.

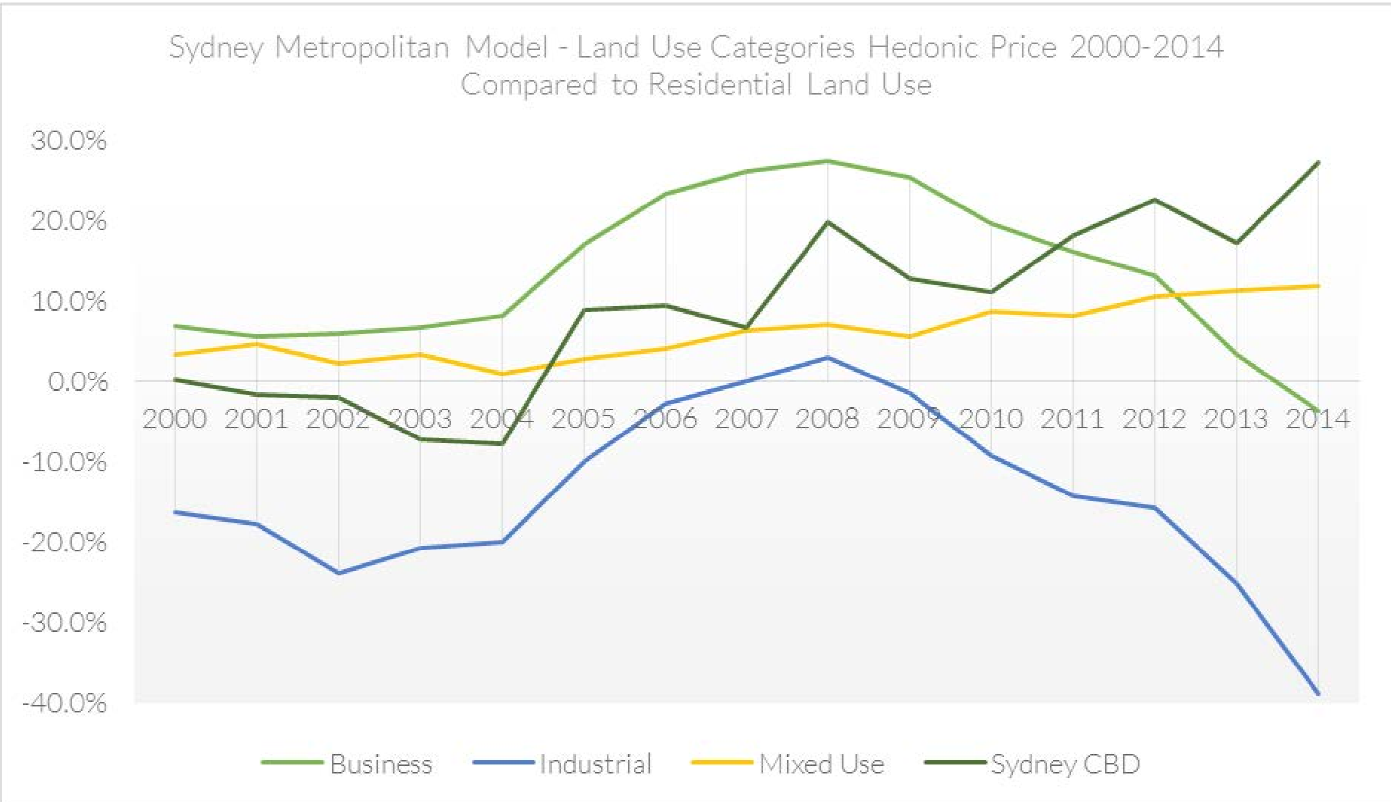

Figure 26 – Metropolitan Region Panel Data Hedonic Price Model Results for Sydney Core Land Use Zones (2000–2014) (Compared to Residential)

4.2.2 METROPOLITAN REGION VALUE CREATION VALUES

This section demonstrates how these modelling outputs can be interpreted and applied to estimate the land value impacts of building a new transit station, rezoning land, and increasing the development capacity of land by raising FSR. For the purposes of the metropolitan-wide analysis, the transit accessibility benefit is taken from the 2014 cross-sectional model.

4.2.2.1 APPROXIMATION OF THE ACCESSIBILITY VALUE CREATED BY PROXIMITY TO A TRANSIT STATION IN SURROUNDING LAND MARKETS

The accessibility based value created by the presence of the heavy rail transit stations in their surrounding land market catchments can be interpreted in accordance with Equation 6.

Equation 6 – Interpretation of the Accessibility-based Land Value Impact on the Sydney Greater Metropolitan Area

Accessibility Based Land Value Uplift (%) = Exp(0–400m Catchment Hedonic Price) – 1

As an example to illustrate the application of Equation 6, the average uplift across the Sydney Metropolitan Area associated with being within 400 m of a heavy rail station is calculated as illustrated in Equation 7.

Equation 7 – Approximation of the Station Catchment Accessibility Value Uplift

Accessibility Based Land Value Uplift (%) = Exp(0.045) – 1 = 4.6% Uplift in land value

4.2.2.2 APPROXIMATION OF THE VALUE CREATED BY A CHANGE OF ZONING IN THE LAND MARKETS SURROUNDING A TRANSIT STATION TO THEIR HIGHEST AND BEST USE

The value created by changing the zoning of land to raise the land markets that surround transit stations to their highest and best use can be interpreted in accordance with Equation 8.

Equation 8 – Interpretation of the Zoning Change-based Land Value Impact on the Sydney Greater Metropolitan Area

Change of Zoning Based Land Value Uplift (%) = Exp(Proposed land market zoning hedonic price) – Exp(Current land market zoning hedonic price)

To illustrate the application of Equation 8, let's assume a new heavy rail line was proposed for the North Shore of the harbour. Assuming the current land use is 'Industrial' and to capitalise on the investment in transit the land was rezoned to 'Mixed Use', the approximation of the change of zoning based value in the station catchment is presented in Equation 9.

Equation 9 – Approximation of the Zoning Change-based Value Uplift for a Metropolitan Station Catchment

Change of Zoning Based Land Value Uplift (%) = Exp(0.118) – Exp(-0.389) = 44.8% Uplift in land value

4.2.3 APPROXIMATION OF THE VALUE CREATED BY INCREASING THE FLOOR SPACE RATIO IN THE LAND MARKETS SURROUNDING A TRANSIT STATION TO THEIR HIGHEST AND BEST USE

In NSW, the FSR is the key metric for determining the allowable development density on a land parcel. The FSR is fundamental in determining the intensity of the development on each site and, as such, has an important impact on unimproved land value. However, not all councils have adopted FSR controls for all land parcels within Local Government Areas. In order to have a complete dataset, where FSR controls were non-existent, the project team made certain assumptions on the current development capacity within different land use zones considering the nature of the area, other planning controls for the site, and FSR controls for comparable sites. The assumptions for residential land in the various council areas where no zoning information was available are outlined below in Table 6; otherwise, layers containing information on FSR controls were sourced from the Department of Planning and Environment. For all Industrial zones that did not have existing FSR controls, an FSR of 1:1 was assumed.

The increasing FSR elasticity over the analysis period for the Sydney Metropolitan Region and 2014 value of 0.239 highlights the increasing importance of higher density urban regeneration in Sydney and the changing nature of development in the metropolitan region. However, the importance of FSR in determining land values varies across the metropolitan region, which is evidenced by the individual subregion analyses conducted in subsequent sections of this report. This is because the importance of FSR varies with respect to the demand for land, and one can expect higher FSR values to be valued more in areas where land is more desirable.

Table 6 – FSR Assumptions for Residential Land in the Various Council Areas where FSR has not been defined

	Low-Density Residential	Medium-Density Residential	High-Density Residential
Ku-ring-gai	0.3:1		
Kogarah	0.5:1	3:1	
North Sydney	1.4:1	2:1	30:1 (North Sydney Centre)
Sutherland	0.55:1	0.7:1	1.5:1
Campbelltown	0.55:1	0.75:1	2:1
Woollahra	0.75:1		
Other Sydney LGAs without FSR controls	0.5:1	0.8:1	1.5:1

The value created from raising development capacity in land markets surrounding transit stations to maximise residential and commercial activity can be interpreted in accordance with Equation 10.

Equation 10 – Interpretation of the FSR Increase-based Land Value Impact on the Sydney Greater Metropolitan Area

$$\text{FSR Based Land Value Uplift (\%)} = [(\text{Proposed FSR} - \text{Existing FSR}) / \text{Existing FSR})] * (\text{FSR Coefficient})$$

4. METROPOLITAN-WIDE ANALYSIS OF THE WILLINGNESS TO PAY FOR TRANSPORTATION INFRASTRUCTURE, URBAN ACTIVATION AND INTENSIFICATION

A coefficient estimate of 0.239 can be interpreted as a 0.239% change in land value given 1% change in FSR. To illustrate the application of Equation 10, as an example, assume a current FSR of 0.5 (single detached dwelling) and a proposed FSR to capitalise on the investment in transit and to bring the land to its highest development capacity of 4.0 (five to ten storey apartment block). The approximation of the FSR-based value uplift for the station catchment, as illustrated in Equation 11, would be 167%.

Equation 11 – Approximation of the FSR-based Value Uplift for a North Shore Station Catchment

$$\text{FSR Based Land Value Uplift (\%)} = [(4-0.5)/0.5] * (0.239) = 167\% \text{ Uplift in land value}$$

4.2.4 SUMMARY OF THE METROPOLITAN REGION HEDONIC PRICE MODEL RESULTS

The graphs in this section as well as the results in Tables 4 and 5 highlight that at a metropolitan level, there is significant value created in Sydney's land markets from the investment in transit, especially when coordinated with land use change and intensification. However, this value varies by mode and the location in the metropolitan area as well.

The importance of the integration of land use and transportation planning is highlighted in the strong land market value creation from changing the zoning of the land around rail stations to enable suitable development to take place in close proximity to transit. In addition to the zoning change benefit, the land capacity must be increased to maximise the residential and commercial activity and yield surrounding the infrastructure investment. Giving consideration to the three phases of the land market value creation process of increasing accessibility, changing zoning, and increasing FSR ensures that all the land market potential created from the investment in transit is appropriately considered and, where possible, implemented to ensure that the NSW government obtains the most benefit from their investment in transit if land value-capture strategies are pursued.

There is no single metropolitan-wide solution to the integration of transit into their surrounding land uses, as each location has different existing land uses and development densities that are appropriate to that area. When suitable interventions have been identified for an area, however, Equations 6, 8, and 10 can be used to understand the value potential created from the investment in transit across the city. Again, as the Sydney Metropolitan area is very large and diverse, the parameter estimates from this analysis can be expected to be relatively subdued as all of the coefficients are spatially static (fixed) and transit catchment coefficients are being averaged for the entire modal alignment and compared with large, unrelated out-of-catchment areas. The subregional models presented in the next section will analyse the impacts of land use and transit at a subregional level and be able to better control for local levels of demand for the controlled land attributes.

5.

SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

As discussed in the metropolitan-wide analysis of the WTP for land use and transit, Sydney has a number of different modes of transit differentially integrating with the land markets in each of their catchments. As the WTP pay for transit accessibility will vary for each mode and across the different submarkets in the metropolitan area, subregional analysis enables more location-specific parameters to be estimated at the cost of larger sample size and leverage in the control variables.

Given the potential diversity in Sydney's submarkets, a number of transit projects across the metropolitan area have been selected for more detailed analysis of their WTP, based on them being developed and commencing operations over the assessment period (2000–2014) as well as their representation of different transit modes and transit-oriented urban renewal attributes.

The transit and land use projects analysed and discussed include:

- Heavy Rail
  - Epping to Chatswood
- Light Rail Transit (LRT)
  - Dulwich Hill Extension
- Bus Rapid Transit (BRT)
  - Parramatta to Liverpool T-Way
  - Parramatta to Rouse Hill T-Way
- Transit Oriented Urban Renewal
  - Airport Link Stations (Green Square and Mascot)

Each of these transit and land use development projects is introduced with a background description to the project, and their regional contexts are analysed through their catchments' transit and land use maps. A set of descriptive statistics for each of the models is also provided to aid interpretation of the local context of the catchment.

As with the metropolitan model, the cross-sectional hedonic price models analyse all the catchment characteristics, focusing on the transit and non-transit-related land market attributes and, in doing so, highlight the WTP for the different land use zones and FSRs within the catchments.

Panel data models for the Residential, Mixed, and Business land uses are undertaken over the assessment period (2000–2014) to specifically draw out the impacts of the new transit infrastructure projects on their land markets. The industrial land parcels were excluded from the panel data models, as the investment in transit does not impact industrial land owing to a lack of WTP for proximity to it. Industrial land markets have a greater WTP for proximity to freeways and in some industrial sectors, there is a WTP for proximity to rail freight hubs, but as this report is focussed on the interaction between public transit and their catchments, the industrial land parcels were excluded from the panel data accessibility analyses. Industrial land, however, does feature in the cross-sectional models and this can enable predictions of land value uplift associated with a change in land use to be estimated.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

The results for each of the value creation phases (accessibility, change of zoning to highest and best use, and increase in FSR) are analysed for each project. These results are contrasted and discussed to draw out the WTP implications for the development of future transit projects in Sydney and to highlight what these results mean for use in the 'Value Sharing Virtuous Cycle' presented in Figure 8.

5.1 HEAVY RAIL PROJECTS

5.1.1 THE EPPING TO CHATSWOOD RAIL LINE

The Epping to Chatswood Rail Line serves an important section of Sydney's Global Economic Corridor, which accommodates a significant concentration of Sydney's knowledge jobs including sectors such as education, financial and other business services, communications, high-tech manufacturing, and emerging industries such as biotechnology. The Epping to Chatswood line is a 12–km, fully tunnelled underground rail line, connecting the North Shore line at Chatswood to the Main Northern line at Epping. The line included new underground stations at Epping and Chatswood and three new stations in between. Construction of the line commenced in November 2002 and operations commenced in February 2009.

A map of the sub-region along with the heavy rail catchments is presented in Figure 27. The focus of the analysis is on the three new stations of North Ryde, Macquarie Park, and Macquarie University as they incurred the greatest benefit whist the existing Epping and Chatswood stations just gained a relatively minor increase in accessibility. The new stations have recently had transit-oriented planning controls introduced to induce greater levels of development in the areas surrounding the stations. These include the North Ryde Station Urban Activation Precinct, which was finalised in July 2013 and includes new planning controls that allow the development of the area into a mixed use precinct and the finalisation of the precinct planning for the Macquarie University Station Precinct (also known as Herring Road Precinct). The Minister for Planning announced amendments to the Ryde Local Environmental Plan 2014 on 24 September 2014. A key feature of the plan is a B4 Mixed Use zoning 'academic core' at Macquarie University and opportunities for urban renewal and new dwellings within the station catchment.

5.1.1.1 THE EPPING TO CHATSWOOD HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The Epping to Chatswood subregional hedonic price model contains 108,781 records over the period 2000 to 2014, accounting for land use categories falling into the broad categories of Residential, Commercial and Industrial. The model's input variables and the dataset's descriptive statistics are presented in Table 7.

A map of the hedonic price model's catchments is presented in Figure 27, and a map of the corridor land market zonings is presented in Figure 28.

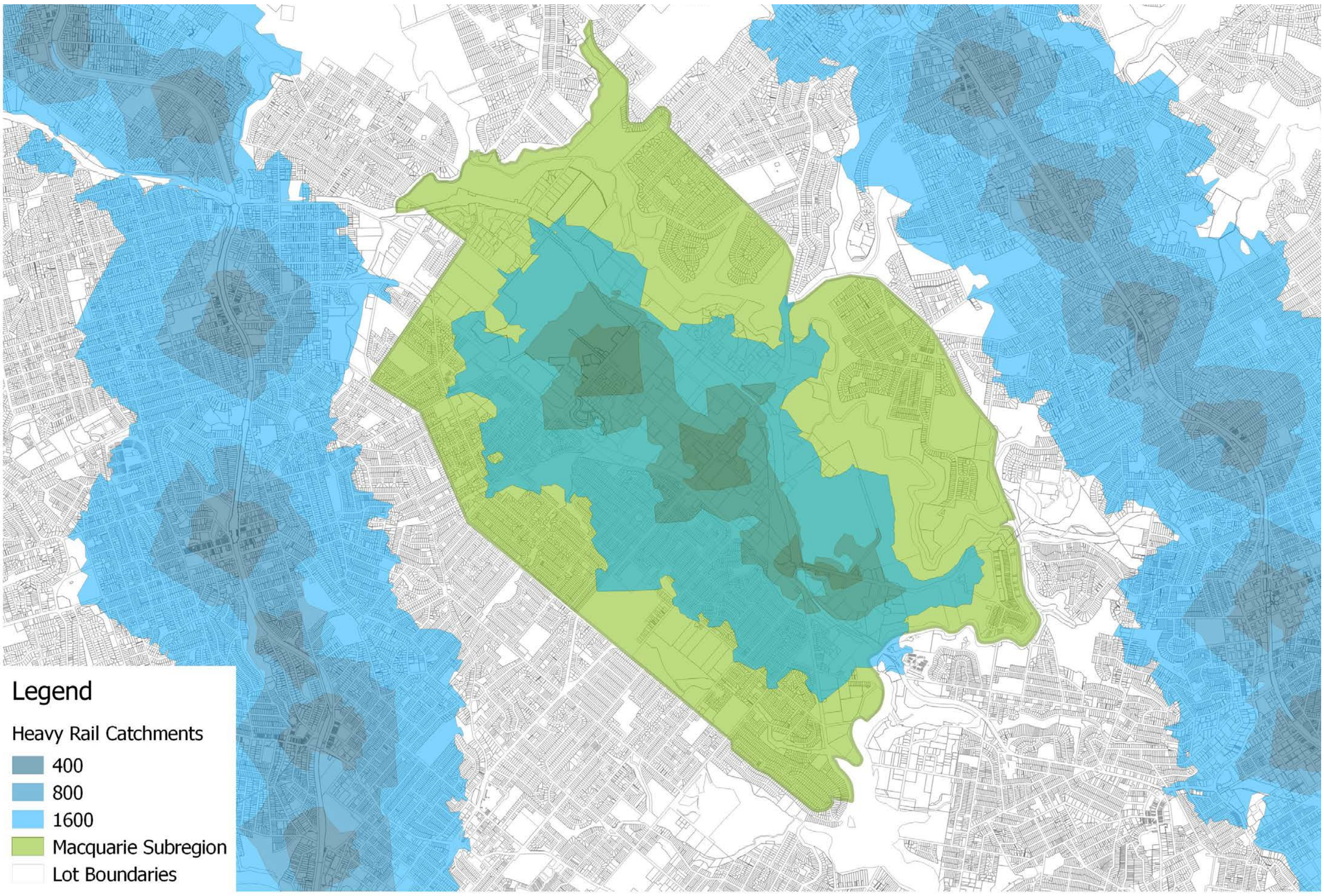

Figure 27 – Subregion Map of the Hedonic Price Modelling Catchments for the New Stations of the Epping to Chatswood Rail Line

Figure 28 – Epping to Chatswood Rail Line's Pedestrian Catchment Land Use Zoning Map for All Stations along the Alignment

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Table 7 – Epping to Chatswood Subregion – Hedonic Price Model Descriptive Statistics (2014)

Continuous Variables	Average Values
Unimproved land value (ulv)	$937,857.07
ln_ulv	13.51
Unimproved land value per square metre (ulvpsm)	1064.51
ln_ulvpsm	6.93
Land area (m^2)	1043.05
Floor Space Ratio (fsr)	0.5
Distance to Any CBD	11.37
Distance to Activity Centre Level 1	11.37
Distance to Activity Centre Level 2	2.3
Distance to Activity Centre Level 3	2.64
Distance to Activity Centre Level 4	0.65
Distance to Coast	2.65
SNAMUTS (2011)	9.62
Effective Job Density	206817.52
SEIFA Score	78
Dummy Variables	**% of Subregion within the Catchment**
Heavy Rail 0–400 m	2.0%
Heavy Rail 400–800 m	5.0%
Heavy Rail 800–1600 m	38.0%
Main Road 0–100 m	17.0%
Main Road 0–200 m	33.0%

5.1.1.2 EPPING TO CHATSWOOD 2014 CROSS-SECTIONAL HEDONIC PRICE MODEL RESULTS

The Epping to Chatswood Line cross-sectional model analyses the importance of all the explanatory variables on the natural log of unimproved land value per square metre in 2014. The HPM equation for the model is presented in Equation 12.

Equation 12 – Epping to Chatswood Subregion – Cross-Sectional Hedonic Price Modelling Equation

$$log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) + log(distanycbd) + log(distctr2) + log(distctr3) + hrail\_0\_400 + hrail\_400\_800 + hrail\_800\_1600 + main\_road\_0\_100 + main\_road\_1\_200 + log(snamuts11) + log(seifa\_per) + log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

Figures 27 and 28 illustrate that the Epping to Chatswood line connects the North Shore Line at Chatswood to the Main Northern Line at Epping, with three underground stations along the alignment. Figure 28 illustrates that these underground stations sit predominately within Business-zoned land catchments, with limited integration with the surrounding land uses. Table 8 presents the results of the cross-sectional hedonic price modelling for 2014 for the new station catchments along the Epping to Chatswood line.

Whilst the coefficient of determination (R2) for the Epping to Chatswood line model is lower than that for other models, it still explains nearly 60% of the variation in the data, with all the key attributes used for forecasting being significant within the 99.9% confidence interval.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

The cross-sectional model reports a very high and significant average benefit of 54.6% for being within 400 m of one of the stations in the subregion. The proximity benefit quickly dissipates in the 800m and 1600m catchments, but the effects are still positive and significant. The disadvantages of being near a main road in the corridor of -6.2% is lower than the metropolitan model, though this may be due to the significant number of main roads running through the catchment.

The Residential zoning is reported to be valued the highest (being the control zone), followed by Business and Mixed Use. There is also a very high elasticity for the FSR within the corridor of 0.342, which indicated that a 100% increase in FSR will lead to a 34.2% increase in land value. The distance to centre metrics can be deemed fairly unreliable in the model as the subregion is small and the range of distance values would be narrow, potentially leading to misleading results.

5.1.1.3 EPPING TO CHATSWOOD PANEL DATA HEDONIC PRICE MODEL (2000–2014)

In addition to the 2014 cross-sectional model, a panel data model from 2000 to 2014 was estimated to determine the impact of the line on the land markets in the surrounding catchments. As the Epping to Chatswood Line was opened in 2009, this model fully analyses its impact from the announcement, through construction and to approximately five years after the beginning of operation. The Epping to Chatswood panel data hedonic price modelling equation is presented in Equation 13. Note that SEIFA was excluded from this model to prevent records that had no SEIFA value from dropping out, as there were quite a few in the

Table 8 – Epping to Chatswood Subregion – 2014 Cross-Sectional Hedonic Price Model Results

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heavy Rail 0–400 m	54.6%	0.061 (***)	log(Area)	-0.237	0.006 (***)
Heavy Rail 400–800 m	7.3%	0.017 (***)	log(FSR)	0.342	0.031 (***)
Heavy Rail 800–1600 m	10.4%	0.008 (***)	log(Dist. to coast)	0.120	0.010 (***)
Heritage	-21.7%	0.074 (**)	log(Dist. to Any CBD)	-0.752	0.091 (***)
Strata	21.7%	0.015 (***)	log(Dist. to 2nd tier Centre)	0.233	0.022 (***)
Zoning B – Business (+)	-19.6%	0.029 (***)	log(Dist. to 3rd tier Centre)	0.110	0.013 (***)
Zoning M – Mixed Use (+)	-56.1%	0.060 (***)	log(SEIFA)	0.043	0.014 (***)
Main Road 0–100 m	-6.2%	0.007 (***)			
Main Road 100–200 m	0.9%	0.007 ( )			

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.5943 with 7082 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

subregion. This helped with the model results as a fair bit of rezoning occurred over the analysis period. SEIFA was deemed to have a small effect as indicated in the cross-sectional model, and it was not highly correlated with any other variable.

Equation 13 – Epping to Chatswood Subregion – Panel Data Hedonic Price Modelling Equation

$$log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) + log(distanycbd) + log(distctr2) + log(distctr3) + hrail\_0\_400 + hrail\_4\_800 + hrail\_8\_1600 + year2001 + year2002 + year2003 + year2004 + year2005 + year2006 + year2007 + year2008 + year2009 + year2010 + year2011 + year2012 + year2013 + year2014 + hrail400myear2001 + hrail400myear2002 + hrail400myear2003 + hrail400myear2004 + hrail400myear2005 + hrail400myear2006 + hrail400myear2007 + hrail400myear2008 + hrail400myear2009 + hrail400myear2010 + hrail400myear2011 + hrail400myear2012 + hrail400myear2013 + hrail400myear2014 + hrail800myear2001 + hrail800myear2002 + hrail800myear2003 + hrail800myear2004 + hrail800myear2005 + hrail800myear2006 + hrail800myear2007 + hrail800myear2008 + hrail800myear2009 + hrail800myear2010 + hrail800myear2011 + hrail800myear2012 + hrail800myear2013 + hrail800myear2014 + hrail1600myear2001 + hrail1600myear2002 + hrail1600myear2003 + hrail1600myear2004 + hrail1600myear2005 + hrail1600myear2006 + hrail1600myear2007 + hrail1600myear2008 + hrail1600myear2009 + hrail1600myear2010 + hrail1600myear2011 + hrail1600myear2012 + hrail1600myear2013 + hrail1600myear2014 + main\_road\_0\_100 + main\_road\_1\_200 + log(snamuts11) + log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

Figure 29 shows the trend in catchment values and it is interesting that there was not a significant land market response to the commencement of construction, as there has been in other jurisdictions[14], with the main response to the commencement of operations seen in early 2009. The 53.7% increase in first three years of operation is a massive land market response to the increase in accessibility, which is reduced in the fourth year back to an uplift of 37.2%. Experience from other jurisdictions shows that this correction is likely to be short lived once the land market redevelopment starts to take place[15].

Interestingly, the increase in the perceived benefit of the increase in accessibility is limited to the 400m pedestrian catchments, as the 800m and 1600m catchments are basically unaffected by the opening of the line although they begin to trend upwards in the later years. This lack of WTP in the areas surrounding the 400m

14 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 Vol. 67, September 2014, 320–339

15 http://www.ryde.nsw.gov.au/Business-and-Development/Town-Centres/Macquarie-Park-Corridor

Table 9 – Epping to Chatswood New Stations – Residential, Business and Mixed Use Land Uses Only – Station Catchment Panel Data Hedonic Price Model Results (2000–2014)

	0m-400m		400m-800m		800m-1600m	
2000	34.4%	0.029 (***)	-2.6%	0.012 (*)	5.2%	0.005 (***)
2001	32.1%	0.038 ( )	-6.5%	0.016 (*)	3.9%	0.006 (*)
2002	22.3%	0.038 (**)	-3.2%	0.016 ( )	6.7%	0.006 (*)
2003	24.6%	0.038 (*)	-0.9%	0.016 ( )	10.1%	0.006 (***)
2004	19.7%	0.038 (***)	-1.1%	0.016 ( )	6.3%	0.006 (.)
2005	18.1%	0.038 (***)	-3.3%	0.016 ( )	3.7%	0.006 (*)
2006	15.0%	0.043 (***)	-1.0%	0.016 ( )	6.3%	0.006 (.)
2007	16.2%	0.043 (***)	4.0%	0.016 (***)	8.3%	0.006 (***)
2008	17.1%	0.043 (***)	5.4%	0.016 (***)	8.0%	0.006 (***)
2009	17.2%	0.043 (***)	3.9%	0.016 (***)	6.7%	0.006 (*)
2010	15.2%	0.050 ( )	9.4%	0.016 (***)	14.2%	0.006 (***)
2011	41.1%	0.060 ( )	8.6%	0.016 (***)	12.7%	0.006 (***)
2012	62.2%	0.062 (***)	8.9%	0.016 (***)	12.8%	0.006 (***)
2013	68.9%	0.062 (***)	13.3%	0.016 (***)	15.0%	0.006 (***)
2014	52.4%	0.060 (**)	12.0%	0.016 (***)	14.1%	0.006 (***)

Notes: Adjusted R-squared: 0.7445 with 105277 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

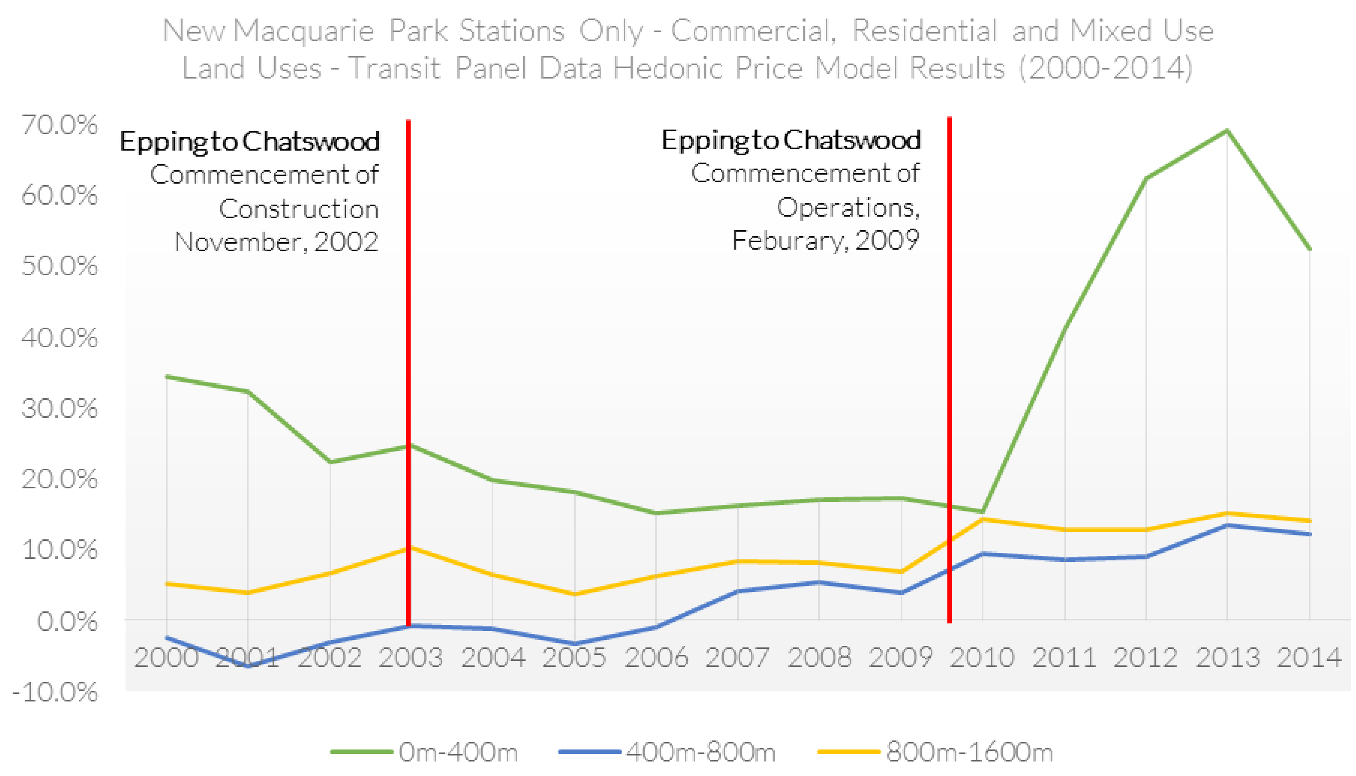

Figure 29 – New Macquarie Park Stations Only – Residential, Business and Mixed Use Land Uses Only – Heavy Rail Panel Data Hedonic Price Model Results (2000–2014)

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

pedestrian catchments demonstrates the finite spatial relationship between transit stations and the perceived benefit or the nexus between the levels of accessibility and the value impact on the surrounding land market. It should be noted, however, that the spatial extent of the model is relatively small, which could be having an effect on some of the estimated coefficients along with the overall model's explanatory power.

The panel data model also included interaction terms between the land use control variables and year to estimate how the different zones have changed in value over time; however, the results are not reported or discussed here as they were largely insignificant and the Mixed Use zone was not even present in the sample for most years.

5.1.1.4 EPPING TO CHATSWOOD LINE ACCESSIBILITY BENEFIT IMPACT ON LAND VALUE

Equation 14 demonstrates the application of the land value uplift calculation in the context of the Epping to Chatswood Line, utilising the results from Table 9 and focussing on the 0.372 increase in the 400m heavy rail coefficient from 2010 to 2014[16], which leads to a land value uplift for proximity to the Epping to Chatswood Line of 47.7%.

Equation 14 – Interpretation of the Accessibility-based Land Value Impact on the Epping to Chatswood Subregion

Accessibility Based Land Value Uplift (%) = Exp(0.372) – 1 = 47.7%

16 Assuming a 6-month lag from government-assessed value to translate the land market value response to the rail line.

5.1.1.5 EPPING TO CHATSWOOD LINE CHANGE OF ZONING BENEFIT IMPACT ON LAND VALUE

The cross-sectional hedonic price modelling reports that the highest value zone for the Epping to Chatswood corridor is the Residential zone, which has a coefficient 0.196 higher than the Business zoned land co-efficient. Therefore, using the cross-sectional model outputs to convert a Business-zoned catchment to a Residential zone creates an uplift in land value of 17.8%.

Equation 15 – Interpretation of the Change in the Zoning-based Land Value Impact on the Epping to Chatswood Subregion

Change of Zoning Based Land Value Uplift (%) = Exp(0) – Exp(-0.196) – 1 = 17.8%

5.1.1.6 EPPING TO CHATSWOOD LINE CHANGE OF FSR BENEFIT IMPACT ON LAND VALUE

The cross-sectional model reports that the FSR hedonic price for the new stations of the Epping to Chatswood Line catchment is 0.342. Equation 16 demonstrates the calculation of land value uplift associated with an increase in FSR in the Epping to Chatswood Line subregion, assuming an increase from an existing average FSR of 0.5 (see Table 7) to that of Chatswood around the station with an FSR 4.

Equation 16 – Interpretation of the Increase in FSR-based Land Value Impact on the Epping to Chatswood Subregion

*FSR Based Land Value Uplift (%) = [(4 – 0.5)/0.5] * 0.342 = 239.4%*

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

These results of the WTP for transit accessibility, change in zoning to highest and best use, and increase in the FSR demonstrate that there is significant benefit from integrating appropriate land uses at higher densities within the Epping to Chatswood station catchments.

5.3 LIGHT RAIL TRANSIT (LRT)

5.3.1 DULWICH HILL EXTENSION TO THE INNER WEST LRT

In Sydney, the Inner West LRT which runs from Sydney's Central rail station to the Dulwich Hill rail station is the only line that is currently in operation although there are three proposed and under construction Light Rail Transit (LRT) lines within the Sydney metropolitan area. The first stage of the Inner West LRT from Pyrmont to Central Station opened in August 1997, with the second stage west from Wentworth Park to Lilyfield opening in August 2000, and the third stage heading to the southwest from Lilyfield to Dulwich Hill opening in March 2014[17]. The LRT corridor from Wentworth Park to the Dulwich Hill Train Station is on an old freight corridor, with the land uses in the surrounding 400m catchments significantly depressed with respect to the surrounding 800m and 1600m catchments. The spatial distribution of the current Sydney LRT network is shown in the Metropolitan Sydney Transit Catchment Map in Figure 30.

The Dulwich Hill Extension is a 5.6-km addition to the existing two stages of the Inner West LRT that runs along the former Rozelle freight rail corridor with 9 new light rail stops between Lilyfield and Dulwich Hill. It serves the suburbs of Lilyfield, Leichhardt, Petersham, Lewisham and Dulwich Hill. The line commenced construction in May 2012 and commenced operations commenced in 2014[18].

The land in the immediate catchment of the LRT is generally underutilised though it has great renewal potential. The station catchment used for analysis is presented in Figure 31, and the land use planning controls for the catchment are illustrated in Figure 32. This section analyses the impact of the extension on its land markets alone to determine its impacts from announcement through construction and to operation.

5.3.1.1 HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The extension to the Inner West LRT to Dulwich Hill hedonic price model contains 48,385 records over the period 2000 – 2014, accounting for land use categories falling into the broad categories of Residential, Commercial and Industrial. The model's input variables and the dataset's descriptive statistics are presented in Table 10.

17 LRT in Sydney, 2015 https://en.wikipedia.org/wiki/Light_rail_in_Sydney
18 Dulwich Hill Extension https://en.wikipedia.org/wiki/Dulwich_Hill_Line

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

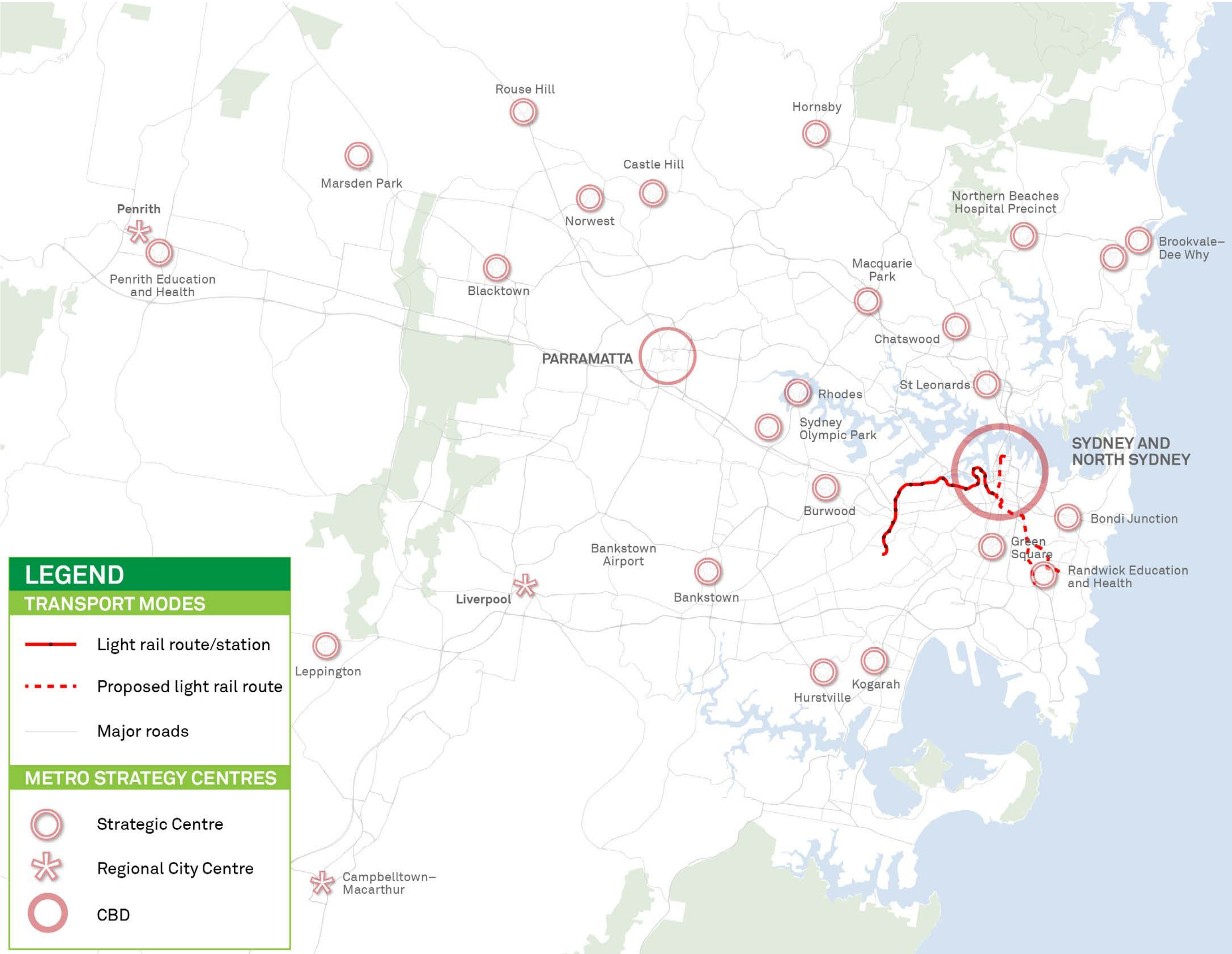

Figure 30 – Sydney's Light Rail Network (LUTI Consulting, Mecone Planning)

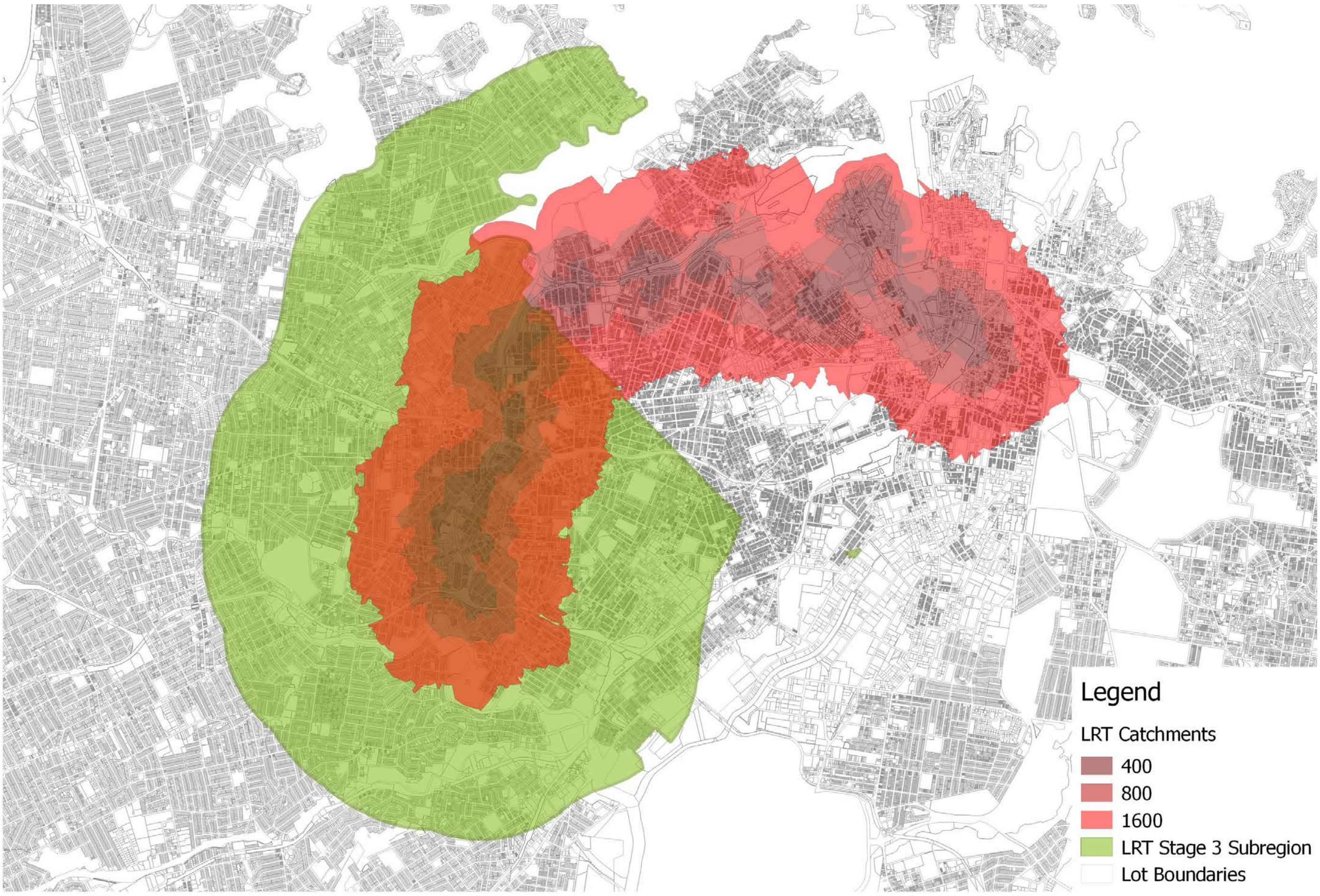

Figure 31 – Dulwich Hill Extension to the Inner West LRT Subregion Map

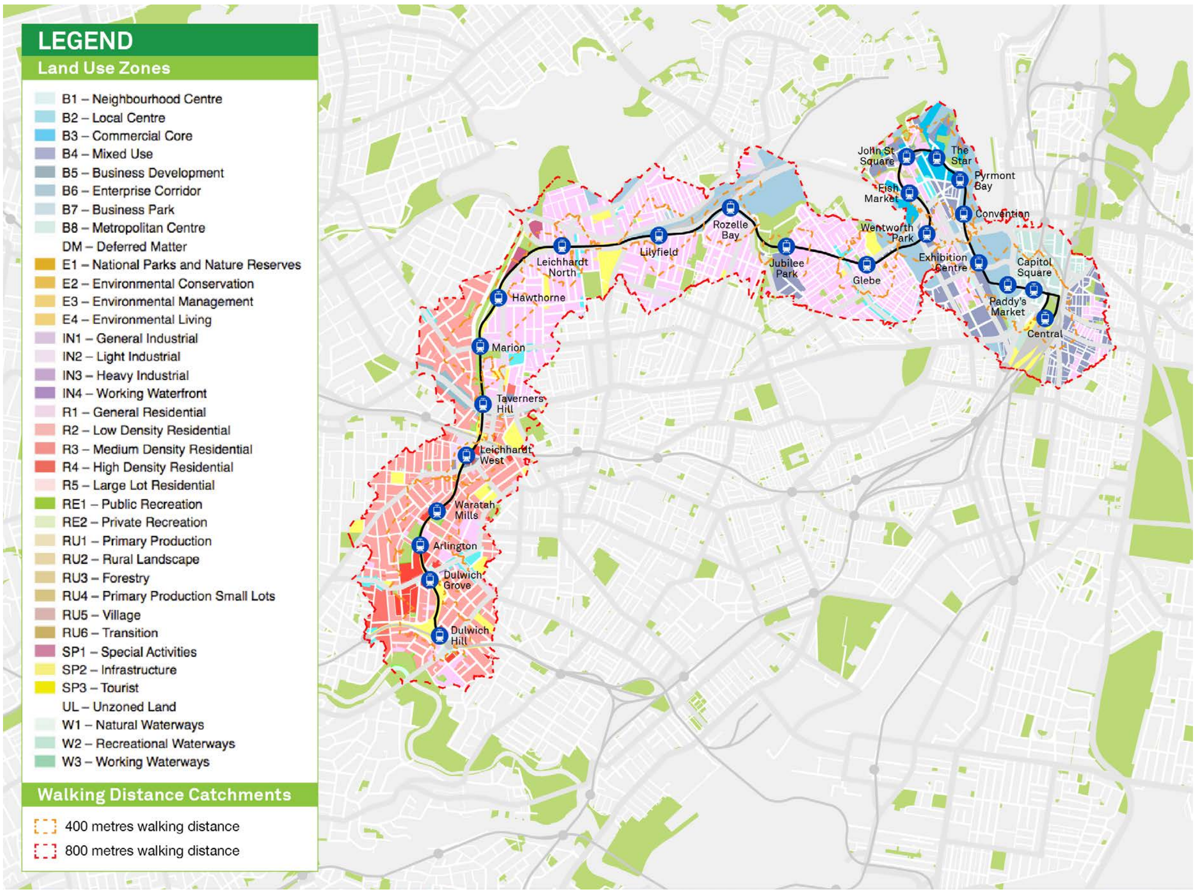

Figure 32 – Inner West LRT Land Use Zoning Map

Table 10 – Dulwich Hill Extension to the Inner West LRT Subregion – Hedonic Price Model Descriptive Statistics (2014)

Continuous Variables	Average Values
Unimproved land value (ulv)	$787,851
ln_ulv	13.43
Unimproved land value per square metre (ulvpsm)	$1,847
ln_ulvpsm	7.45
Land area (m^2)	509.56
Floor Space Ratio (fsr)	0.65
Distance to Any CBD	4.89
Distance to Activity Centre Level 1	4.9
Distance to Activity Centre Level 2	4.22
Distance to Activity Centre Level 3	1.98
Distance to Activity Centre Level 4	0.65
Distance to Coast	2.85
SNAMUTS (2011)	13.97
Effective Job Density	234,299
SEIFA Score	62
Dummy Variables	**% of Subregion within the Catchment**
LRT 0–400 m	6%
LRT 400–800 m	9%
LRT 800–1600 m	19%
Heavy Rail 0–400 m	13%
Heavy Rail 400–800 m	27%
Heavy Rail 800–1600 m	41%
Main Road 0–100 m	33%
Main Road 0–200 m	56%

5.3.1.2 DULWICH HILL EXTENSION TO INNER WEST LRT 2014 CROSS-SECTIONAL HEDONIC PRICE MODEL

The cross-sectional model of the Dulwich Hill Extension to the Inner West LRT analyses the importance of all the explanatory variables on unimproved land value per square metre in 2014. The cross-sectional HPM equation for the Dulwich Hill Extension to the Inner West LRT is presented in Equation 17.

Equation 17 – Dulwich Hill Extension to the Inner West LRT Subregion – Hedonic Price Modelling Equation

$$log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) + log(distanycbd) + log(distctr2) + log(distctr3) + hrail\_0\_400 + hrail\_400\_800 + hrail\_800\_1600 + lrt\_0\_400 + lrt\_400\_800 + lrt\_800\_1600 + main\_road\_0\_100 + main\_road\_1\_200 + log(snamuts11) + log(seifa\_per) + log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

Figure 32 illustrates that the Inner West LRT line connects the heavy rail line to the Bankstown line at Dulwich Hill, and the LRT stations along the line sit predominately within old freight line catchments, with limited to no integration with the surrounding land uses. Table 11 presents the results of the cross-sectional hedonic price modelling for 2014 for the station catchments along the Dulwich Hill Extension to the Inner West LRT Line.

Whilst there are number of important features within the hedonic price model of the Dulwich Hill Extension to the Inner West LRT, the model coefficient of determination (R2) is 0.57, which is relatively low compared to the coefficients of some of the other models estimated in this study. That said, all the important variables are significant within the 99.9% range.

5.3.2 DULWICH HILL EXTENSION TO THE INNER WEST LRT PANEL DATA HEDONIC PRICE MODEL (2000–2014)

In addition to the 2014 cross-sectional model of the Dulwich Hill Extension to the Inner West LRT, a panel data model from 2000 to 2014 was created to determine the impact of the line on the land markets in the surrounding catchments. This model fully analyses the impact of the opening of the Dulwich Hill Extension to the Inner West LRT Line from several years prior to announcement, through construction and to approximately one year after operation.

The Inner West LRT Line Panel Data hedonic price modelling equation is presented in Equation 18 on the following page. Note that the interaction terms between land use and year have been omitted for brevity.

Table 11 – Dulwich Hill Extension to the Inner West LRT Subregion – Cross-Sectional Hedonic Price Model Results

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heritage	4.2%	0.004 (***)	log(Area)	-0.263	0.002 (***)
Strata	22.9%	0.006 (***)	log(FSR)	0.154	0.008 (***)
Zoning B – Business (+)	-12.5%	0.009 (***)	log(Dist. to coast)	-0.099	0.003 (***)
Zoning I – Industrial (+)	-50.2%	0.012 (***)	log(Dist. to Any CBD)	-0.086	0.008 (***)
Zoning M – Mixed Use (+)	20.9%	0.015 (***)	log(Dist. to 2nd tier Centre)	0.009	0.012 (***)
Main Road 0m – 100m	-7.6%	0.003 (***)	log(Dist. to 3rd tier Centre)	-0.032	0.005 (**)
Main Road 100m – 200m	0.0%	0.003 ( )	log(SEIFA)	0.031	0.005 (***)

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.5697 with 47939 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Equation 18 – Dulwich Hill Extension to the Inner West LRT Subregion – Panel Data Hedonic Price Modelling Equation

$$\begin{aligned}
&log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) \\
&+ log(distanycbd) + log(distctr2) + log(distctr3) + \\
&hrail_0_400 + hrail_4_800 + hrail_8_1600 + lrt_0_400 \\
&+ lrt_4_800 + lrt_8_1600 + year2001 + year2002 \\
&+ year2003 + year2004 + year2005 + year2006 \\
&+ year2007 + year2008 + year2009 + year2010 \\
&+ year2011 + year2012 + year2013 + year2014 \\
&+ hrail400myear2001 + hrail400myear2002 \\
&+ hrail400myear2003 + hrail400myear2004 + \\
&hrail400myear2005 + hrail400myear2006 + \\
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&lrt1600myear2009 + lrt1600myear2010 + \\
&lrt1600myear2011 + lrt1600myear2012 + \\
&lrt1600myear2013 + lrt1600myear2014 + main_ \\
&road_0_100 + main_road_1_200 + log(snamuts11) + \\
&log(seifa_per) + log(high_school_catchment) + heritage \\
&+ strata + zoning + suburb + constant
\end{aligned}$$

The results of the panel data hedonic price modelling of the Inner West LRT Line are presented in Tables 12 and 13, and illustrated in Figures 33 and 34.

The land catchments for the Dulwich Hill extension to the Inner West LRT presented in Figure 33 have undergone a significant growth in value over the analysis period. The 400m catchment, in particular, has grown in value compared to the control catchment, from -21.4% in 2000 to 4.0% in 2014; however, the most important growth period is from the year of project announcement to 2014, where the 400m catchment went from -2.5% to 4.0%. A 6.5% growth in the hedonic price for this catchment over this period is likely to be significantly understated as the line opened in 2014, and with the

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Epping to Chatswood line experiencing all their growth in the years after the commencement of operations, it is likely that there are a number of years of additional growth in the catchment that we cannot yet see in the data.

Another important aspect to note is that in 2014, the 400m catchment surpassed the 800m and 1600m catchments in value, and this change can be directly attributed to the investment in the LRT extension, and bodes well for future regeneration of the whole corridor through the area.

The analysis of land use zoning hedonic price changes interestingly mirrors the results of the metropolitan-wide analysis very closely. Both Industrial and Business land have been declining in value relative to Residential land for the second half of the analysis period, while the Mixed Use zone value has been gradually increasing.

5.3.3 DULWICH HILL EXTENSION TO THE INNER WEST LRT LINE: ACCESSIBILITY BENEFIT IMPACT ON LAND VALUE

Equation 19 demonstrates the application of the land value uplift calculation based on a change in accessibility in the Dulwich Hill Extension to the Inner West LRT subregion, utilising the Table 12 results from the period of announcement to commencement of operations (2010 to 2014)[19] .

Equation 19 – Interpretation of the Accessibility-based Land Value Impact on the Dulwich Hill Extension to the Inner West LRT subregion

$$\textit{Accessibility Based Land Value Uplift (\%)} = Exp(0.065) - 1 = 6.7\%$$

5.3.4 DULWICH HILL EXTENSION TO THE INNER WEST LRT LINE: CHANGE OF ZONING BENEFIT IMPACT ON LAND VALUE

The highest value zone in the Dulwich Hill subregion is the Business zone and the lowest is the Industrial zone. Equation 20 demonstrates how a rezoning of industrial to business land generates and estimated 62.8% uplift.

Equation 20 – Interpretation of the Change of the Zoning-based Land Value Impact on the Dulwich Hill Extension to the Inner West LRT subregion

$$\textit{Change of Zoning Based Land Value Uplift (\%)} = Exp(0.209) - Exp(-0.502) = 62.7\%$$

5.3.5 DULWICH HILL EXTENSION TO THE INNER WEST LRT LINE: CHANGE OF FSR BENEFIT IMPACT ON LAND VALUE

The cross-sectional results report a FSR elasticity for the Dulwich Hill Extension of 0.154. Assuming an increase in existing FSR values from the corridor average of 0.65 (see Table 10) to that of Pyrmont with a FSR of around 4, Equation 21 demonstrates the calculated impact on land values.

Equation 21 – Interpretation of the Increase in FSR-based Land Value Impact on the Dulwich Hill Extension to the Inner West LRT subregion

$$\textit{FSR Based Land Value Uplift (\%)} = [(4 - 0.65)/0.65] * 0.154 = 79.4\%$$

These results of WTP for transit accessibility, change in zoning to highest and best use, and increasing the FSR demonstrate that there is significant benefit from integrating appropriate land uses at higher densities within the Dulwich Hill Extension to the Inner West LRT station catchments.

19 This period accounts for the announcement of the Dulwich Hill extension to the Inner West LRT in 2010 and means that the 2014 data probably understates the benefit to be realised from the extension of the line, as it is expected that land market benefits will accrue in the next 2–3 years.

Table 12 – Dulwich Hill Extension to the Inner West LRT Subregion – Residential, Business and Mixed Use Land Uses Only – LRT Panel Data Hedonic Price Model Results (2000–2014)

	0m-400m		400m-800m		800m-1600m	
2000	-21.4%	0.007 (***)	-12.1%	0.006 (***)	-8.2%	0.004 (***)
2001	-16.6%	0.007 (***)	-10.1%	0.006 (**)	-6.7%	0.004 (***)
2002	-9.6%	0.007 (***)	-6.2%	0.006 (***)	-4.3%	0.004 (***)
2003	-10.1%	0.007 (***)	-7.6%	0.006 (***)	-5.3%	0.004 (***)
2004	-9.5%	0.007 (***)	-7.5%	0.006 (***)	-6.3%	0.004 (***)
2005	-3.3%	0.007 (***)	-1.1%	0.006 (***)	-3.2%	0.004 (***)
2006	-2.7%	0.007 (***)	-2.2%	0.006 (***)	-3.8%	0.004 (***)
2007	-4.4%	0.007 (***)	-0.7%	0.006 (***)	-1.9%	0.004 (***)
2008	0.7%	0.007 (***)	2.6%	0.006 (***)	1.0%	0.004 (***)
2009	2.1%	0.007 (***)	5.0%	0.006 (***)	1.7%	0.004 (***)
2010	-2.5%	0.007 (***)	2.5%	0.006 (***)	-1.2%	0.004 (***)
2011	-0.5%	0.007 (***)	2.2%	0.006 (***)	-1.4%	0.004 (***)
2012	-0.5%	0.007 (***)	1.4%	0.006 (***)	-1.1%	0.004 (***)
2013	0.9%	0.007 (***)	1.3%	0.006 (***)	-0.6%	0.004 (***)
2014	4.0%	0.007 (***)	1.7%	0.006 (***)	0.5%	0.004 (***)

Notes: Adjusted R-squared: 0.7397 with 684514 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

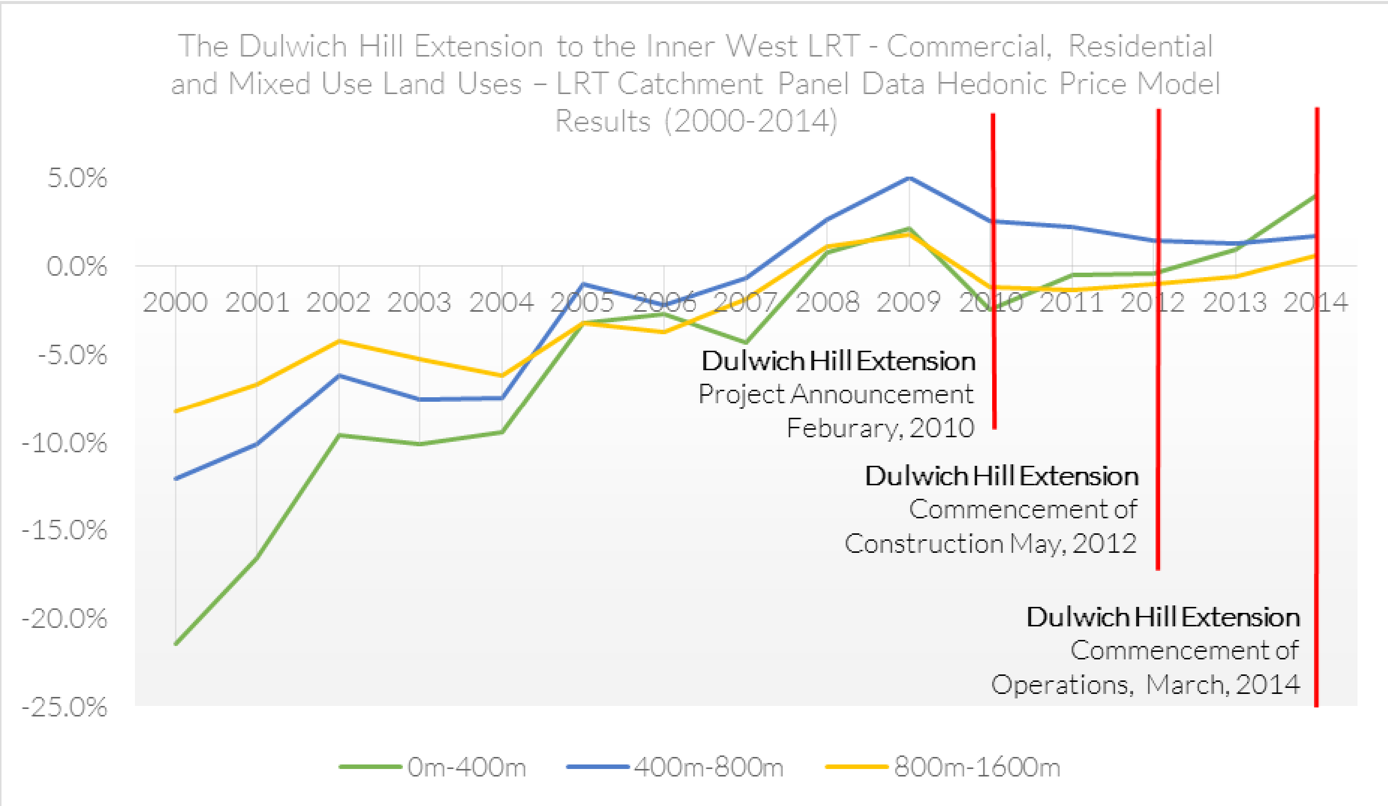

Figure 33 – Dulwich Hill Extension to the Inner West LRT Subregion – Residential, Business and Mixed Use Land Uses Only – LRT Panel Data Hedonic Price Model Results (2000–2014)

Table 13 – Dulwich Hill Extension to the Inner West LRT Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

	Business		Industrial		Mixed Use	
2000	8.0%	0.008 (***)	-30.1%	0.012 (***)	-13.2%	0.056 (***)
2001	5.0%	0.008 (***)	-28.7%	0.012 ( )	-15.6%	0.056( )
2002	5.3%	0.008 (***)	-33.4%	0.012 (**)	-20.8%	0.053 ( )
2003	7.2%	0.008 ( )	-29.4%	0.012 ( )	-7.8%	0.053 (***)
2004	9.4%	0.008 (.)	-28.2%	0.012 (***)	5.5%	0.053 (***)
2005	19.4%	0.008 (***)	-14.0%	0.012 (***)	22.2%	0.053 (***)
2006	21.7%	0.008 (***)	-10.5%	0.012 (***)	23.0%	0.053 (***)
2007	21.9%	0.008 (***)	-11.9%	0.012 (***)	21.6%	0.053 (***)
2008	21.0%	0.008 (***)	-5.7%	0.012 (***)	11.8%	0.053 (***)
2009	17.2%	0.008 (***)	-8.2%	0.012 (***)	4.7%	0.054 (***)
2010	11.6%	0.008 (***)	-14.4%	0.012 (***)	27.4%	0.043 (***)
2011	9.0%	0.008 ( )	-19.9%	0.012 (***)	27.7%	0.043 (***)
2012	5.5%	0.007 (***)	-21.6%	0.013 (***)	20.2%	0.043 (***)
2013	2.6%	0.007 (***)	-25.8%	0.013 (***)	17.9%	0.043 (***)
2014	-5.0%	0.007 (***)	-37.3%	0.013 (***)	26.3%	0.042 (***)

Notes: Adjusted R-squared: 0.7402 with 697103 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1
Results are compared to the Residential zoned land

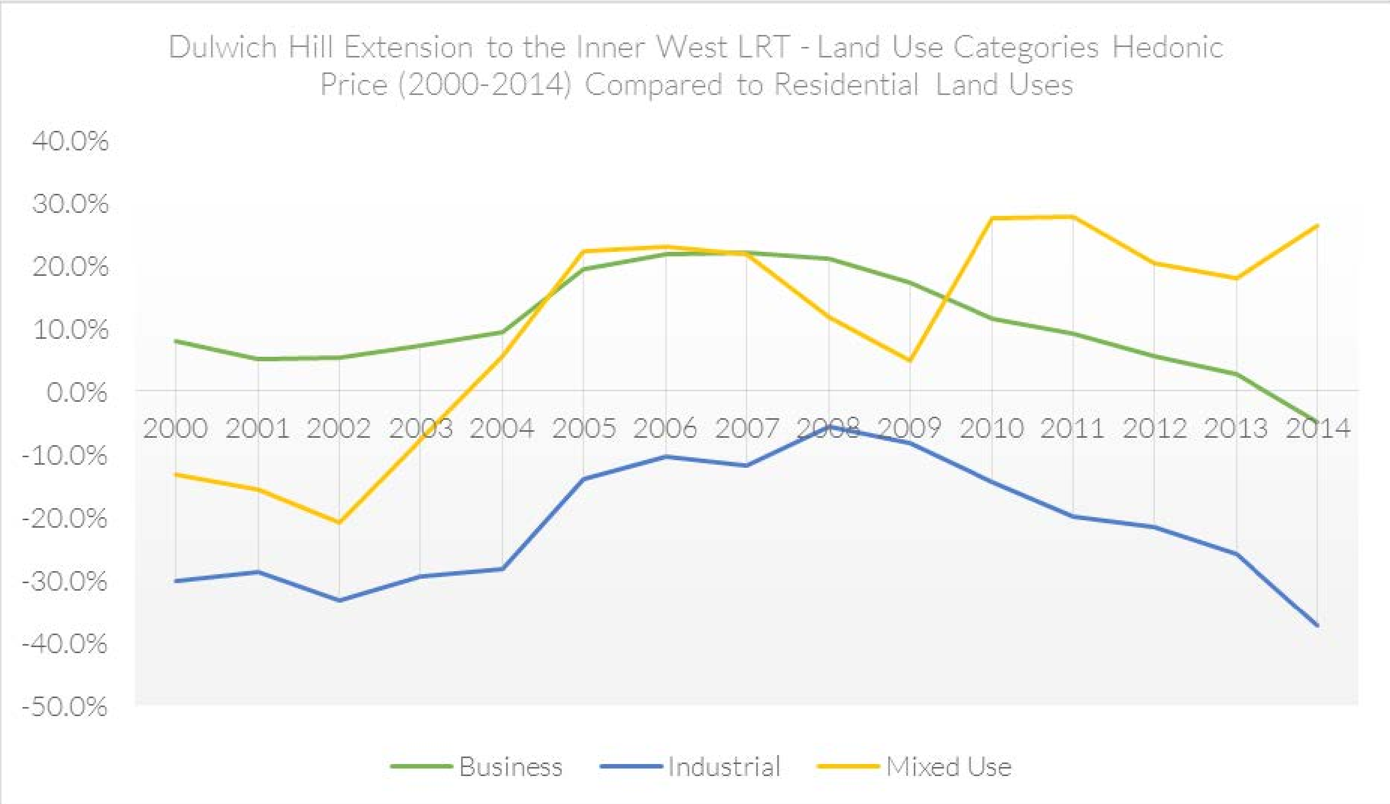

Figure 34 – Dulwich Hill Extension to the Inner West LRT Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

5.4 BUS RAPID TRANSIT

In Sydney, there are two Bus Rapid Transit (BRT) corridors:

- Parramatta to Liverpool T-Way that opened in February 2003, and
- North West T-Way that opened in March 2007, with its two sections including:
    - Parramatta to Rouse Hill and
    - Blacktown to Parklea

Both of these BRT Lines are discussed and analysed separately, as whilst they join at Parramatta, they operate independently serving different markets connecting them to Parramatta and not as an integrated network. Sydney's BRT network is presented in Figure 35.

5.4.1 THE PARRAMATTA TO LIVERPOOL T-WAY

The Parramatta to Liverpool T-Way is a 31–km transit route that links Parramatta Transport Interchange to Liverpool interchange. The route runs through a number of bus-only roadways and bus lanes and includes 35 BRT stops. The route generally serves the suburbs of Parramatta, Mays Hill, South Wentworthville, Merrylands West, Woodpark, Smithfield, Wetherill Park, Prairiewood, Busby, Cartwright, Miller, Prestons, Lurnea and Liverpool.

The Parramatta to Liverpool T-Way commenced operation in 2003, but failed to meet expectations in the earlier years with the patronage being almost half the initial forecasts. Since 2006, the annual patronage on the Parramatta to Liverpool BRT is believed to have increased. The BRT serves land markets that are predominantly zoned low density residential with employment zones and industrial areas in Wetherill Park, Greystanes and Smithfield.

5.4.1.1 HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The Parramatta to Liverpool T-Way hedonic price model catchment (See Figure 36) contains 102,482 records, accounting for land use categories falling into the broad categories of Residential, Commercial and Industrial (see Figure 37). The model's input variables and the dataset's descriptive statistics are presented in Table 14.

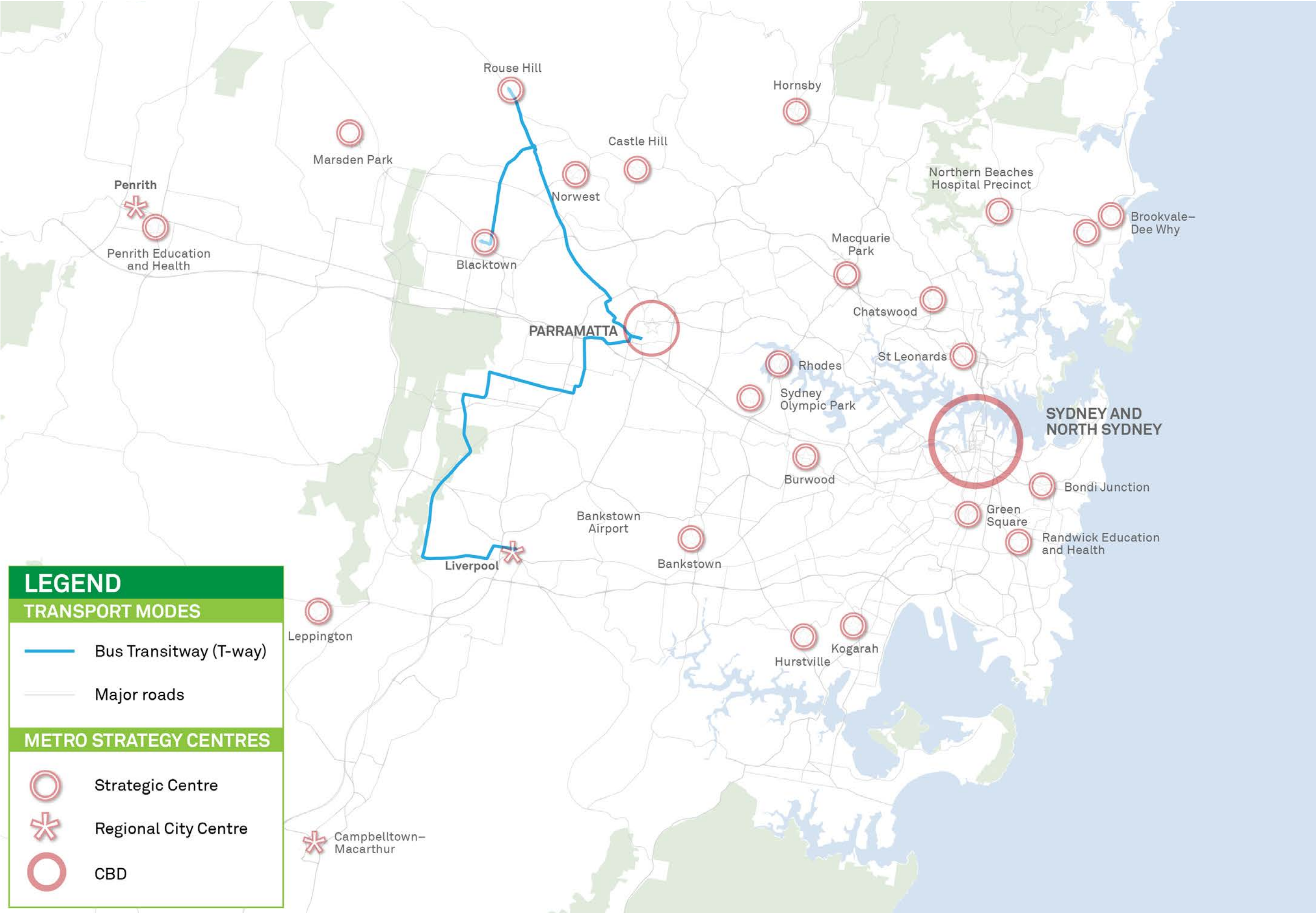

Figure 35 – Sydney's Bus Rapid Transit Rail Network (LUTI Consulting, Mecone Planning)

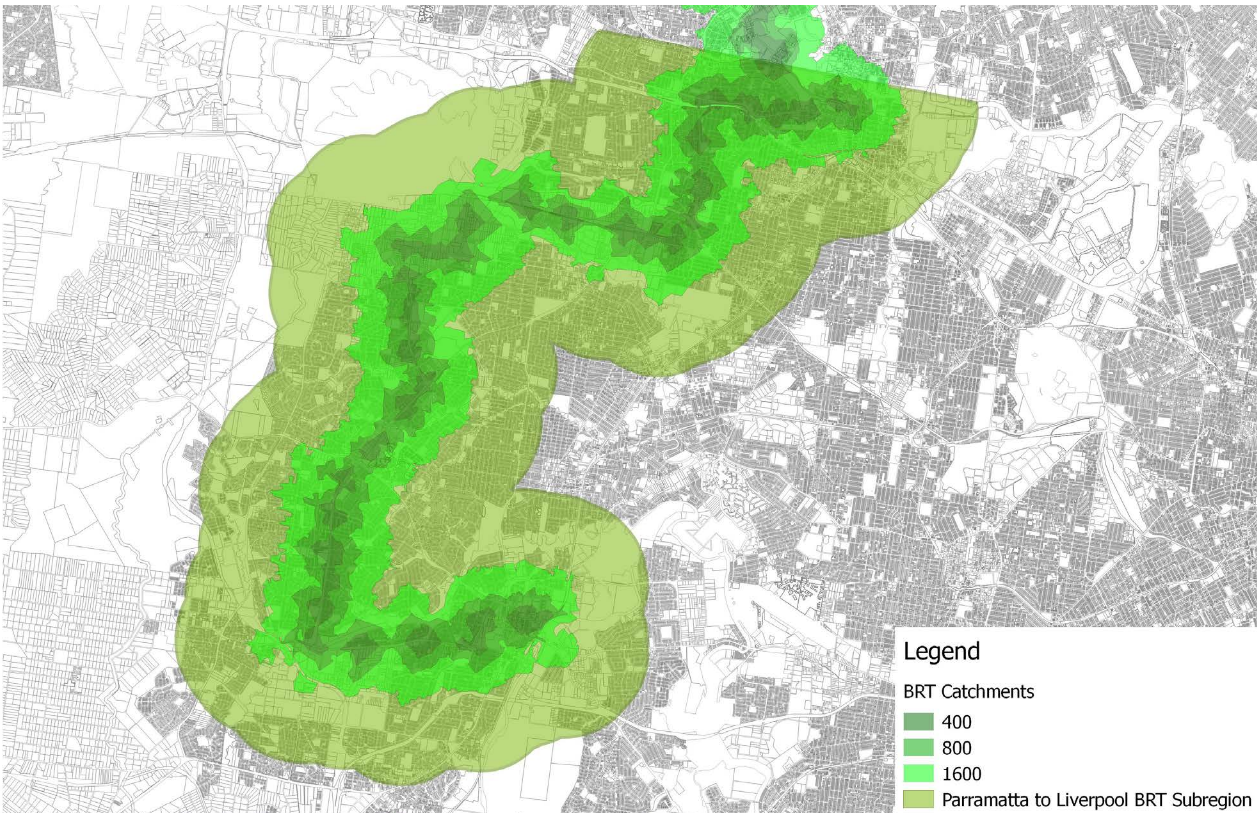

Figure 36 – Parramatta to Liverpool T-Way Subregion Map

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

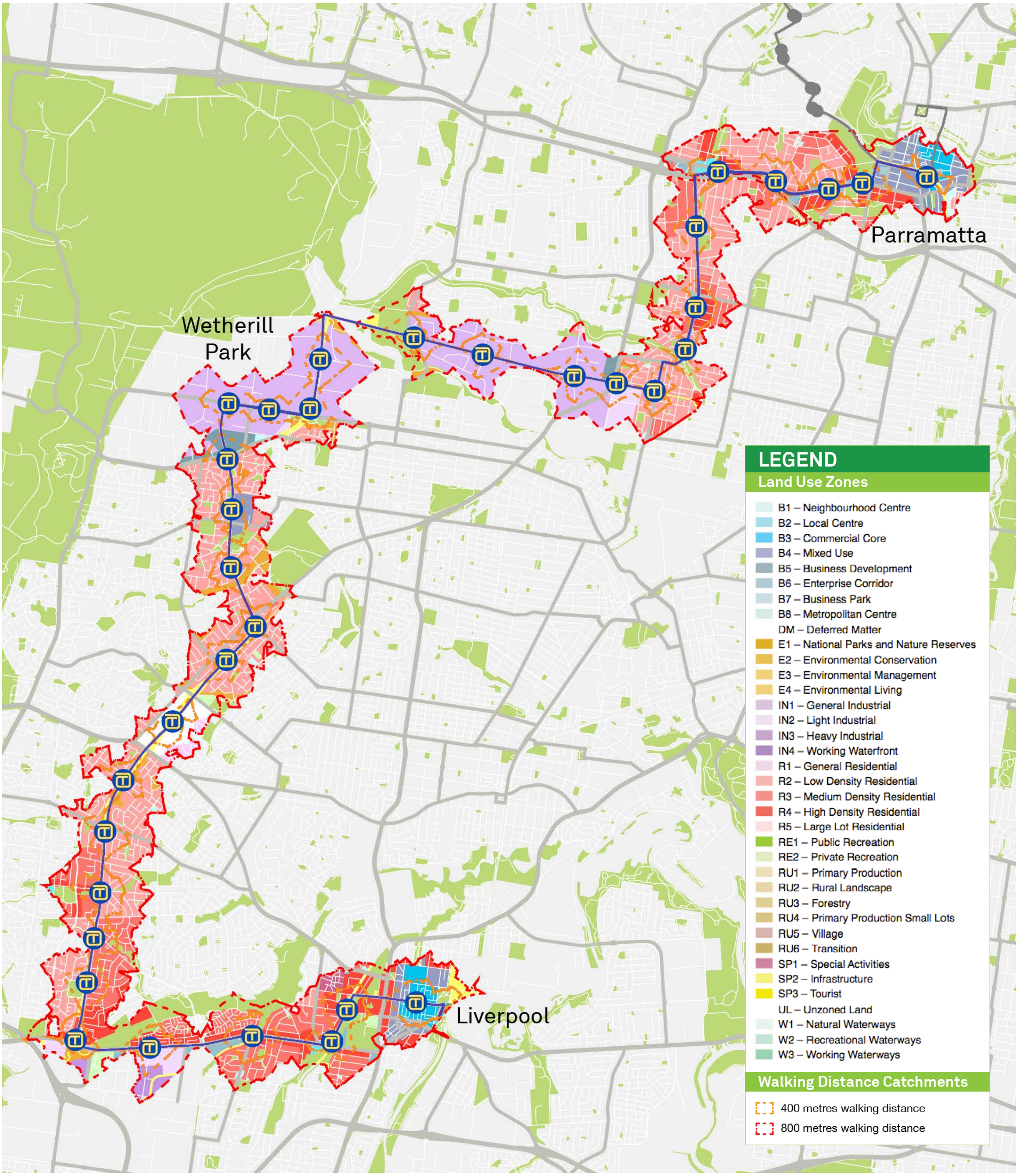

Figure 37 – Parramatta to Liverpool T-Way Land Use Zoning Map

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Table 14 – Parramatta to Liverpool T-Way – Hedonic Price Model Descriptive Statistics (2014)

Continuous Variables	Average Values
Unimproved land value (ulv)	$410,001
ln_ulv	12.72
Unimproved land value per square metre (ulvpsm)	$572
ln_ulvpsm	6.29
Land area (m^2)	867.33
Floor Space Ratio (fsr)	0.62
Distance to Any CBD	26.95
Distance to Activity Centre Level 1	26.95
Distance to Activity Centre Level 2	5.73
Distance to Activity Centre Level 3	2.74
Distance to Activity Centre Level 4	1.0
Distance to Coast	11.66
SNAMUTS (2011)	3.27
Effective Job Density	143,753
SEIFA Score	33
Dummy Variables	**% of Subregion within the Catchment**
BRT 0–400 m	5%
BRT 400–800 m	12%
BRT 800–1600 m	24%
Heavy Rail 0–400 m	2%
Heavy Rail 400–800 m	6%
Heavy Rail 800–1600 m	14%
Main Road 0–100 m	17%
Main Road 0–200 m	31%

5.4.1.2 PARRAMATTA TO LIVERPOOL T-WAY 2014 CROSS-SECTIONAL HEDONIC PRICE MODEL

The Parramatta to Liverpool T-Way cross-sectional model analyses the importance of all the explanatory variables on unimproved land value per square metre in 2014. The HPM equation for the Parramatta to Liverpool T-Way cross-sectional model is presented in Equation 22. Note that the model includes both BRT coefficients for the Parramatta to Liverpool T-Way as well as the heavy rail coefficients for the rail stations it intersects with at Parramatta and Liverpool.

Equation 22 – Parramatta to Liverpool T-Way – Hedonic Price Modelling Equation

$$\begin{gathered} log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) \\ + log(distanycbd) + log(distctr2) + log(distctr3) \\ + hrail\_0\_400 + hrail\_400\_800 + hrail\_800\_1600 + \\ brt\_0\_400 + brt\_400\_800 + brt\_800\_1600 + ferry\_0\_400 \\ + ferry\_400\_800 + ferry\_800\_1600 + main\_road\_0\_100 + \\ main\_road\_1\_200 + log(seifa\_per) + heritage + strata + \\ zoning + suburb + constant \end{gathered}$$

Figure 37 illustrates that the Parramatta to Liverpool T-Way connects the heavy rail line at Parramatta and Liverpool. The BRT stations along the line are at grade along main roads, with limited to no integration with the surrounding land uses. Table 15 presents the results of the cross-sectional hedonic price modelling for 2014 data and for the station catchments along the Parramatta to Liverpool T-Way.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Table 15 – Parramatta to Liverpool T-Way – Cross-Sectional Hedonic Price Model Results

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heritage	-17.8%	0.006 (***)	log(Area)	-0.351	0.001 (***)
Strata	32.0%	0.004 (***)	log(FSR)	0.242	0.003 (***)
Zoning B – Business (+)	9.5%	0.005 (***)	log(Dist. to coast)	0.106	0.018 (***)
Zoning I – Industrial (+)	-19.1%	0.011 (***)	log(Dist. to Any CBD)	-0.049	0.046 (*)
Zoning M – Mixed Use (+)	21.8%	0.007 (***)	log(Dist. to 2nd tier Centre)	-0.097	0.004 (***)
Main Road 0m – 100m	-6.2%	0.002 (***)	log(Dist. to 3rd tier Centre)	-0.036	0.002 (***)
Main Road 100m – 200m	-1.2%	0.002 (***)	log(SEIFA)	0.010	0.001 (***)

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.6968 with 100953 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

5.4.1.3 THE PARRAMATTA TO LIVERPOOL BRT CATCHMENT PANEL DATA HEDONIC PRICE MODEL RESULTS (2000–2014)

In addition to the 2014 cross-sectional hedonic price model of the Parramatta to Liverpool T-Way, a panel data model from 2000 to 2014 was undertaken to determine the impact of the BRT stations on the land markets in the surrounding catchments. This model fully analyses the impact of the opening of the Parramatta to Liverpool T-Way from the announcement, during construction and through to several years after operation. The Parramatta to Liverpool T-Way Panel Data hedonic price modelling equation is presented in Equation 23. Note that the interaction terms between land use and year and between ferry catchment and year have been omitted for brevity.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Equation 23 – Parramatta to Liverpool T-Way – Panel Data Hedonic Price Modelling Equation

$$
\begin{aligned}
&log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) \\
&+ log(distanycbd) + log(distctr2) + log(distctr3) + \\
&hrail\_0\_400 + hrail\_4\_800 + hrail\_8\_1600 + brt\_0\_400 \\
&+ brt\_400\_800 + brt\_800\_1600 + ferry\_0\_400 + \\
&ferry\_400\_800 + ferry\_800\_1600 + year2001 + \\
&year2002 + year2003 + year2004 + year2005 + \\
&year2006 + year2007 + year2008 + year2009 + \\
&year2010 + year2011 + year2012 + year2013 + \\
&year2014 + hrail400myear2003 + hrail400myear2004 \\
&+ hrail400myear2005 + hrail400myear2006 + \\
&hrail400myear2007 + hrail400myear2008 + \\
&hrail400myear2009 + hrail400myear2010 + \\
&hrail400myear2011 + hrail400myear2012 + \\
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&brt1600myear2009 + brt1600myear2010 + \\
&brt1600myear2011 + brt1600myear2012 + \\
&brt1600myear2013 + brt1600myear2014 + main\_ \\
&road\_0\_100 + main\_road\_1\_200 + log(snamuts11) + \\
&log(seifa\_per) + log(high\_school\_catchment) + heritage \\
&+ strata + zoning + suburb + constant
\end{aligned}
$$

The panel data hedonic price modelling results for the Parramatta to Liverpool T-Way are presented in Tables 16 and 17 and illustrated in Figures 38 and 39.

Table 16 – Parramatta to Liverpool T-Way Subregion – Residential, Business and Mixed Use Land Uses Only – BRT Panel Data Hedonic Price Model Results (2000–2014)

	0m-400m		400m-800m		800m-1600m	
2000	-1.5%	0.004 (***)	-1.2%	0.003 (***)	-1.9%	0.002 (***)
2001	-2.3%	0.004 (*)	-1.0%	0.003 ( )	-1.1%	0.002 (***)
2002	-0.6%	0.004 (*)	0.1%	0.003 (***)	-0.9%	0.002 (***)
2003	3.0%	0.004 (***)	2.4%	0.003 (***)	-0.2%	0.002 (***)
2004	-1.7%	0.004 ( )	-2.9%	0.003 (***)	-3.7%	0.002 (***)
2005	-2.9%	0.004 (***)	-3.6%	0.003 (***)	-3.4%	0.002 (***)
2006	0.0%	0.004 (***)	-2.1%	0.003 (**)	-3.6%	0.002 (***)
2007	-1.1%	0.004 ( )	-3.4%	0.003 (***)	-4.3%	0.002 (***)
2008	-3.5%	0.004 (***)	-4.1%	0.003 (***)	-4.8%	0.002 (***)
2009	-3.9%	0.004 (***)	-4.5%	0.003 (***)	-5.3%	0.002 (***)
2010	-2.9%	0.004 (***)	-4.0%	0.003 (***)	-5.1%	0.002 (***)
2011	-2.0%	0.004 ( )	-3.5%	0.003 (***)	-5.2%	0.002 (***)
2012	-0.9%	0.004 ( )	-2.5%	0.003 (***)	-4.5%	0.002 (***)
2013	-0.7%	0.004 (*)	-3.2%	0.003 (***)	-4.8%	0.002 (***)
2014	0.4%	0.004 (***)	-2.7%	0.003 (***)	-4.4%	0.002 (***)

Notes: Adjusted R-squared: 0.7496 with 1,432,290 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

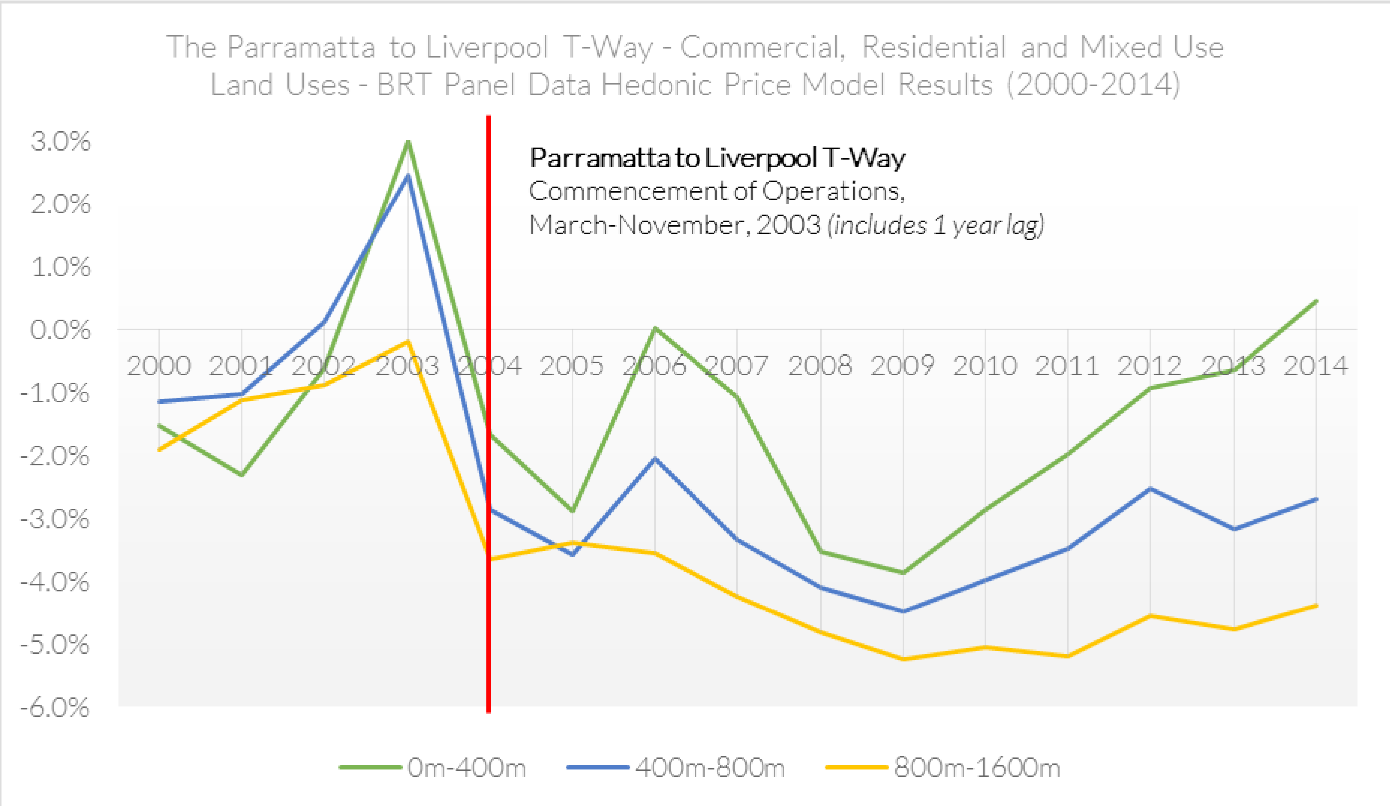

Figure 38 – Parramatta to Liverpool T-Way Subregion – Residential, Business and Mixed Use Land Uses Only – BRT Panel Data Hedonic Price Model Results (2000–2014)

Table 17 – Parramatta to Liverpool T-Way Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

	Business		Industrial		Mixed Use	
2000	15.1%	0.007 (***)	-19.8%	0.016 (***)	-10.4%	0.019 (***)
2001	16.2%	0.007 ( )	-16.5%	0.016 ( )	-13.6%	0.019 (.)
2002	13.4%	0.007 (*)	-18.1%	0.016 ( )	-20.6%	0.019 (***)
2003	17.4%	0.007 (**)	-21.9%	0.016 ( )	-26.0%	0.019 (***)
2004	16.1%	0.007 ()	-18.6%	0.016 (***)	-16.9%	0.019 (***)
2005	37.9%	0.007 (***)	1.6%	0.016 (***)	-13.7%	0.019 (.)
2006	44.4%	0.007 (***)	5.0%	0.016 (***)	-13.0%	0.019 ( )
2007	48.0%	0.007 (***)	9.8%	0.016 (***)	-9.4%	0.019 ( )
2008	48.6%	0.007 (***)	13.6%	0.016 (***)	-5.3%	0.019 (**)
2009	46.5%	0.007 (***)	12.0%	0.016 (***)	-3.1%	0.019 (***)
2010	42.8%	0.007 (***)	5.7%	0.016 (***)	16.1%	0.019 (***)
2011	41.1%	0.007 (***)	2.7%	0.016 (***)	29.2%	0.019 (***)
2012	38.0%	0.007 (***)	1.3%	0.016 (***)	30.5%	0.019 (***)
2013	18.6%	0.007 (***)	-7.1%	0.016 (***)	32.0%	0.019 (***)
2014	13.9%	0.007 (*)	-14.0%	0.016 (***)	26.1%	0.019 (***)

Notes: Adjusted R-squared: 0.7496 with 1,437,290 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1
Results are compared to the Residential zoned land

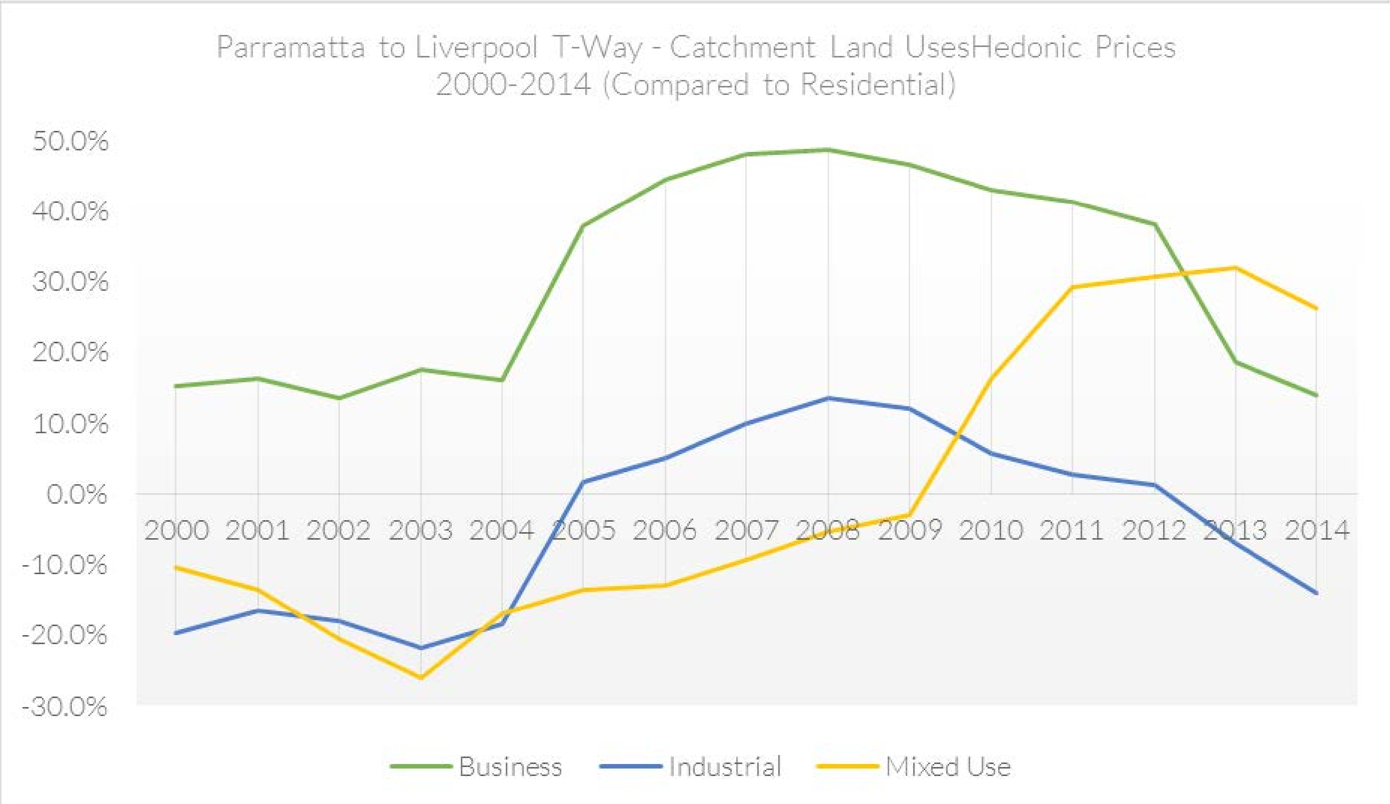

Figure 39 – Parramatta to Liverpool T-Way Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

The Parramatta to Liverpool T-Way corridor results are among the most surprising and interesting of the whole analysis, showing a small increase in the hedonic price leading up to the time of opening in 2003, followed by a stark drop in prices, a modest increase in value prior to the opening of the Parramatta to Rouse Hill T-Way, another drop, and then a gradual recovery in prices between 2009 and the present day. It appears that property price speculation may have driven prices up, but a lack of demand and possibly poor integration with surrounding bus services led to land prices falling until patronage on the services began to increase.

The trend in land zoning values indicates that the Mixed Use zone has been increasing in value since 2003 relative to the Residential zone while the Business and Industrial zones have comparatively come down in price, which is consistent with the metropolitan-wide analysis.

5.4.1.4 PARRAMATTA TO LIVERPOOL T-WAY LINE: ACCESSIBILITY BENEFIT IMPACT ON LAND VALUE

Equation 24 presents the uplift calculation of the Parramatta to Liverpool T-Way although owing to the volatility in the trends in the catchment values, it is unclear whether a true uplift actually occurred, so the calculation is left unspecified.

Equation 24 – Interpretation of the Accessibility-based Land Value Impact of the Parramatta to Liverpool T-Way Subregion

Accessibility Based Land Value Uplift (%) = Inconclusive

5.4.1.5 PARRAMATTA TO LIVERPOOL T-WAY: CHANGE OF ZONING BENEFIT IMPACT ON LAND VALUE

The highest valued land use in the Parramatta to Liverpool T-Way corridor is Mixed Use and the least values is Industrial. Equation 25 demonstrates the land value impact calculation associated with the conversion of industrial land to mixed use, which estimates an uplift of 41.7%.

Equation 25 – Interpretation of the Zoning Change-based Land Value Impact of the Parramatta to Liverpool T-Way Subregion

$$\text{Change of Zoning Based Land Value Uplift (\%)} = Exp(0.218) - Exp(-0.191) = 41.7\%$$

5.4.1.6 PARRAMATTA TO LIVERPOOL T-WAY: CHANGE OF FSR BENEFIT IMPACT ON LAND VALUE

The cross-sectional model reports an FSR elasticity of 0.242. Equation 26 demonstrates how this elasticity can be used to calculate the land value impacts associated with an FSR increase in the Parramatta to Liverpool T-Way corridor, assuming an FSR increase from 0.62 (the corridor average) to an FSR of 4.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Equation 26 – Interpretation of the Increase in FSR-based Land Value Impact on the Parramatta to Liverpool T-Way Subregion

$$FSR\ Based\ Land\ Value\ Uplift\ (\%) = [(4 - 0.62) / 0.62] * 0.242 = 132\%$$

The WTP results for a change in zoning to a higher and better use and increasing FSR demonstrate that there is significant benefit from enabling more intensive urban development within the Parramatta to Liverpool T-Way subregion if activated by the appropriate transit infrastructure. The BRT system may unlock a degree of development potential but investor confidence appears to be absent, as suggested by the modelling results.

5.4.2 THE NORTH WEST T-WAY

The North West T-way consists of two sections, one linking Parramatta railway station and Rouse Hill and the other linking Blacktown and Parklea. The lines intersect at Burns interchange in Parklea.

The North West T-Way is a 24km long bus rapid transit line that includes:

- 21 km of bus-only roads connecting to 3 km of bus lanes on existing roads
- 30 bus stations
- 10 new bridges
- 2 new underpass
- 20 km of off-road cycleway

Private bus operators Busways and Hillsbus operate the T-Way services with many services traversing the T-Way either on the entire route or a section of it. About 20 services currently use the North West T-Way. The T-Way project was approved in February 2004 and construction commenced in mid-2005. The BRT line had a staged opening with the Merriville to Parramatta section opening on 10 March 2007, with Sanctuary and Rouse Hill opening on 25 September 2007 upon the opening of the Rouse Hill Town Centre development, and the final section from Blacktown to Parklea branch opening on 4 November 2007.

The area adjoining the North West T-Way is generally low-density residential with some medium to high-density residential, business and mixed-use zones in the Parramatta and Rouse Hill town centres. The BRT is not believed to have had a considerable impact on land use zoning and densities in the catchments of BRT stops.

5.4.2.1 HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The North West T-Way cross-sectional hedonic price model catchment (see Figure 40) contains 86,605 records, accounting for land use categories falling into the broad categories of Residential, Commercial and Industrial (see Figure 41). The model's input variables and the dataset's descriptive statistics are presented in Table 18.

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Table 18 – North West T-Way Subregion – Hedonic Price Model Descriptive Statistics (2014)

Continuous Variables	Average Values
Unimproved land value (ulv)	$425,590
ln_ulv	12.8
Unimproved land value per square metre (ulvpsm)	$620.55
ln_ulvpsm	6.36
Land area (m^2)	826.32
Floor Space Ratio (fsr)	0.56
Distance to Any CBD	30.64
Distance to Activity Centre Level 1	30.64
Distance to Activity Centre Level 2	4.15
Distance to Activity Centre Level 3	3.62
Distance to Activity Centre Level 4	1.14
Distance to Coast	13.48
SNAMUTS (2011)	3.68
Effective Job Density	139291.82
SEIFA Score	66.47
Dummy Variables	**% of Subregion within the Catchment**
BRT 0–400 m	3%
BRT 400–800 m	9%
BRT 800–1600 m	24%
Heavy Rail 0–400 m	2%
Heavy Rail 400–800 m	4%
Heavy Rail 800–1600 m	17%
Main Road 0–100 m	13%
Main Road 0–200 m	26%

5.4.2.2 NORTH WEST T-WAY 2014 CROSS-SECTIONAL HEDONIC PRICE MODEL

The North West T-Way cross-sectional model analyses the importance of all the explanatory variables on unimproved land value per square metre in 2014. The HPM equation for the North West T-Way cross-sectional model is presented in Equation 27. Note that the model includes controls for the North West T-Way as well as the heavy rail lines it intersects with at Parramatta and Blacktown.

Equation 27 – North West T-Way Subregion – Hedonic Price Modelling Equation

$$\begin{gathered} log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) \\ + log(distanycbd) + log(distctr2) + log(distctr3) \\ + hrail\_0\_400 + hrail\_400\_800 + hrail\_800\_1600 \\ + brt\_0\_400 + brt\_400\_800 + brt\_800\_1600 + + \\ ferry\_0\_400 + ferry\_400\_800 + ferry\_800\_1600 + \\ main\_road\_0\_100 + main\_road\_1\_200 + log(seifa\_per) + \\ heritage + strata + zoning + suburb + constant \end{gathered}$$

The BRT stations along the route are at grade along main roads, with limited to no integration with the surrounding land uses. Table 19 presents the results of the cross-sectional hedonic price modelling for 2014.

Interestingly, compared to the Parramatta to Liverpool T-Way cross-sectional model, the signs on the two BRT models are similar with regard to the magnitudes of their estimated FSR and Industrial zone coefficients, with the FSR being among the highest reported by any of the models and industrial land and proximity to a main

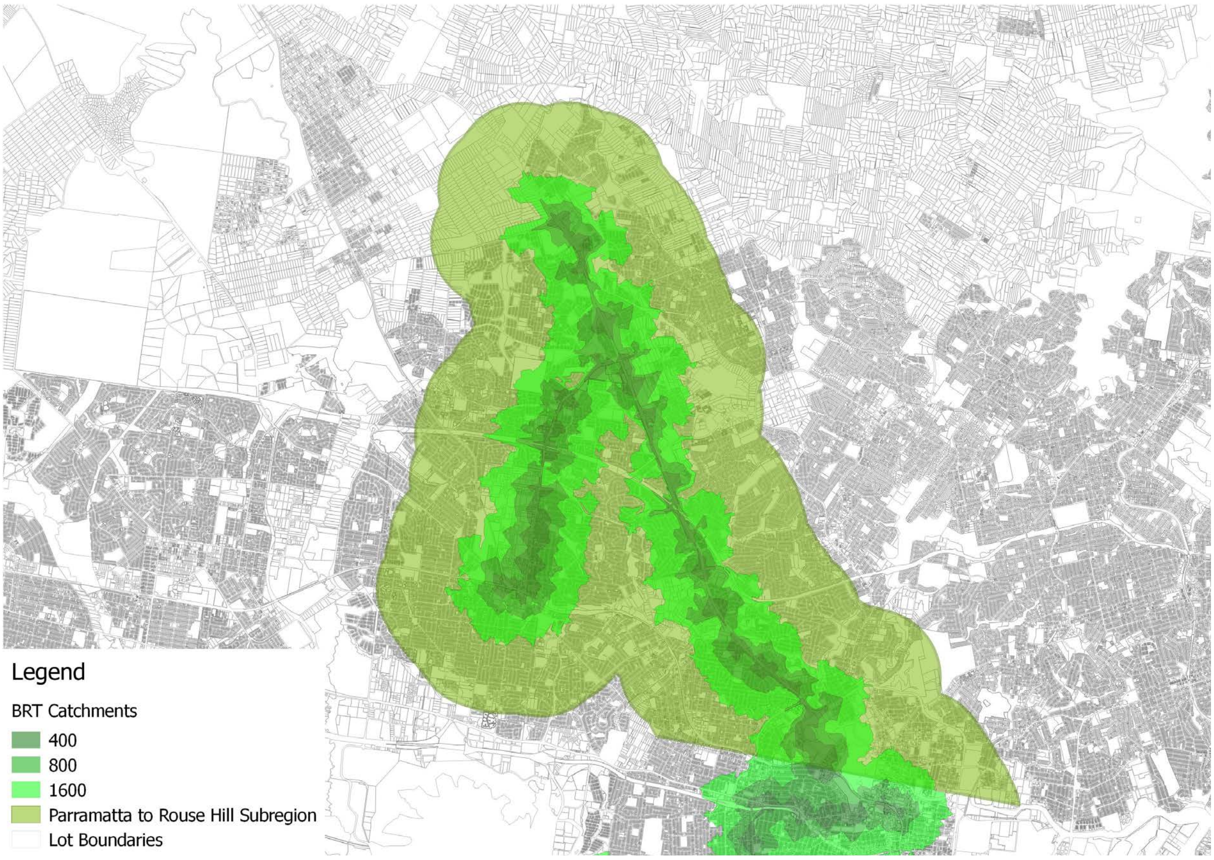

Figure 40 – North West T-Way Subregion Map

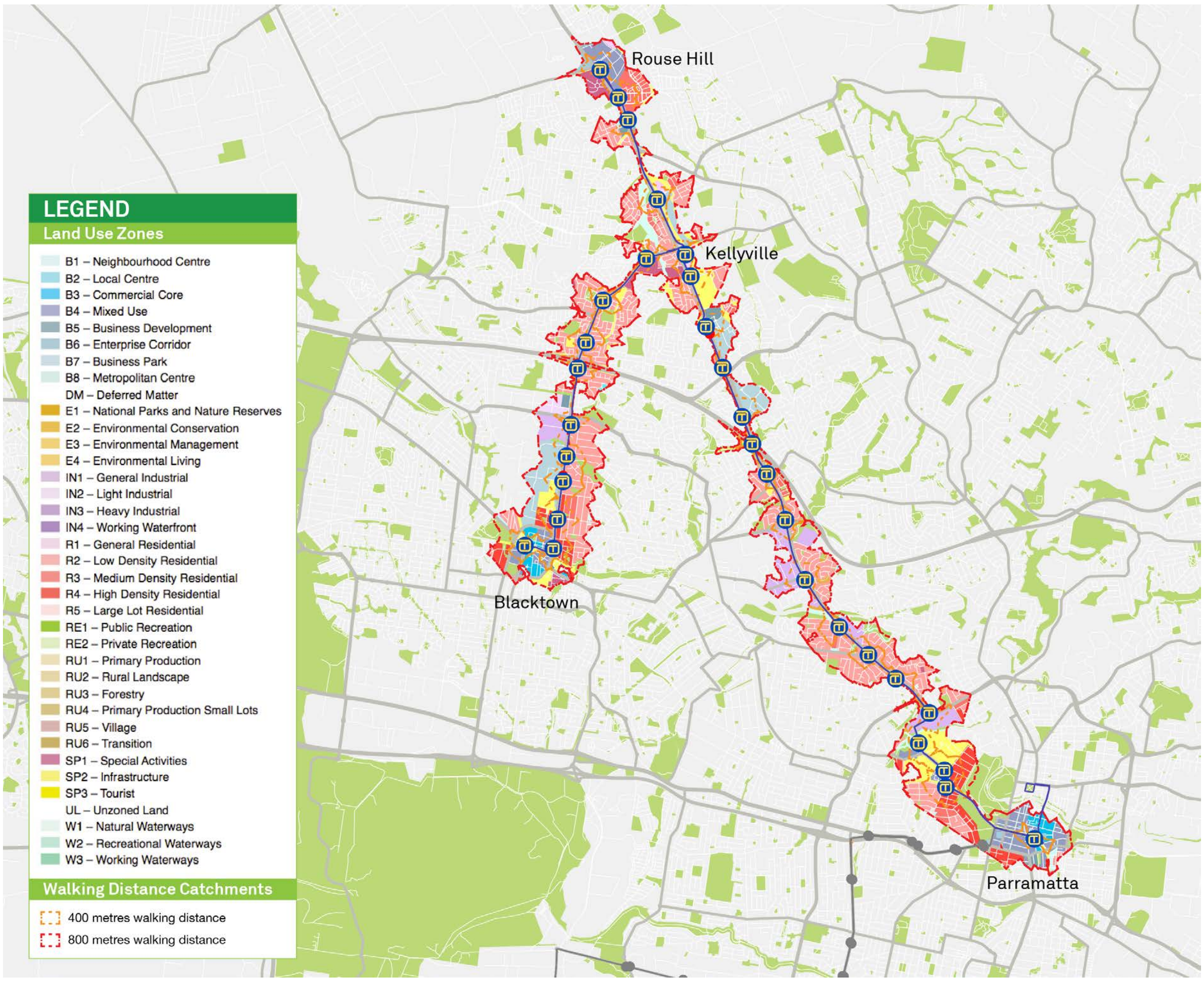

Figure 41 – North West T-Way Land Use Zoning Map

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

road being among the least negative. The relatively high FSR values could simply be the result of the overall low FSR values for both subregions so any increase from a very low base could lead to significant value uplift.

5.4.3 NORTH WEST T-WAY CATCHMENT PANEL DATA HEDONIC PRICE MODEL RESULTS (2000–2014)

In addition to the 2014 cross-sectional hedonic price model of the Parramatta to Rouse Hill T-Way, a panel data model from 2000 to 2014 was created to determine the impact of the BRT route on the land markets in the surrounding catchments over time. This model fully analyses the impact of the opening of the Parramatta to Rouse Hill T-Way from announcement, through construction and to several years after operation. The Parramatta to Rouse Hill T-Way panel data hedonic price modelling equation is presented in Equation 28.

Note that the interaction terms between land use and year and between ferry catchment and year have been omitted for brevity.

Table 19 – North West T-Way Subregion – Cross-Sectional Hedonic Price Model Results

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heritage	-7.5%	0.009 (***)	log(Area)	-0.425	0.001 (***)
Strata	32.1%	0.004 (***)	log(FSR)	0.298	0.004 (***)
Zoning B – Business (+)	2.2%	0.007 (**)	log(Dist. to coast)	-0.057	0.017 (***)
Zoning I – Industrial (+)	-14.0%	0.022 (***)	log(Dist. to Any CBD)	0.088	0.035 (*)
Zoning M – Mixed Use (+)	33.1%	0.011 (***)	log(Dist. to 2nd tier Centre)	-0.023	0.002 (***)
Main Road 0m – 100m	-4.5%	0.002 (***)	log(Dist. to 3rd tier Centre)	-0.008	0.002 (***)
Main Road 100m – 200m	1.6%	0.002 (***)	log(SEIFA)	0.051	0.001 (***)

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.8078 with 85,662 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

5. METROPOLITAN SYDNEY SUBREGIONAL HEDONIC PRICE MODELS

Equation 28 – North West T-Way Subregion – Panel Data Hedonic Price Modelling Equation

$$\log(ulvpsm) \sim \log(area) + \log(fsr) + \log(distcoast) + \log(distanycbd) + \log(distctr2) + \log(distctr3) + hrail\_0\_400 + hrail\_4\_800 + hrail\_8\_1600 + brt\_0\_400 + brt\_400\_800 + brt\_800\_1600 + ferry\_0\_400 + ferry\_400\_800 + ferry\_800\_1600 + year2001 + year2002 + year2003 + year2004 + year2005 + year2006 + year2007 + year2008 + year2009 + year2010 + year2011 + year2012 + year2013 + year2014 + hrail400myear2001 + hrail400myear2002 + hrail400myear2003 + hrail400myear2004 + hrail400myear2005 + hrail400myear2006 + hrail400myear2007 + hrail400myear2008 + hrail400myear2009 + hrail400myear2010 + hrail400myear2011 + hrail400myear2012 + hrail400myear2013 + hrail400myear2014 + hrail800myear2001 + hrail800myear2002 + hrail800myear2003 + hrail800myear2004 + hrail800myear2005 + hrail800myear2006 + hrail800myear2007 + hrail800myear2008 + hrail800myear2009 + hrail800myear2010 + hrail800myear2011 + hrail800myear2012 + hrail800myear2013 + hrail800myear2014 + hrail1600myear2001 + hrail1600myear2002 + hrail1600myear2003 + hrail1600myear2004 + hrail1600myear2005 + hrail1600myear2006 + hrail1600myear2007 + hrail1600myear2008 + hrail1600myear2009 + hrail1600myear2010 + hrail1600myear2011 + hrail1600myear2012 + hrail1600myear2013 + hrail1600myear2014 + brt400myear2001 + brt400myear2002 + brt400myear2003 + brt400myear2004 + brt400myear2005 + brt400myear2006 + brt400myear2007 + brt400myear2008 + brt400myear2009 + brt400myear2010 + brt400myear2011 + brt400myear2012 + brt400myear2013 + brt400myear2014 + brt800myear2001 + brt800myear2002 + brt800myear2003 + brt800myear2004 + brt800myear2005 + brt800myear2006 + brt800myear2007 + brt800myear2008 + brt800myear2009 + brt800myear2010 + brt800myear2011 + brt800myear2012 + brt800myear2013 + brt800myear2014 + brt1600myear2001 + brt1600myear2002 + brt1600myear2003 + brt1600myear2004 + brt1600myear2005 + brt1600myear2006 + brt1600myear2007 + brt1600myear2008 + brt1600myear2009 + brt1600myear2010 + brt1600myear2011 + brt1600myear2012 + brt1600myear2013 + brt1600myear2014 + main\_road\_0\_100 + main\_road\_1\_200 + \log(snamuts11) + \log(seifa\_per)\ \log(high\_school\_catchment) + heritage + strata + zoning + suburb + constant$$

The panel data hedonic price modelling results for the North West T-Way are presented in Tables 20 and 21 and illustrated in Figures 42 and 43.

The trend in land values within the T-Way BRT catchments in Figure 42 suggests that opening of the BRT route had a positive effect on land values as at the commencement of operation, the prices progressively improved, with a slight dip towards the end of the time series. The scale of the uplift in the value is around 4–5% which may be due to a range of factors including the impending announcement of the North West Rail (now Sydney Metro) project.

With respect to the land use prices in Figure 43, the results show quite clearly an appreciation in the Mixed Use zone and some depreciation in the Business and Industrial zones relative to the Residential zone, which matches the trend in the Parramatta to Liverpool

Table 20 – North West T-Way Subregion – Residential, Business and Mixed Use Land Uses Only – BRT Panel Data Hedonic Price Model Results

	400m		800m		1600m	
2000	3.9%	0.005 (***)	3.8%	0.003 (***)	2.1%	0.002 (***)
2001	1.8%	0.005 (***)	1.7%	0.003 (***)	0.9%	0.002 (***)
2002	0.3%	0.005 (***)	0.0%	0.003 (***)	-0.2%	0.002 (***)
2003	-1.9%	0.005 (***)	-1.1%	0.003 (***)	-1.2%	0.002 (***)
2004	-2.3%	0.005 (***)	-2.7%	0.003 (***)	-2.1%	0.002 (***)
2005	-2.8%	0.005 (***)	-3.0%	0.003 (***)	-2.1%	0.002 (***)
2006	-2.2%	0.005 (***)	-2.1%	0.003 (***)	-1.7%	0.002 (***)
2007	0.3%	0.005 (***)	0.3%	0.003 (***)	0.0%	0.002 (***)
2008	3.3%	0.005 ( )	1.9%	0.003 (***)	0.7%	0.002 (***)
2009	1.5%	0.005 (***)	1.2%	0.003 (***)	0.2%	0.002 (***)
2010	0.6%	0.005 (***)	0.9%	0.003 (***)	0.2%	0.002 (***)
2011	1.5%	0.005 (***)	2.2%	0.003 (***)	1.2%	0.002 (***)
2012	1.3%	0.005 (***)	2.0%	0.003 (***)	1.4%	0.002 (***)
2013	3.7%	0.005 ( )	3.7%	0.003 ( )	2.8%	0.002 (***)
2014	2.6%	0.005 (**)	2.6%	0.003 (***)	2.1%	0.002 ( )

Notes: Adjusted R-squared: 0.8389 with 1,144,080 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

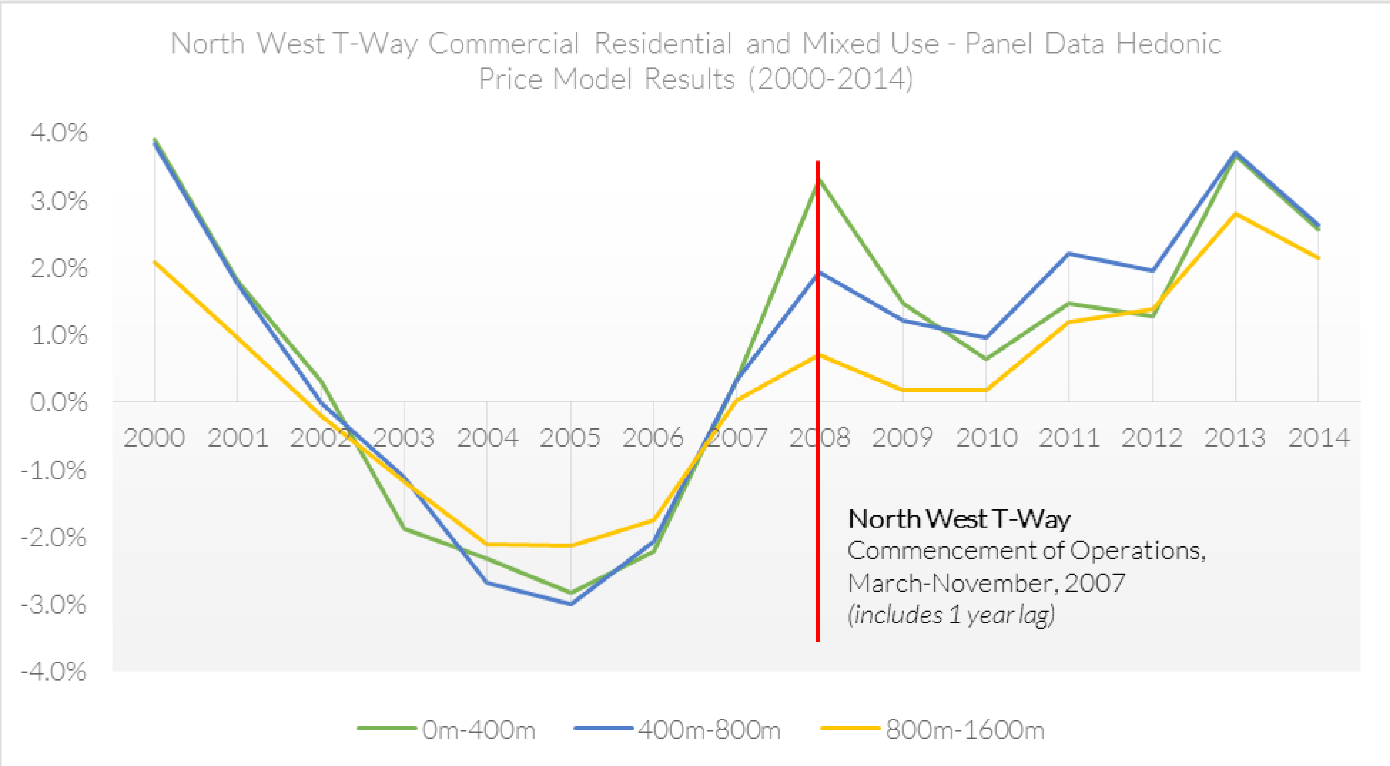

Figure 42 – North West T-Way – Residential, Business and Mixed Use Land Uses Only – BRT Panel Data Hedonic Price Model Results (2000–2014)

Table 21 – North West T-Way Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

	Business		Industrial		Mixed Use	
2000	8.0%	0.009 (***)	22.7%	0.017 (***)	-27.8%	0.044 (***)
2001	8.0%	0.009 ( )	21.4%	0.017 ( )	-27.0%	0.044 ( )
2002	1.7%	0.009 (***)	15.5%	0.017 (***)	-29.3%	0.044 ( )
2003	-6.4%	0.009 (***)	4.0%	0.017 (***)	-32.2%	0.044 ( )
2004	-4.0%	0.009 (***)	-3.0%	0.017 (***)	-28.0%	0.044 ( )
2005	8.1%	0.009 ( )	6.6%	0.017 (***)	-26.3%	0.044 ( )
2006	15.9%	0.009 (***)	16.2%	0.017 (***)	-24.4%	0.044 ( )
2007	32.1%	0.009 (***)	25.9%	0.017 (.)	-11.1%	0.044 (***)
2008	33.8%	0.009 (***)	27.1%	0.017 (**)	-8.7%	0.044 (***)
2009	33.2%	0.009 (***)	28.0%	0.017 (**)	-4.7%	0.044 (***)
2010	32.0%	0.009 (***)	22.7%	0.017 ( )	-2.2%	0.044 (***)
2011	27.6%	0.009 (***)	42.5%	0.017 (***)	21.8%	0.044 (***)
2012	24.6%	0.009 (***)	35.5%	0.017 (***)	21.1%	0.044 (***)
2013	15.0%	0.009 (***)	7.9%	0.017 (***)	47.1%	0.044 (***)
2014	10.2%	0.009 (*)	-6.4%	0.017 (***)	43.7%	0.044 (***)

Notes: Adjusted R-squared: 0.8389 with 1,144,080 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1
Results are compared to the Residential zoned land

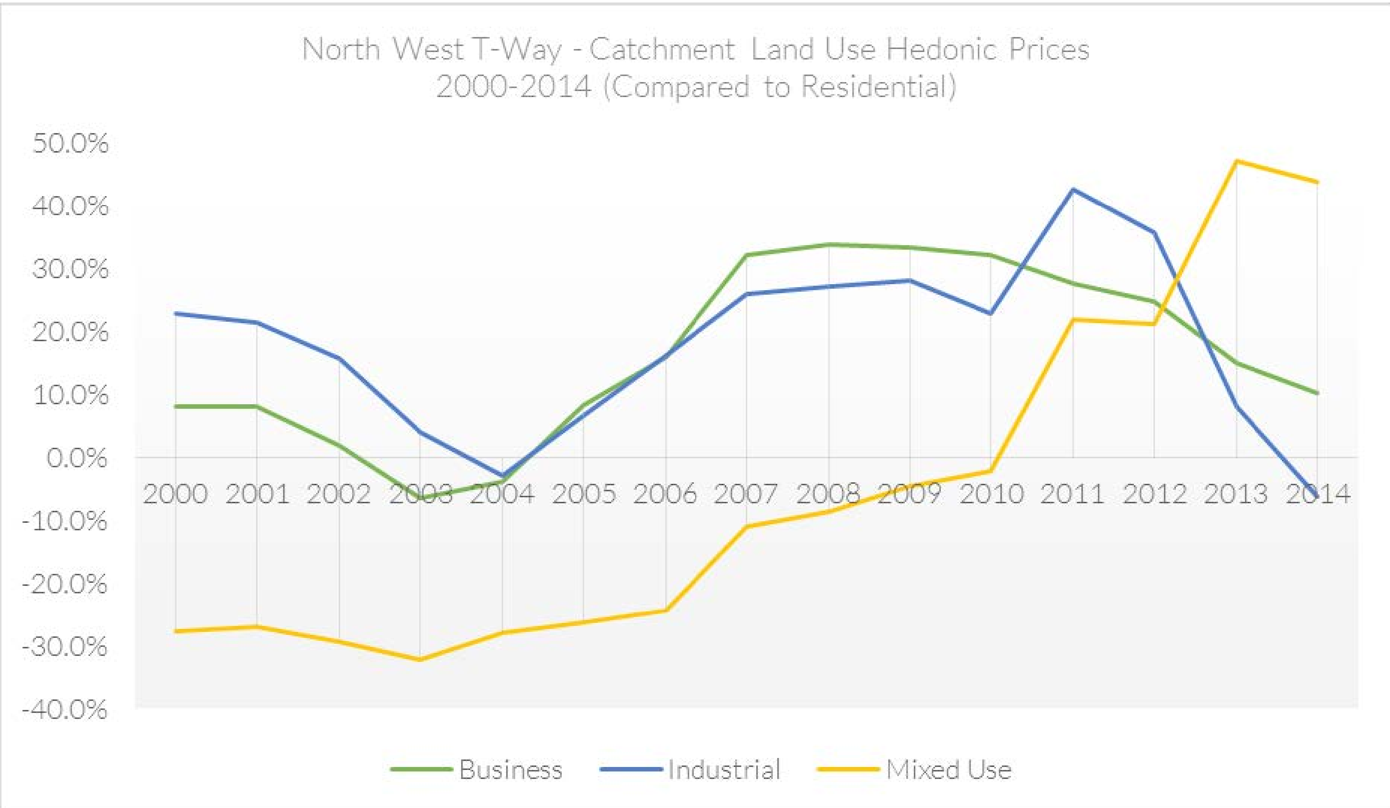

Figure 43 – North West T-Way Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014) (Compared to Residential Land Use)

T-Way subregion model as well as the metropolitan-wide modelling. This might be because Mixed Use and Residential zoned land are going up in value as the centres along the alignment, and Parramatta City in particular, continue to grow in population.

5.4.3.1 PARRAMATTA TO ROUSE HILL T-WAY LINE: ACCESSIBILITY BENEFIT IMPACT ON LAND VALUE

Equation 29 demonstrates the calculated uplift associated with the investment in the Parramatta to Rouse Hill T-Way; however, owing to the volatility of land values in the subregion suggesting negative impacts during announcement and construction with a gradual recovery several years after the start of operations, the calculation is left unspecified.

Further, complexity is associated with the North West Rail Link, mainly it was announced a few times, had the concept plan approved in 2006, was re-announced in 2011 and got planning approval and property acquisition in 2012, and construction started in 2013. There is a valid argument that property values in this corridor would have been impacted by this, especially in the northern section of the BRT closer to Rouse Hill. This reinforces the decision to leave it unspecified.

Equation 29 – Interpretation of the accessibility based Land Value impact on the Parramatta to Rouse Hill T-Way subregion

Accessibility Based Land Value Uplift (%) = Inconclusive

5.4.3.2 PARRAMATTA TO ROUSE HILL T-WAY: CHANGE OF ZONING BENEFIT IMPACT ON LAND VALUE

The cross-sectional model results report that the Mixed Use zone is valued the most in the subregion and the Industrial zone is valued the least. Equation 30 demonstrates the calculated uplift associated with the rezoning of land from Industrial to Mixed Use.

Equation 30 – Interpretation of the Zoning Change-based Land Value Impact on the Parramatta to Rouse Hill T-Way Subregion

$$\text{Change of Zoning Based Land Value Uplift (\%)} = Exp(0.331) - Exp(-0.140) = 52.3\%$$

5.4.4 PARRAMATTA TO ROUSE HILL T-WAY CHANGE OF FSR BENEFIT IMPACT ON LAND VALUE

The estimated FSR elasticity for the Parramatta to Rouse Hill T-Way subregion is 0.298. Equation 31 demonstrates the calculated land value uplift associated with increasing a land parcel's FSR from the existing corridor average of 0.56 to an FSR of 4.

Equation 31 – Interpretation of the Increase in FSR-based Land Value Impact on the Parramatta to Rouse Hill T-Way Subregion

$$\text{FSR Based Land Value Uplift (\%)} = [(4 - 0.56)/0.56] * 0.298 = 183.1\%$$

These WTP results for a change in zoning to a higher and better use and increasing FSR demonstrate that there is significant benefit from enabling more intensive urban development within the Parramatta to Rouse Hill

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T-Way subregion if activated by the appropriate transit infrastructure. The BRT system may unlock a degree of development potential but investor confidence appears to be absent, as suggested by the modelling results.

5.5 TRANSIT-ORIENTED URBAN RENEWAL

There are always a significant number of urban renewal and regeneration projects being undertaken in Sydney at any time. The Green Square and Mascot urban renewal precincts along the Airport Link Rail Corridor have been selected for analysis, as they are ongoing projects that are located near transit, they include a mix of public sector and private sector projects in relatively typical locations (away from the coast), and they have some legacy issues to overcome. These projects have also been undertaken over a relatively long period of time which corresponds to the land valuation data set used for this study.

Both of these redevelopment precincts along the Airport Link rail line are analysed together over the period 2000 to 2014. Although both of these sites are still under redevelopment, the analysis captures the majority of the pre- and post-redevelopment change for the site and the surrounding area.

The Sydney Airport Link connects the airport to the Sydney CBD to the north at Central, and onto Sydney's south-west suburbs by the East Hills Line (T2) to the south at Wolli Creek. A private company operates the line (the Airport Link Company), and under their contract, they can charge a surcharge on top of the normal fare.

The line was first proposed in 1990, its construction began in 1995, and it opened in 2000. Five stations were constructed, with two at the airport's international and domestic terminals, one each at the urban redevelopment areas at Green Square and Mascot, and a new station at Wolli Creek where it joins the East Hills Line. The pedestrian catchments to the Green Square and Mascot urban renewal areas are presented in Figure 44, and land uses present in the catchments are presented in Figure 45.

5.5.1 GREEN SQUARE

The Green Square Urban Renewal Area is approximately 278 hectares of land located in the suburbs of Alexandria, Zetland, Waterloo, Roseberry and Beaconsfield, about 4 km south of Sydney's CBD. Green Square is one of Australia's biggest urban renewal projects and is serviced by the Green Square Railway Station.

The Green Square area was previously an industrial precinct and is envisioned to be transformed into 'a place of innovative housing design, bespoke business and retail, and creative and engaged communities proud of their area's past and future' (City of Sydney Council). The area is expected to accommodate 10,000 additional apartments in the next 4 years with the population of Green Square projected to increase by 19,000 in 2019 and reach 53,000 at full completion by around 2030.

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The development of the Green Square Urban Renewal Area commenced around the former ACI Glassworks site and Victoria Park in 1997. Progress of the development was initially slow but picked up pace substantially in recent years. The development of Green Square Town Centre commenced in 2007, following an international design competition; however, the project made relatively slow progress during the period between 2007 and 2012. In 2012, the Government announced the demolition of the dilapidated Joynton Smith building at the old Royal South Sydney Hospital site to kick-start the $8 billion project. In 2011, the amended LEP was approved, which included additional development height and bulk, increased retail and commercial space, and a new library and plaza near the Green Square railway station.

Figure 44 – Green Square Urban Renewal Area (Urban Growth, NSW, 2016)

5.5.2 MASCOT STATION PRECINCT

The Mascot Station Precinct is located within the southern industrial area adjacent to Sydney Airport. Successive planning studies, including the 'Botany Bay Planning Strategy 2031' and the 'LEP Standards and Urban Design Controls for the City of Botany Bay' have identified Mascot Station Town Centre Precinct as the focus for increased population growth in the City of Botany Bay. The natural transition of the precinct from its traditional general industrial land use base to more intensive forms of employment generating development was initially hampered by constraints which included generally small lot sizes, multiple property owners, zoning restrictions, a restricted road network, and limited access associated with the construction of the Mascot Station.

In 2012, the Council finalised a masterplan for the area (see Figure 45) that identified revised height and FSR controls for the area. Since approval of this plan, the area has seen rapid development of the town centre including a mixed use residential and retail precinct around the station and high-density residential uses further afield. The new LEP allows for heights of 44 m or 13 levels within mixed use developments throughout the area. This will accommodate around 4,200 new dwellings and 4,000 new jobs.

Figure 45 – Mascot Station Precinct Urban Renewal Area (Botany Council, 2015)

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Table 22 – Green Square/Mascot Urban Renewal Areas – Hedonic Price Model Descriptive Statistics

Continuous Variables	Average Values
Unimproved land value (ulv)	$1,457,247
ln_ulv	13.71
Unimproved land value per square metre (ulvpsm)	$2,139
ln_ulvpsm	7.58
Land area (m^2)	883.14
Floor Space Ratio (fsr)	1
Distance to Any CBD	4.91
Distance to Activity Centre Level 1	4.91
Distance to Activity Centre Level 2	3.36
Distance to Activity Centre Level 3	1.79
Distance to Activity Centre Level 4	0.7
Distance to Coast	3.34
SNAMUTS (2011)	11.76
Effective Job Density	263165.96
SEIFA Score	59.96
Dummy Variables	**% of Subregion within the Catchment**
Heavy Rail 0–400 m	3%
Heavy Rail 400–800 m	13%
Heavy Rail 800–1600 m	28%
Main Road 0–100 m	32%
Main Road 0–200 m	56%

5.5.3 AIRPORT LINK PANEL DATA HEDONIC PRICE MODEL DESCRIPTIVE STATISTICS

The Green Square/Mascot urban renewal area hedonic price model catchment (see Figure 46) contains 27,351 records in 2014, accounting for land use classifications falling into the broad categories of Residential, Commercial, and Industrial (see Figure 47). The model's input variables and the dataset's descriptive statistics are presented in Table 22.

5.5.4 GREEN SQUARE/MASCOT URBAN RENEWAL AREAS: 2014 CROSS-SECTIONAL HEDONIC PRICE MODEL

The Green Square/Mascot urban renewal areas cross-sectional model analyses the importance of all the explanatory variables on the natural log of unimproved land value per square metre. The estimated model is presented below in Equation 32.

Equation 32 – Airport Link Subregion – Cross-Sectional Hedonic Price Modelling Equation

$$log(ulvpsm) \sim log(area) + log(fsr) + log(distcoast) + log(distanycbd) + log(distctr2) + log(distctr3) + hrail\_0\_400 + hrail\_400\_800 + hrail\_800\_1600 + main\_road\_0\_100 + main\_road\_1\_200 + log(seifa\_per) + heritage + strata + zoning + suburb + constant$$

As illustrated in Figures 44 and 45, the Airport Line passes through two large urban renewal precincts, two of Australia's busiest airport terminals, and runs adjacent to the port and industrial land markets of Port Botany. The complexity of these land markets introduces

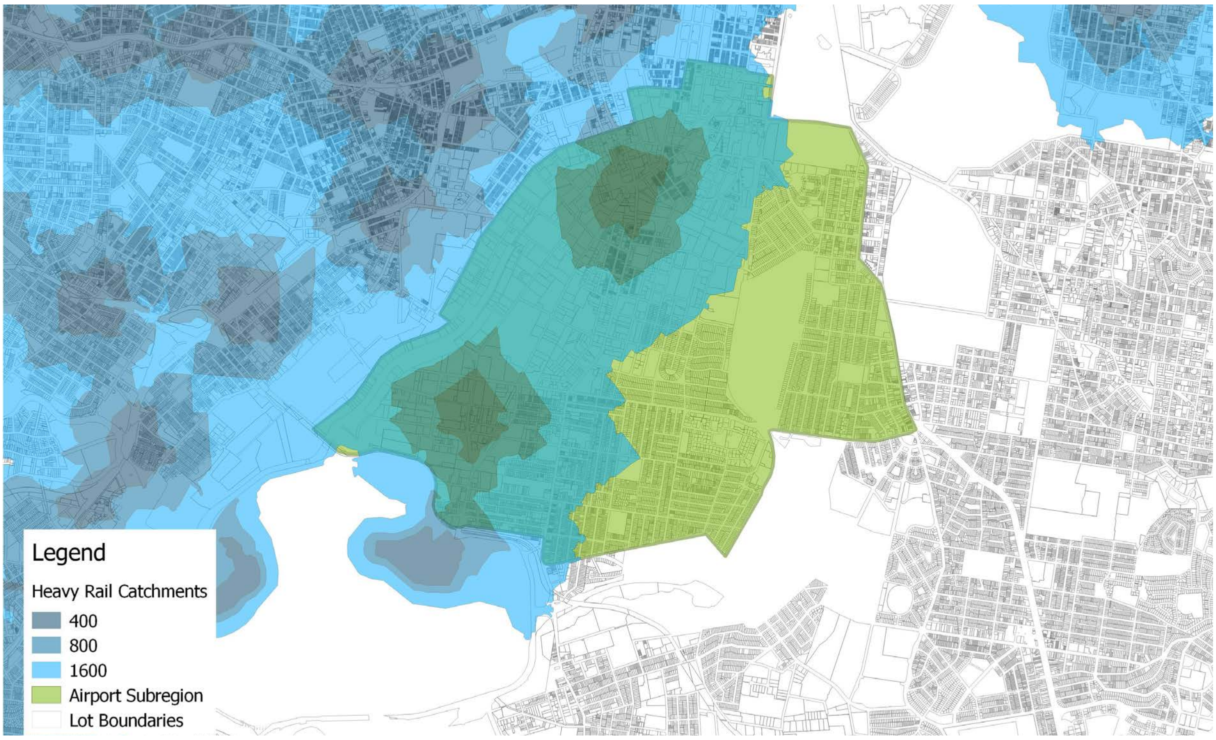

Figure 46 – Green Square/Mascot Urban Renewal Areas Subregion Map

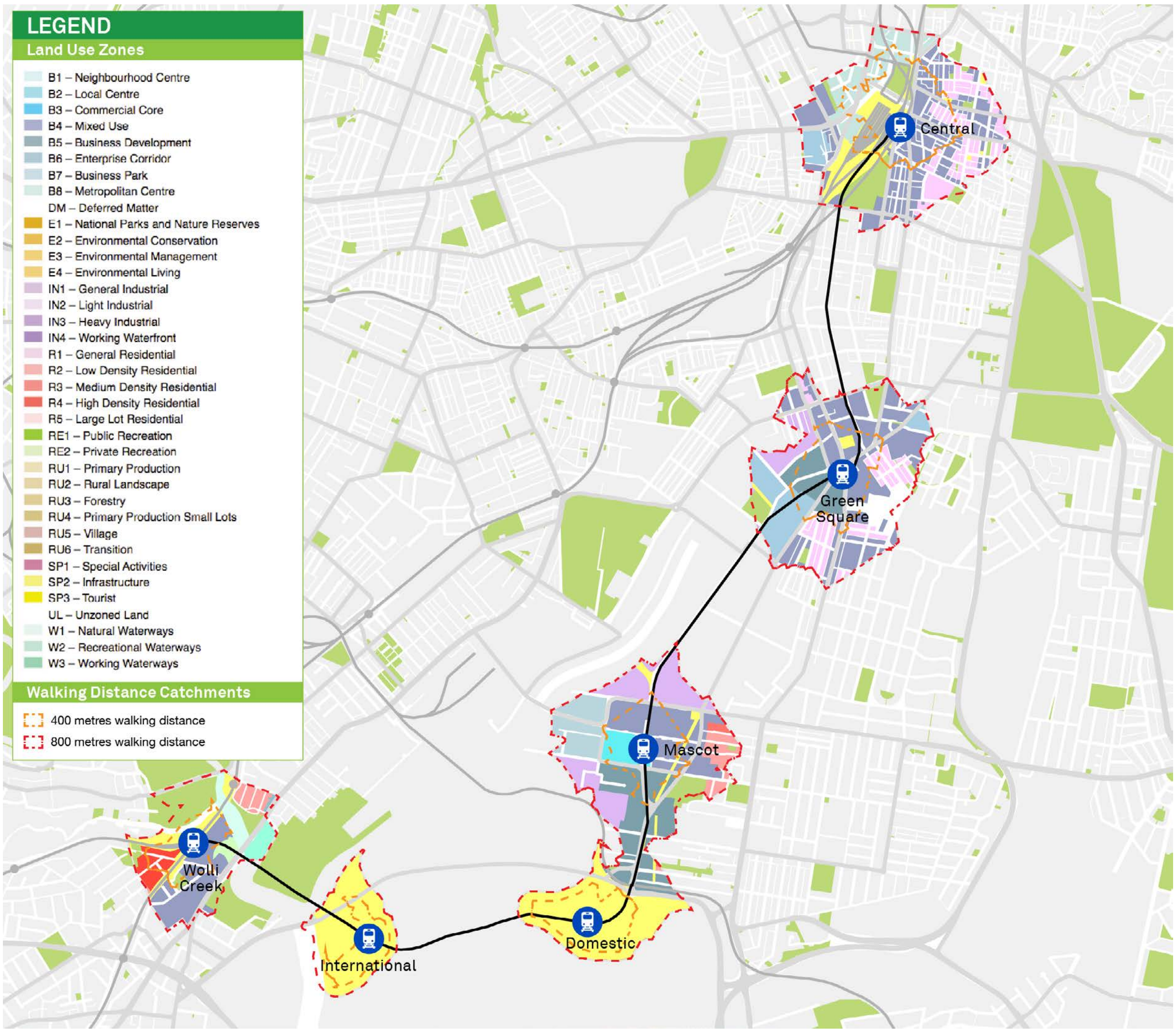

Figure 47 – Airport Link Land Use Zoning Map, with the Green Square/Mascot Urban Renewal Areas Presented along the Alignment

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Table 23 – Green Square/Mascot Urban Renewal Areas – 2014 Cross-Sectional Hedonic Price Model Results

Key Statistics for the Region	% Uplift in Land Value	Standard Error (Sig. Level)		Elasticity	Standard Error (Sig. Level)
Dummy Catchments (% Value premium)			**Continuous Variables (Elasticity)**		
Heritage	-19.0%	0.012 (***)	log(Area)	-0.227	0.005 (***)
Strata	20.9%	0.014 (***)	log(FSR)	0.204	0.012 (***)
Zoning B – Business (+)	-25.4%	0.016 (***)	log(Dist. to coast)	-0.033	0.049 ( )
Zoning I – Industrial (+)	-44.6%	0.037 (***)	log(Dist. to Any CBD)	0.098	0.053 (.)
Zoning M – Mixed Use (+)	-1.0%	0.016 ( )	log(Dist. to 2nd tier Centre)	-0.219	0.024 (***)
Main Road 0m – 100m	-5.0%	0.008 (***)	log(Dist. to 3rd tier Centre)	-0.112	0.013 (***)
Main Road 100m – 200m	-1.6%	0.008 (*)	log(SEIFA)	0.028	0.008 (***)

Notes: (+) Compared to the Residential zoning
Adjusted R-squared: 0.4679 with 8,602 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

a significant level of uncertainty in the hedonic price modelling of the land markets to determine the impact of the airport line and urban regeneration on land values, and this is reflected in the adjusted R2 of 46.8%, which is considerably lower than that noted for the metropolitan-wide or any other project-based model.

Table 23 presents the 2014 cross-sectional HPM results and reports a modestly high FSR elasticity of 0.20, which is slightly below that of the metropolitan-wide model. The model reports that the most valued land uses are Residential and Mixed Use with no difference between them, as the Mixed Use zoning coefficient is small and statistically insignificant. The distance to coast coefficient is small and negative and the distance to CBD coefficient is of an unexpected sign; however, given the small geographic extent of the subregion, it is understandable that some of the distance metrics may not report robustly owing to a lack of leverage (variation) in the data.

5.5.5 MASCOT AND GREEN SQUARE PANEL DATA HEDONIC PRICE MODEL

In addition to the 2014 Mascot and Green Square cross-sectional HPM, a panel data model for the subregion was analysed from 2000 to 2014, from commencement of operations to current day. Whilst it would have been preferable to analyse the impact of the line prior to announcement and during the construction of the line, this was not possible owing to issues with the recording of land valuations data prior to 2000. The Mascot and Green Square panel data hedonic price modelling equation is presented in Equation 33. Note that the interaction terms between land use and year have been omitted for brevity.

Equation 33 – Airport Link Subregion – Panel Data Hedonic Price Modelling Equation

$$\begin{aligned}
&\mathit{log(ulvpsm)} \sim \mathit{log(area)} + \mathit{log(fsr)} + \mathit{log(distcoast)} + \mathit{log(distanycbd)} + \mathit{log(distctr2)} + \mathit{log(distctr3)} + \\
&\mathit{hrail_0_400} + \mathit{hrail_4_800} + \mathit{hrail_8_1600} + \mathit{year2001} + \mathit{year2002} + \mathit{year2003} + \mathit{year2004} + \mathit{year2005} + \\
&\mathit{year2006} + \mathit{year2007} + \mathit{year2008} + \mathit{year2009} + \mathit{year2010} + \mathit{year2011} + \mathit{year2012} + \mathit{year2013} + \\
&\mathit{year2014} + \mathit{hrail400myear2001} + \mathit{hrail400myear2002} + \mathit{hrail400myear2003} + \mathit{hrail400myear2004} + \\
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&\mathit{hrail1600myear2013} + \mathit{hrail1600myear2014} + \mathit{main_road_0_100} + \mathit{main_road_1_200} + \mathit{log(snamuts11)} + \\
&\mathit{log(seifa_per)} + \mathit{log(high_school_catchment)} + \mathit{heritage} + \mathit{strata} + \mathit{zoning} + \mathit{suburb} + \mathit{constant}
\end{aligned}$$

5.5.6 SUMMARY OF THE MASCOT AND GREEN SQUARE PANEL DATA HEDONIC PRICE MODEL RESULTS

The catchments of the airport link stations experienced significant land use change over the analysis period, particularly with the establishment of the Green Square Urban Renewal Area and commencement of construction of the Green Square Town Centre in 2007, which saw the beginning of the transformation of the area from its industrial past into what is envisioned to be a vibrant and active mixed use precinct. The Airport Link between Green Square and International Airport has been relatively underutilised as compared with the rest of Sydney's rail network[20,21]. According to the Compendium of Sydney Rail Travel Statistics (2012), only 7% of all trips generated within the station catchments of the Airport Link used rail as the mode of travel to work, while 58% of journeys were made by private vehicles and 22% by buses.

The average percentage of rail usage in Sydney's overall rail catchment area is 18%. The relative low usage of rail in the Airport Link subregion could be associated with the surcharge station access fees for the first 10 years of operation of the project. In 2011, the State Government announced that the Government would cover the station access fees to Green Square and Mascot stations, meaning passengers could pay normal fees to access these stations. This can go some way to explain the sudden increase in hedonic prices from 2011 onwards, particularly in the 400m and 800m catchments, demonstrating the demand for residential and business land and development within proximity to the Airport Link rail stations.

20 Compendium of Sydney Rail Travel Statistics (2012) http://www.bts.nsw.gov.au/ArticleDocuments/79/r2012-11-rail-compendium.pdf.aspx

21 This has picked up massively with the removal of the station access fee for Mascot/Green Square

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Although the modelling does not extend back far enough to determine the impact of the monetisation of accessibility into the land markets, the HPM does demonstrate a strong positive response to being within the catchment over the analysis period. Figure 48 illustrates that whilst the land value fluctuations are likely owing to the urban renewal investment cycle at Mascot and Green Square, the long-term trend is a benefit of 16.3% within the 400m catchments, 16.0% within the 400m to 800m catchments, and 18.5% within the 800m to 1600m catchments, relative to all land parcels in the subregion beyond 1600m from a station. Again, notably the catchment land values began to increase after 2007 when the development of the Green Square commenced.

Table 25 and Figure 49 demonstrate the zoning premium of the Business zone (i.e. Commercial, Business Parks, etc.), reflecting the dominance of this land use category and the fact that both the Business and Industrial zones seem to move together in Figure 49 suggests that they may in fact have remained relatively constant over the analysis period and that it was Residential zoned land that decreased in the middle years, as that was the reference category.

5.5.7 PHASE 1 – GREEN SQUARE AND MASCOT: ACCESSIBILITY BENEFIT IMPACT ON LAND VALUE

In this case study, the uplift percentage due to accessibility is unknown as the monetisation of accessibility into the Green Square and Mascot land markets occurred prior to the assessment period and is therefore impossible to be determined; however, an uplift associated with urban renewal taking place around the stations can be considered. In this case, we adopted the change in land values that occurred between the years 2007 and 2014 in the 0-m to 400m catchment.

Equation 34 – Interpretation of the Impact of Changing Accessibility on Land Values in the Airport Link Subregion

$$\textit{Urban Renewal Based Land Value Uplift (\%)} = \\ Exp(0.163) - 1 = 17.7\%$$

5.5.8 PHASE 2 – GREEN SQUARE AND MASCOT: CHANGE OF ZONING BENEFIT IMPACT ON LAND VALUE

The highest valued land use in the assessment subregion is the Residential zone. Therefore, utilising the outputs from the cross-sectional model and converting an Industrial zoned catchment to a Residential zone generates a land value uplift of 40.0%.

Equation 35 – Interpretation of the Impact of Changing Land Use Zoning on Land Values in the Airport Link Subregion

$$\textit{Change of Zoning Based Land Value Uplift (\%)} = Exp(0) - \\ Exp(-0.446) = 40.0\%$$

Table 24 – Green Square/Mascot Subregion – Residential, Business and Mixed Use Land Uses Only – Heavy Rail Panel Data Hedonic Price Model Results (2000–2014)

	400m		800m		1600m	
2000	-8.5%	0.021 (***)	-9.5%	0.009 (***)	-4.8%	0.006 (***)
2001	-5.5%	0.033 ( )	-8.7%	0.017 ( )	-6.2%	0.009 ( )
2002	-3.4%	0.033 ( )	-7.5%	0.017 ( )	-5.6%	0.009 ( )
2003	-7.1%	0.033 ( )	-13.3%	0.016 (*)	-10.0%	0.009 (***)
2004	-3.7%	0.033 ( )	-9.4%	0.016 ( )	-7.3%	0.009 (**)
2005	-3.6%	0.033 ( )	-8.9%	0.016 ( )	-6.6%	0.009 (*)
2006	-1.7%	0.032 (*)	-9.0%	0.016 ( )	-8.4%	0.009 (***)
2007	-8.2%	0.032 ( )	-12.0%	0.016 ( )	-7.9%	0.009 (***)
2008	0.3%	0.032 (***)	-5.1%	0.016 (**)	-3.0%	0.009 (*)
2009	0.7%	0.032 (***)	-1.9%	0.016 (***)	-0.3%	0.009 (***)
2010	4.0%	0.031 (***)	1.3%	0.016 (***)	-0.7%	0.009 (***)
2011	8.6%	0.031 (***)	5.4%	0.016 (***)	2.7%	0.009 (***)
2012	8.1%	0.031 (***)	6.4%	0.016 (***)	4.8%	0.009 (***)
2013	10.7%	0.029 (***)	5.2%	0.015 (***)	8.4%	0.009 (***)
2014	8.1%	0.029 (***)	4.0%	0.015 (***)	10.6%	0.009 (***)

Notes: Adjusted R-squared: 0.7609 with 122,143 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

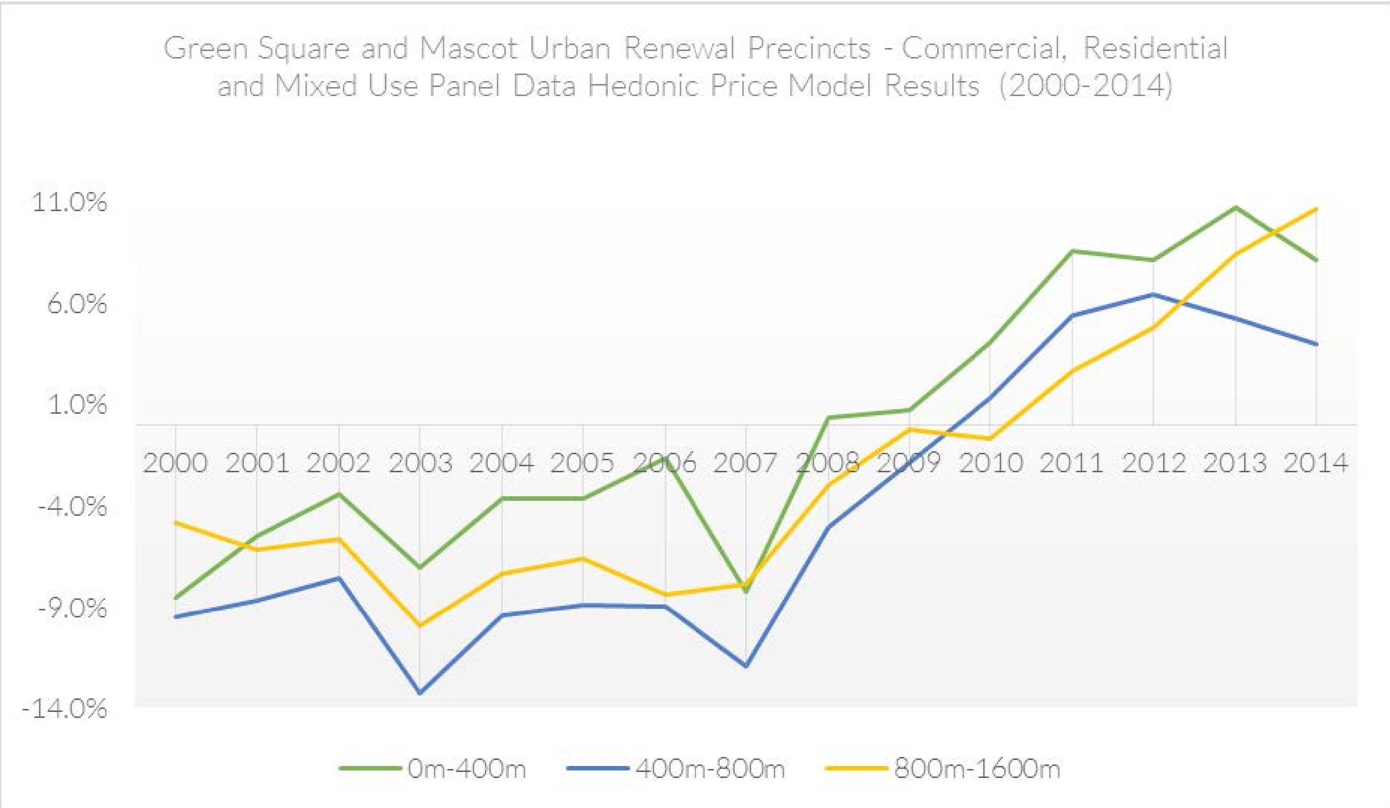

Figure 48 – Airport Link Subregion – Residential, Business and Mixed Use Land Uses Only – Heavy Rail Panel Data Hedonic Price Model Results (2000–2014)

Table 25 – Green Square/Mascot Subregion – Land Use Panel Data Hedonic Price Model Results (2000–2014)

	Business		Industrial		Mixed Use	
2000	-9.6%	0.021 (***)	-19.5%	0.025 (***)	7.2%	0.016 (***)
2001	-12.5%	0.021 ( )	-22.9%	0.025 ( )	2.7%	0.016 (**)
2002	-16.2%	0.021 (**)	-22.3%	0.025 ( )	0.1%	0.016 (***)
2003	-15.6%	0.021 (**)	-16.3%	0.025 ( )	10.8%	0.016 (*)
2004	-10.5%	0.021 ( )	-13.4%	0.025 (*)	9.6%	0.016 ( )
2005	-9.9%	0.021 ( )	-22.0%	0.026 ( )	-8.8%	0.016 (***)
2006	10.5%	0.021 (***)	-4.0%	0.026 (***)	-10.3%	0.016 (***)
2007	11.3%	0.021 (***)	21.0%	0.026 (***)	2.7%	0.016 (**)
2008	8.9%	0.021 (***)	16.2%	0.026 (***)	6.5%	0.016 ( )
2009	10.2%	0.020 (***)	4.2%	0.025 (***)	0.6%	0.016 (***)
2010	3.6%	0.020 (***)	-10.3%	0.025 (***)	-9.0%	0.015 (***)
2011	-3.2%	0.020 (**)	-18.8%	0.025 ( )	-17.4%	0.015 (***)
2012	0.0%	0.018 (***)	-16.7%	0.029 ( )	-10.8%	0.017 (***)
2013	-11.9%	0.018 ( )	-26.2%	0.029 (*)	-7.5%	0.016 (***)
2014	-9.0%	0.021 ( )	-32.0%	0.025 (***)	8.9%	0.016 (***)

Notes: Adjusted R-squared: 0.7614 with 124,910 DF, Model p-value: < 2.2e-16
Significance Codes: (***) 0.001, (**) 0.01, (*) 0.05, (.) 0.1, ( ) 1

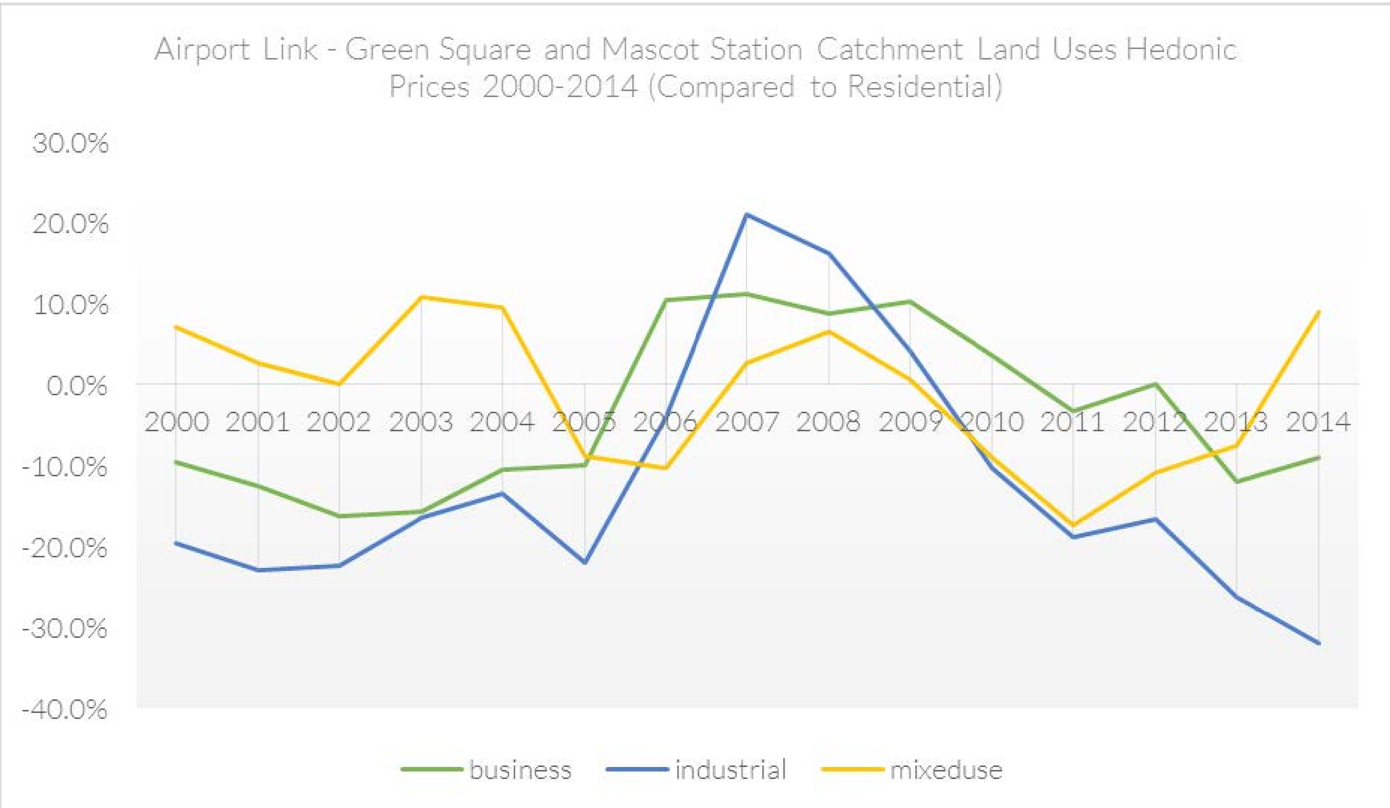

Figure 49 – Green Square/Mascot Subregion – Land Use Panel Data Hedonic Price Mode Results (2000–2014)

5.5.9 PHASE 3 – GREEN SQUARE AND MASCOT: CHANGE OF FSR BENEFIT IMPACT ON LAND VALUE

Table 23 shows that the FSR elasticity for the Airport Link catchment is 0.204. Equation 36 demonstrates how this FSR coefficient can be applied to an FSR increase in the Airport Link subregion, assuming an FSR change from an existing average of 0.75 (see Table 20) around a station to an FSR comparable to Chatswood's (i.e. an FSR of 4).

Equation 36 – Interpretation of the Impact of Changing FSR on Land Values on the Airport Link Subregion

$$\textit{FSR Based Land Value Uplift (\%)} = (4 - 0.75/0.75) * 0.204 = 88.4\%$$

These results of carrying out urban renewal, rezoning land to highest and best use, and increase in the FSR demonstrate that there is significant benefit from the integration of appropriate land uses at higher densities within the Mascot and Green Square station catchments.

6.

DISCUSSION OF RESULTS

6. DISCUSSION OF RESULTS

6.1 INTRODUCTION

This study investigated the impacts of transit accessibility, land use zoning, and permissible development density (i.e. FSR) on land values in Metropolitan Sydney by estimating a series of regression-based hedonic models. Cross-sectional models were estimated to determine near present-day marginal effects of varying parameters representing controls for transit access, land use and FSR, while panel data models were estimated to determine how the impacts of these controls have changed over time. More importantly, however, the panel data models were designed to capture how new transit investments lead to a monetisation of transit accessibility into land values. When the land value impacts of improving transit accessibility, rezoning land to its highest and best use, and increasing FSR to allow greater densities are considered in combination, the value growth potential is substantial and forms the basis for value capture strategies.

Over the course of the study, metropolitan-wide models and subregion models were estimated. The benefits of the metropolitan-wide model come down to its large sample size and its ability to normalise various disturbances and shortcomings in the input data. Large sample sizes mean more efficiently estimated parameters, but because of the metropolitan scale, there is a significant variation in the data used to identify strong relationships.

Subregional models, on the other hand, are able to produce more localised estimates of the marginal effects of land attributes on land prices, but they do so at the cost of efficiency (due to smaller sample sizes and less variation in the data) and overall robustness. At the local level, issues related to missing data or unobserved omitted variables will have a greater impact on the results. In general, however, it is of value to estimate both types of models to use them as reference cases for each other, as no model is perfect and referring to the results of another model can help validate and interpret the results.

Specifically, this study looked at 5 different subregional models as case studies in addition to the metropolitan-wide modelling, which included:

- Epping to Chatswood Heavy Rail
- Dulwich Hill Extension to the Inner West LRT
- Parramatta to Liverpool T-Way BRT
- Parramatta to Rouse Hill T-Way BRT
- Green Square/Mascot Urban Renewal Precinct

The summary of the results for each of these studies as well as the results from the metropolitan model are presented in Table 26.

The results for each of the value creation phases will now be discussed to draw out the key points and interpret their significance.

6. DISCUSSION OF RESULTS

Table 26 – Summary of the Results of the Value Creation Phase Assessments of the Metropolitan and Subregional Models

	Value Creation Phases		
	Phase 1 Accessibility benefit monetised in station catchments	**Phase 2** Change of land use zoning to highest and best use	**Phase 3** Increase in FSR from corridor average to FSR 4:1
Metropolitan Model	4.6% (Rail)	44.8%	167%
Epping to Chatswood Heavy Rail	47.7%	17.8%	239%
Dulwich Hill Extension to the Inner West LRT	6.7%	62.7%	79.4%
Parramatta to Liverpool T-Way BRT	—	41.7%	132%
Parramatta to Rouse Hill T-Way BRT	—	52.3%	183%
Green Square/Mascot Urban Renewal Precinct	17.8% (Renewal)	40%	88.4%

6.2 VALUE CREATION PHASE 1 – MONETISATION OF ACCESSIBILITY BENEFIT

The results in Table 26 highlight the variability in the regions of Sydney, the modes of accessibility they provide, and the varying levels of value creation for each of the phases analysed.

The Metropolitan model has the lowest level of monetised accessibility though this is to be expected as the metropolitan model does not factor in change in accessibility but merely the perceived benefit of being near a rail station. It does, however, highlight in a conservative way the significant value (4.6% average uplift in value) in living near a rail station, which is a reflection of the WTP for a low generalised cost of travel to the city's urban centres.

The Epping to Chatswood corridor is the only rail-based transit project analysed that underwent project announcement, project construction, and several years of operation, all within the time series available to understand how the improved accessibility benefits were monetised into the surrounding land markets. The analysis of the Epping to Chatswood line highlighted that in Sydney, the real monetisation of the accessibility occurs after the commencement of operations.

This value creation timing impact was also clear on the Dulwich Hill Extension to the Inner West LRT, which indicated modest gains to the 400m catchment (6.7% uplift), but based on the fact that the line opened in 2014 when our time series ended, it is likely that additional value increases are still to come, especially when each station location is rezoned and given an increased FSR.

6. DISCUSSION OF RESULTS

If the Dulwich Hill Extension to the Inner West LRT were in another jurisdiction, say Western Australia[22], where the majority of the uplift for the Mandurah Rail Line occurred during the construction period as suggested by the theory in Figure 11, there may be grounds to believe all the accessibility benefits have already been monetised into land values, but given the experience with the Epping to Chatswood line, it is likely that the majority of the uplift is yet to occur.

Given the lack of clear correlation between key project milestones and changes within the accessibility catchments in the two Parramatta bus rapid transit models analysed, it was not possible to determine the accessibility benefit. This could be the result of a range of factors, but it is most likely the result of the nature of the high transport externality services being provided and potentially the lack of urban renewal opportunities that come with bus-based transit services.

The Green Square/Mascot Urban Renewal areas sit within an existing rail corridor that was constructed and began operating prior to the assessment period, so it was not impossible to interpret the specific transport accessibility benefit that it generated. Having stated that, the rail line unlocked significant development potential that could not have occurred without the investment in such a high-capacity piece of transportation infrastructure and the modelling was able to pick up land value increases associated with the renewal process, distinct from any land use or FSR changes.

6.3 VALUE CREATION PHASE 2 – CHANGE IN ZONE TO HIGHEST AND BEST USE

The Value Creation Phase 2 benefits were reasonably consistent for each of the sub-regions assessed, with the Metropolitan region value creation rate of 44.8% being near the average (41.7%) for the results of each of the subregions. This position of the Metropolitan model at around the average of the regions modelled reflects that whist there are sub-regional variations, the metropolitan rezoning benefit is likely to be the most reliable for broader regional interpretation.

The Phase 2 benefit was highest for the Dulwich Hill Extension to the Inner West LRT, which is to be expected as it is the closest subregion to the CBD, with significant demand for Mixed Use property. The other regions had varying benefit levels, with the BRT catchments being a surprise, but this is probably due to the proximity to Parramatta, Liverpool and Rouse Hill, all of which are increasing their residential density and provision of Mixed Use development.

The change of zoning to highest and best use zoning (Mixed Use) for both the Epping to Chatswood and Green Square subregions is more muted, which potentially reflects the existing significant supply of Mixed Use zoned land in these regions that indicate dampening demand.

Overall, this highlights the subregional demand for each of the zones and the fact that the highest and best use zone will vary depending on the local context and the transit mode it is supporting.

22 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 Vol. 67, September 2014, 320–339 http://www.sciencedirect.com/science/journal/09658564/67

6.4 VALUE CREATION PHASE 3 – INCREASE IN THE DEVELOPMENT CAPACITY ENABLED BY THE INVESTMENT IN TRANSIT

The interpretation of each model shows that every 1:1 increase in FSR equates to a marginal increase in land value based on the corridor elasticity presented in Table 26. The majority of corridors analysed as part of this project had relatively low levels of development density, considering the amount of development capacity unlocked by the investment in the different modes of transit (Green Square/Mascot being an exception to this).

The metropolitan demand for increase in FSR is significant and suggests that where there is adequate transportation infrastructure (all other urban amenities considered), there is a significant demand for an increase in development density. Each of the subregions, especially the Epping to Chatswood corridor, has a significant demand for increases in allowable density, although the variability of the FSR uplift across the subregions highlights the variability across the metropolitan region, so it is recommended that the metropolitan average be used for the interpretation of benefits for new projects.

6.5 SUMMARY

As the discussion of the results in Table 26 demonstrate, it is important to choose the right uplift estimates depending on the specific projects they are being applied to. Overall, the modelling suggests that while there is significant benefit to be experienced from investing in transit infrastructure (depending on the mode and subregional context), the benefit is maximised when accompanied by appropriate land use and FSR changes, and the amount of development capacity that is unlocked will depend on the mode and service level.

Transit infrastructure, and in particular, high-capacity rail based transit that is not susceptible to road congestion (or is not impacted by road congestion) has the ability to provide a high degree of mobility to highly valued locations, and by enabling them to be developed to higher densities, the potential to share in the value created for these sites becomes substantial.

6.6 POTENTIAL FUTURE RESEARCH

Whilst this study is comprehensive in its scope of the assessment of land use and transit integration across metropolitan Sydney for the assessment period (2000–2014), there are a number of projects currently being scoped and assessed as well as a number that are under construction, so it is important that as the relevant data become available, the WTP modelling gets updated. The continued development of a database to support this form of analysis would be highly valuable and the most immediate focus should be on extending the analysis of the Dulwich Hill Extension to the Inner West LRT catchment to include several years after the start of operations.

The WTP analysis could also be extended to cover the land market impacts of the provision of urban motorways, and the large toll roads in particular, especially with the significant number of large motorways proposed for Sydney in the coming years.

It should also be noted that the Government generally considers that additional growth in transport corridors is redistributed and not necessarily show new growth. The project team has undertaken work exploring planning capacity in the Sydney Metropolitan area. Preliminary results reveal that there may not be the capacity anticipated under existing controls, implying that growth may not be redistributed but transport investment is necessary to allow for any further growth. This needs to be assessed in more detail.

THE TEAM

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Roman has over 7 years of experience in developing econometric and GIS applications for urban development and transportation infrastructure projects.

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Ben is the Managing Director of Mecone Planning, with extensive experience in urban planning spanning State Government, Local Government and consultancy.

Ben has a particular interest in transport, development advisory and economics. Having cut his teeth on some of Sydney's highest profile planning projects over the last decade, Ben is able to provide insightful and practical advice that delivers results.

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