26TH ANNUAL PACIFIC RIM REAL ESTATE SOCIETY CONFERENCE

CANBERRA, AUSTRALIA 19TH – 22ND JANUARY 2020

LAND VALUE VS ACCESSIBILITY: TEACHING BID RENT THEORY USING EMPIRICAL EVIDENCE FROM AUSTRALIA

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ABSTRACT

The fixed nature of real property and the underlying relationship between real property value and accessibility is an important underlying concept in property education. Land use and location theory developed by Von Thunen and Alonso are important in understanding the patterns of land use and land value that occur in cities. These theories help students understand the concepts of how accessibility relates to land values and externalities. While textbooks discuss the theories and use "old-world" examples, there is little evidence of how these theories and models apply to a modern city, except in complex econometric equations that are outside of most undergraduate students' grasp. This paper examines some analyses using data across Adelaide to model bid rent curves using a large data set of land values across the metropolitan area. Land value curves are estimated using simple graphical and statistical models to help explain how land uses are distributed and how land value changes with distance to the CBD. Residual analysis is used as quasi estimates of the externality effects. The paper further discusses how this work is used as an authentic learning tool based on a constructivist paradigm.

Keywords: Property Economics, Accessibility, Bid Rent Theory, Locational Externalities, Authentic Learning, Constructivist Learning Environment.

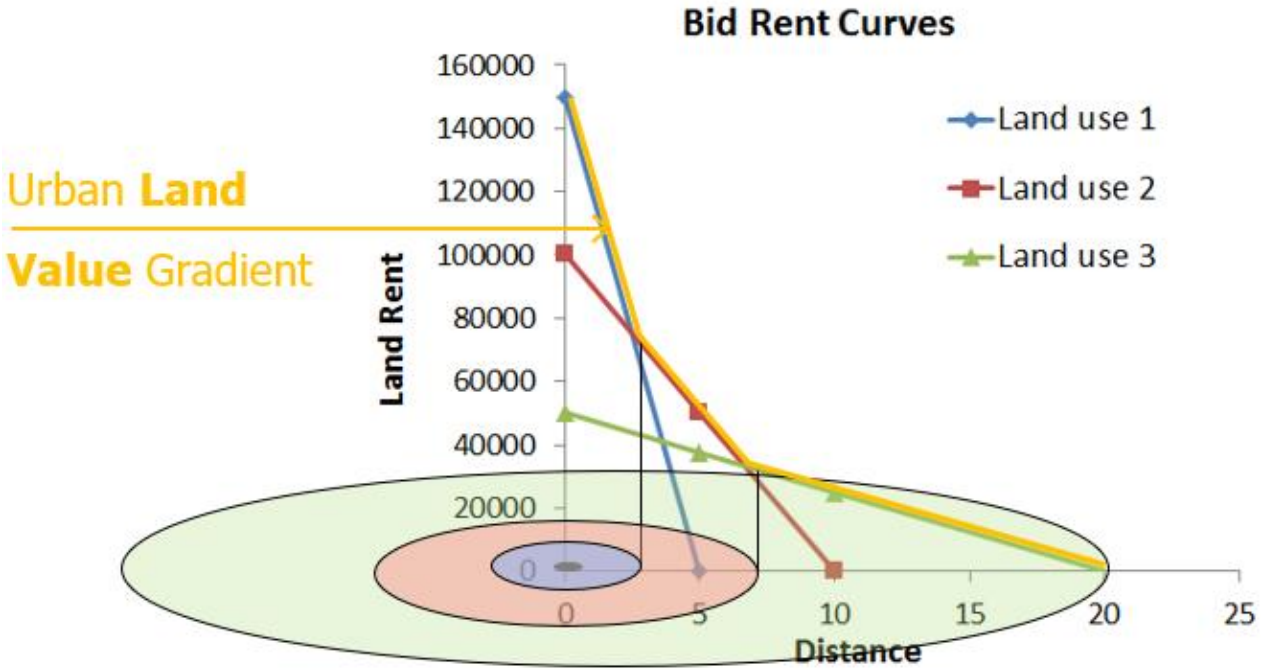
Introduction

Much of the foundation of value is based on the underlying relationship between property value and accessibility. The fixed nature of property and its location is generally seen as the most commanding aspect of property. However, many informal writers about property seem to mix the concepts of accessibility, neighbourhood and externalities and simply talk about location (i.e. location, location location) as being the critical issue. Such authors might consider that location incorporates issues of accessibility (distance to the CBD), neighbourhood (e.g. overlooking a park), externalities (e.g. located in an industrial area) and aspects incorporating site and externalities factors (e.g. a wonderful view). When students study valuation and real estate it is important to develop an underlying set of concepts and principles that can be applied and adapted to various situations. Such concepts differentiate students of property (one who studies and understands the principles and concepts) to simple practitioners who may blissfully work in the industry unaware of the underlying concepts. This distinction might be considered to separate education and training in valuation and real estate. Arguably, practitioners do not need to understand the underlying concepts, simply how to apply processes to facilitate activities in the market, in much the same way that a vehicle diver does not need to understand how a car works, just how to drive it within the road rules.

Theoretical Background

This paper is based on the early theories of the urban land market as proposed by Alonso (1960) building upon earlier work by Johan von Thunen and Richard Hurd who primarily discussed the relationships between accessibility to the CBD, land value and land use in an agricultural context. Alonso introduced the concept of bid rent curves where different land users can bid different amounts for land rent. Different land rent will be paid by different users depending upon the cost of production. In this theory, productivity varies with distance for the CBD because transport costs (other aspects being held constant) increase with distance. In the market place, bid rent curves will evolve for different land uses and uses with higher bid rent curves will "outbid" other land uses at that location. This will lead to a concentric pattern of land uses as the distance from the CBD increases as shown in Figure 1. The outer surface of the intersecting bid rent curves will form the land value gradient which should be observable and shows a pattern of land values that rapidly decrease from the city centre but at a decreasing rate.

Figure 1 - Bid Rent Curves leading to a concentric pattern of land uses



Empirical testing of the theory will typically involve the analysis of values and distance from the city as discussed by Cadwallader (1996) who uses graphic and simple regression analysis to visualise and estimate the relationship. More recently, complex econometric models have been used.

Educational Background

This paper does not propose a particular teaching methodology but aims to provide theory and empirical evidence that would fit into a range of teaching methods. The essential element is linking current empirical evidence to existing theories, that today's students may feel belong to a bygone era. The empirical evidence discussed in this paper has been used as a scaffolding exercise in a course that utilises problem-based learning but could equally serve as an example in a lecture. The paper will consider the traditional theories that link accessibility, land use and land value and investigate how we can use empirical evidence to test these theories. It is not the purpose of this paper to develop complex models for this purpose, that is a discussion for a different, more technical paper, but to use analysis that can be understood by students in an undergraduate course. Models such as those used in the recent Reserve Bank of Australia discussion paper (Kulish, et al., 2011) provides a good background to the models and how to apply these with modern econometrics, however their modelling was based on Australian median house prices and ignores other land uses and the issues of capital vs site (land) value. This is discussed later.

The teaching discussed in this paper draws upon an existing set of educational theory based around the broad concept of radical constructivism (Rorty, 1991). Glasersfeld (1974) suggested that the idea of constructivism started with Piaget in his seminar work in 1937. According to Snowman & Biehler (2000) there are several interpretations of constructivism in terms of education. They believe that students will construct knowledge based on how this applies to the perception of their knowledge. Interaction with their environment is a key element in learning and using examples that are in the student's current knowledge set, or where students will see those examples as a part of everyday life, will enable them to understand theory through the interactions of their experience.

In applying constructivism in this instance, the theory is developed using a four-stage process suggested by Dykstra (2005). These steps require the student to construct their knowledge through elicitation, comparison, resolution and application. In the problem-based teaching model that was used with this material, this was applied as

- Elicitation – ask students to predict the outcomes of the distribution of land values based on their existing experience.

- Comparison – compare to the actual distribution by constructing scatter plots to visualise the model. Mathematically deduced curves are then given to the students showing how the model fits the data. Maps showing the spatial distribution of the residuals allow students to see where the model fits poorly and encourages them to use their local knowledge to explain this.
- Resolution – Students then need to resolve how land uses exist in locations when the model suggest that other uses would outbid them in the market place.
- Application – Students develop a greater understating of the structure of the city and the distribution of land uses and values. They can apply this in real-world problems.

Methodology

This study is based on the metropolitan area of Adelaide, the city in which the student's study. All students have at least some knowledge of the metropolitan area and across the cohort, most parts of the city are well known. The Adelaide metropolitan area is contained by natural and regulatory barriers. To the west, the Gulf of St. Vincent prevents development. To the east and south, the Hills Face Zone and Watershed zones have highly restrictive land-use controls to aid in the amenity and sustainability of the city's resources. To the north of the city and beyond the Hills Face Zone there are significant agricultural areas that represent the majority of the States food bowl and vineyards (e.g. Barossa Valley, McLaren Vale and Adelaide Hills). These are shown on the map in Figure 5. Centrally the Adelaide Parklands occupies around half of the land of the Adelaide City Council (and Adelaide Suburb) but serves as a central place for a wide variety of public and recreational facilities. Adelaide is largely a suburban city with most suburbs being of low density at around 1300 to 3600 people per square kilometre (see Figure 6) but with relatively small amounts of open space at suburban level but with greater amounts of open space and other land uses in outer suburbs. The city centre serves as the central business district (CBD) to a greater extent than other Australian cities particularly Sydney and Melbourne, but in a manner that more closely resembles cities from the time of Alonso. For this analysis, data will be amalgamated at the suburb level. The Australian Bureau of Statistics (ABS) defines 383 suburbs within the study area and these will be mapped using ABS geographical boundaries.

Two sources of data are available to reflect land value. The first is transaction data at the individual property level with actual prices paid for properties. The advantage of this data is that each price most likely represents current market value, as tested by the market and is the type of data used by Kulish et.al (2011). However, there are difficulties in using this data. The first is that sales are relatively scarce. While sales for residential property are significant, those for commercial, industrial and retail are much less frequent and are may not be represented in all spatial regions, while sales for rural remnants are even less available. The second issue is that prices reflect the full value, not land value. For residential land, it may be possible to use vacant land sales, but these are often sparse in some parts of the metropolitan area and when they do occur are most likely to be development value rather than value in use. For other land uses there are simply not likely to be a considerable number of vacant land transactions, if any at all. Kulish et.al (2011) use simple median prices at postcode level, however, this ignores the relative difference in the ratio of capital to land value of suburbs at various stages of development. In inner suburbs, the land value may represent the majority of the capital value of the property while in new emerging suburbs, typically at the city fringes, the land values will typically represent a much higher proportion of the capital value. Put simply, transaction prices representing capital value may not be a good indication of land values, in a relative sense. One approach to overcome this is to abstract the land value from the full transition price. This is technically possible with modelling but is fraught with both logistical and conceptual issues. Statistical modelling (e.g. hedonic regression) requires a significant amount of data, both in the number of transactions and details for each transaction. Financial modelling requires both a significant number of transactions as well as an even greater amount of information about each transaction. While such a method may be possible in term so residential prices, there is not sufficient data to estimate values for non-residential properties.

The second source of data that is available is Government assessed site values available at the individual property level, for every property in the metropolitan area. This data overcomes the problem of data availability by providing a site value for each property as the same date. According to the South Australia Valuation of Land Act 1971 Part 1,5,1 site value is defined as follows.

> "site value of land means the capital amount that an unencumbered estate in fee simple in the land might reasonably be expected to realise upon sale assuming that any improvements on the land, the benefit of which is unexhausted at the time of valuation, had not been made; for the purposes of this

definition— (a) improvements means— (i) buildings and structures (but not including structures in the nature of site works); and (ii) wells, dams and reservoirs; and (iii) the planting of trees for commercial purposes;"

Most jurisdictions in Australia estimate either a site or unimproved value for every property for rating and taxation purposes and while there are issues such as valuation bias, this is the most useful data.

The analysis in this paper uses site values and site area at the individual property level that are converted to a land value/sqm. Some multi-story units and apartments are excluded as they have "common property" and no site area for individual units. The land values/sqm are amalgamated within each suburb to find the median land value/sqm for six different land use categories (as defined by the SA Government in the data set). These land-use definitions include residential, commercial, retail, industrial, rural and public institutions. The median is set as missing (null) if there are less than 5 properties of any given category or the total land area is less than 2500 sqm within a suburb. The distance to the city centre is calculated using PSMA Australia data through the Google Map interface. Distance by road is calculated from the mid-point of each suburb to the GPO in the city centre. All the data is assembled in an Excel file showing the array of land values per square metre for each land use against the suburb name and distance to the CBD.

The starting point for students is to visualise the relationship between land values and distance to the city by creating an Excel chart and then "modelling" this with a trend line. Students can see how various transformations of data can lead to a closer fit of the model. Typically a power curve (log-log model) will fit the data best. Attention is paid to the occurrence of outliers with some discussion about why they occur and how this relates to positive and negative externalities. Later these will be identified spatially.

While students can visualise the relationships of the scatterplots, they lack the ability to estimate and interpret transformed models. This will differ depending upon the order in which students study courses and generally a log-log transformation needed for this problem would be a basic part of an econometrics or business forecasting course. A series of simple regression models using log-log transformations are estimated by the author and the resulting models (line so best fit) are shown on a single chart for comparison. This will enable the students to visualise the various land value curves which are the observable estimates of the bid-rent curves. The residuals from these models are also calculated and serve as quasi estimates of externality effects. The students are presented with a chart of the land value curves and maps showing both the spatial distribution of land values and residuals. These are then used in the classroom exercise.

Results

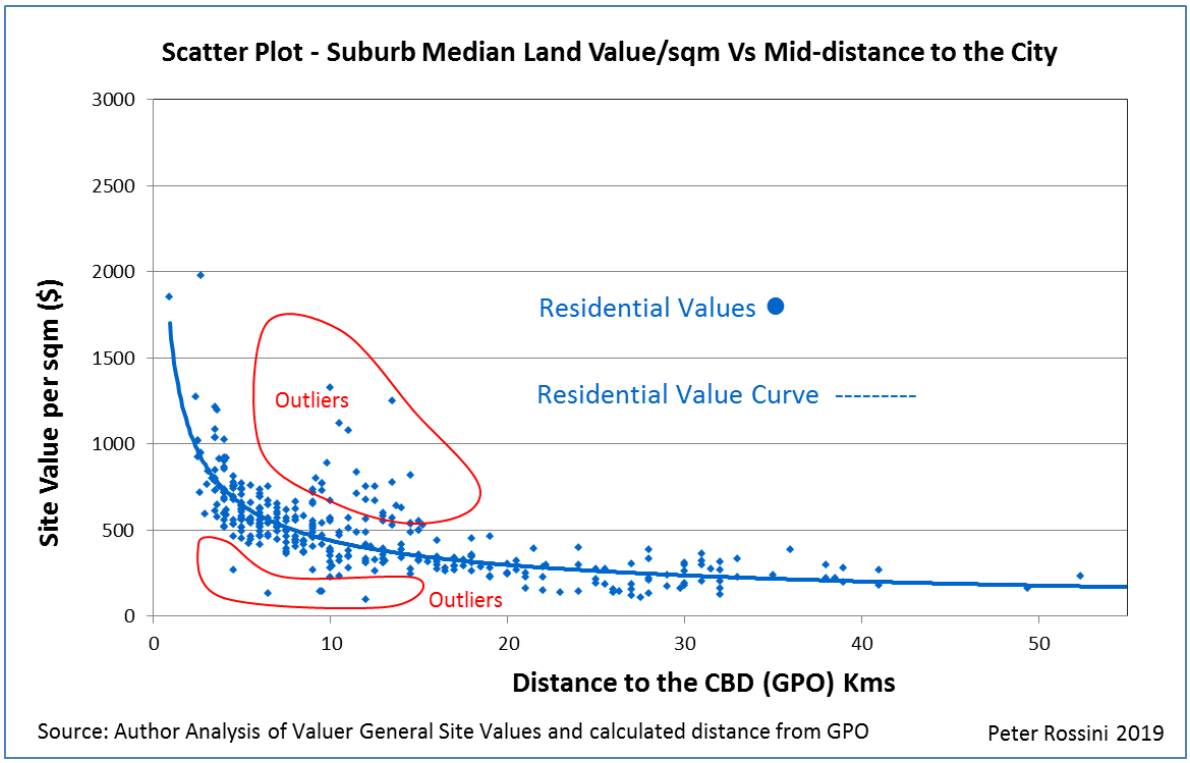
The results of this paper are presented in the manner they are presented to students. An example of the excel data provided to students is shown in Table 1. This shows the suburb name, distance to the GPO and Site Value/sqm for different land uses. Note that in some instances the cells are blank where there is insufficient data as discussed above. Rural land values include parcels of land set aside for community gardens and similar activities but are often remnant rural activities. In Table 1 the rural uses in Adelaide are spaces set aside for community gardens and similar activities, in Aldinga Beach, Andrews Farm and Angle Vale there are active rural land uses while in Athelstone there are remnant market gardens.

Table 1 - Excel Data Provided

Suburb	Dist to GPO (km)	Residential SV/sqm	Commercial SV/sqm	Retail SV/sqm	Industrial SV/sqm	Rural SV/sqm
ABERFOYLE PARK	16	274.47	207.88	135.53		
ADELAIDE	0.9	1857.14	1625.64	1840.00	1320.13	99.63
ALBERTON	10.5	485.61	295.70	338.69	208.04	
ALDINGA BEACH	41	265.75	90.45	129.11	69.10	8.57
ALLENBY GARDENS	5.5	568.91	501.14	496.25	513.07	
ANDREWS FARM	30	298.67		25.61		76.55
ANGLE PARK	9.5	418.01	149.97	149.97	191.71	
ANGLE VALE	32	122.79	66.74	75.50	50.08	5.59
ASCOT PARK	7.5	550.00	402.61	383.45		
ASHFORD	4.1	616.78	461.76	570.26	418.45	
ATHELSTONE	12	486.80	299.52	358.49		140.68
ATHOL PARK	10	373.94	198.10	198.03	157.84	
AULDANA	8.5	376.40			60.65	

From this data set, scatter plots are produced to visualise the relationship and any residuals. In Figure 2 the residential site values are plotted showing values declining rapidly from the city centre and decreasing at a decreasing rate. This relationship is shown using the power curve (log-log model) trendline.

Figure 2 - Residential Land Values/sqm vs distance to CBD (mid-point of suburbs)



Having visualised the residential relationship, other land uses can be added. Figure 3 shows the visualised trend lines for residential and commercial land and the data points for rural land. These plots can be achieved by the students during a tutorial or workshop. Simple regression models using a log-log transformation are then estimated (by the author) for each of the land uses. These results are in Table 2.

Figure 3 - Land Values/sqm (various) vs distance to CBD (mid-point of suburb)

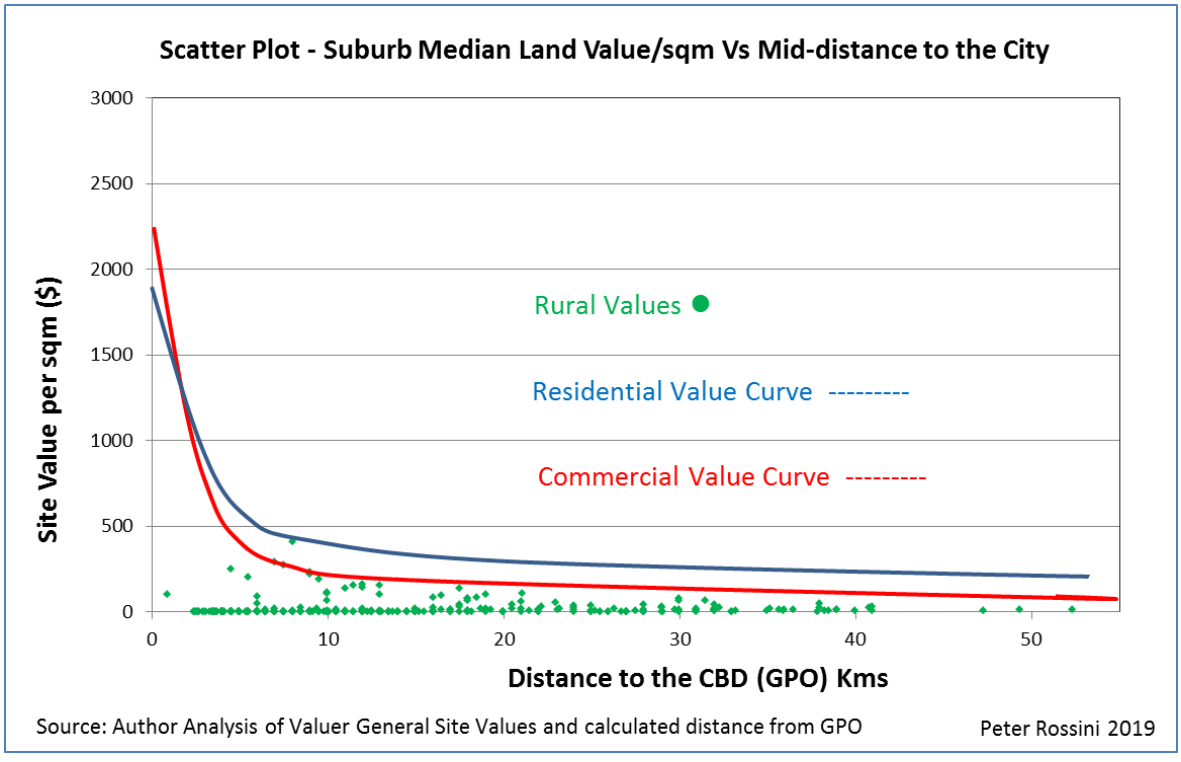
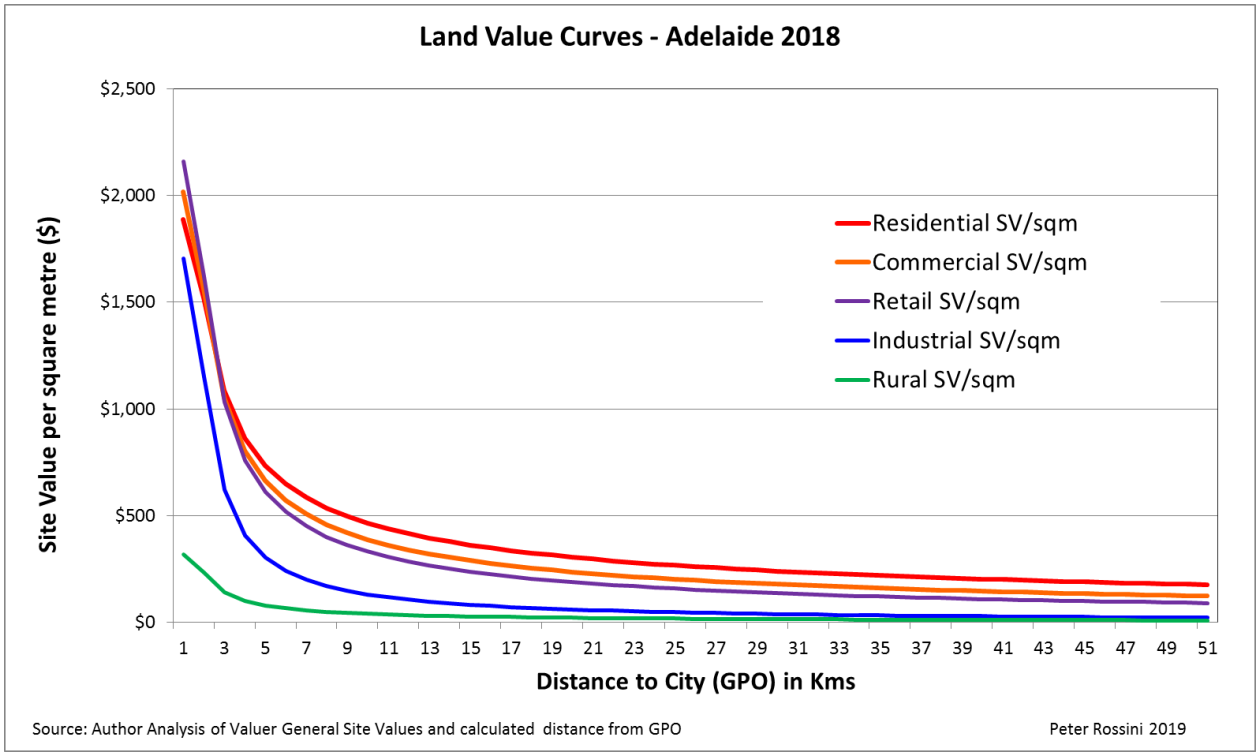


Table 2 - Log-Log Regression Models

	Residential SV/sqm	Commercial SV/sqm	Retail SV/sqm	Industrial SV/sqm	Rural SV/sqm
R Square	0.59	0.43	0.53	0.55	0.17
Standard Error	0.15	0.24	0.22	0.31	0.49
F	499.24	237.53	361.37	181.22	25.35
Intercept	3.2057234	3.2216817	3.2403959	3.1032083	2.4011462
Distance to GPO	-0.5631987	-0.6624188	-0.7532619	-1.0296100	-0.8266250

The regression results show statistically significant relationship for each land use with high r-square values suggesting that accessibility is the major determinate of differences of land value/sqm across the metropolitan area. Using the regression coefficients for each model, the various land value curves can be visualised as shown in Figure 4.

Figure 4 - Land Value Curves for Multiple Land Uses



This chart shows several important outcomes. At the heart of the CBD, retail and commercial land values are higher than residential land values. Commercial and retail uses will out-bid residential uses at the city core. However residential values outbid industrial and rural values which would suggest that when land (development sites) becomes available near the city centre, the outcome is a residential development, if the market for commercial and retail space is exhausted. Similarly, lower-grade commercial spaces would be redeveloped as residential uses in the same situation. Such activity is evident in the Adelaide market at the moment. Industrial land uses undervalue the land compared to other uses (except for rural uses) and will therefore only occur in specially zoned areas, particularly where land quality is poor. Generally speaking land outside of the CBD will achieve its highest value as residential uses and this partly explains the difficulty in promoting non-residential uses in new suburbs at the city fringe. Developers will typically achieve higher land values with residential land and hence will gravitate to residential development except there zoning prevents it. As expected, rural land values are much lower than other uses and where rural land at the city fringes becomes rezoned, it is typically converted quickly.

While the scatterplots allow students to visualise the relationship between land value and distance to the CBD in one dimension, thematic maps allow then to see this in two dimensions. Figure 8 is a thematic map showing the distribution of residential land values/sqm across Adelaide. The map shows a roughly concentric pattern of land values but with obvious disruptions cause by physical factors and regulatory issues

such as development controls. The extent to which the pattern deviates from the basic model (land values decreasing but at a decreasing rate) can be shown by mapping the residuals. Those residuals that were obvious in the scatterplots (see Figure 2) have clear spatial patterns and these are shown in terms of the residential residuals in Figure 7. The interpretation of these thematic maps is reasonably straight forward. Yellow shaded suburbs fit closely to the land value curve model where residuals are within + or -.5 standard deviations of the line of best fit. Suburbs shaded in the red scale (orange at .5 to 1.5 standard deviation from the line of best fit and red shaded suburbs at greater than 1.5 standard deviations) have prices above the predicted value based on the accessibility to the city centre. Properties in these suburbs are influenced by significant positive externalities while those in the green and blue shaded suburbs exhibit an influence of negative externalities. Figure 9 to Figure 16 show similar thematic maps of the land values and residuals for other land uses. Using these maps and there individual local knowledge groups of students can begin to resolve the variations in values and assign these to specific characteristics of the different locations.

Conclusion

This paper uses empirical evidence from Adelaide in South Australia to investigate the relationship between land use, land value and accessibility to the city centre. The paper is presented in a manner that is accessible to students who study property and real estate in a degree program. Land value curves developed using aggregated valuation help explain the distribution of land uses across Adelaide and gives solid evidence of the pattern of decreasing land values as the distance from the CBD increases. The evidence suggests that the bid-rent process suggested by Alonso (1960) is still evident today. The paper supplies artefacts that can be used by other academics as examples of how bid-rent theories apply within a modern city in Australia.

REFERENCES

Alonso, W., 1960. A theory of the urban land market. *Papers and Procedings of the Regional Science Association,* Volume 6, pp. 149-157.

Cadwallader, M., 1996. *Urban geography : an analytical approach.* 1st ed. Upper Saddle River, NJ: Prentice Hall.

Dykstra, D., 2005. Against Realist Instruction, Superfial success masking catatropic failure and an alterbative. *Constructivist Foundations,* 1(1), pp. 49-60.

Glasersfeld, E., 1974. Piaget and the radical constructivist epistemology.. *Epistemology and education,* pp. 1-24.

Kulish, M., Richards, A. & Gillitzer, C., 2011. *Urban Structure and Housing Prices: Some Evidence from Australian Cities,* Canberra: Reserve Bank of Australia.

Rorty, R., 1991. *Objectivity, Relativism, and Truth.* New York: Cambridge University.

Snowman, J. & Biehler, F., 2000. *Psychology Applied to Teaching.* 9 ed. Boston: Houghton Mifflin.

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Figure 5 – Metroplitan Adelaide 2018

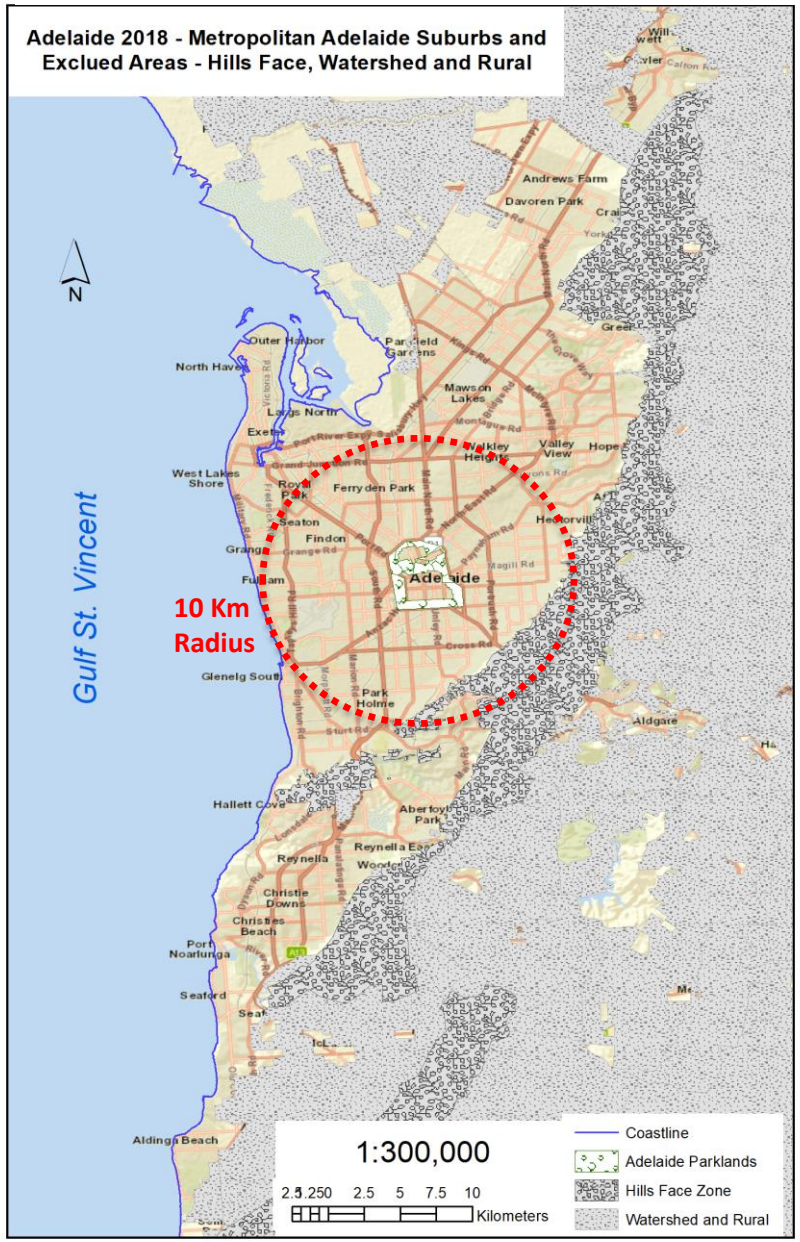
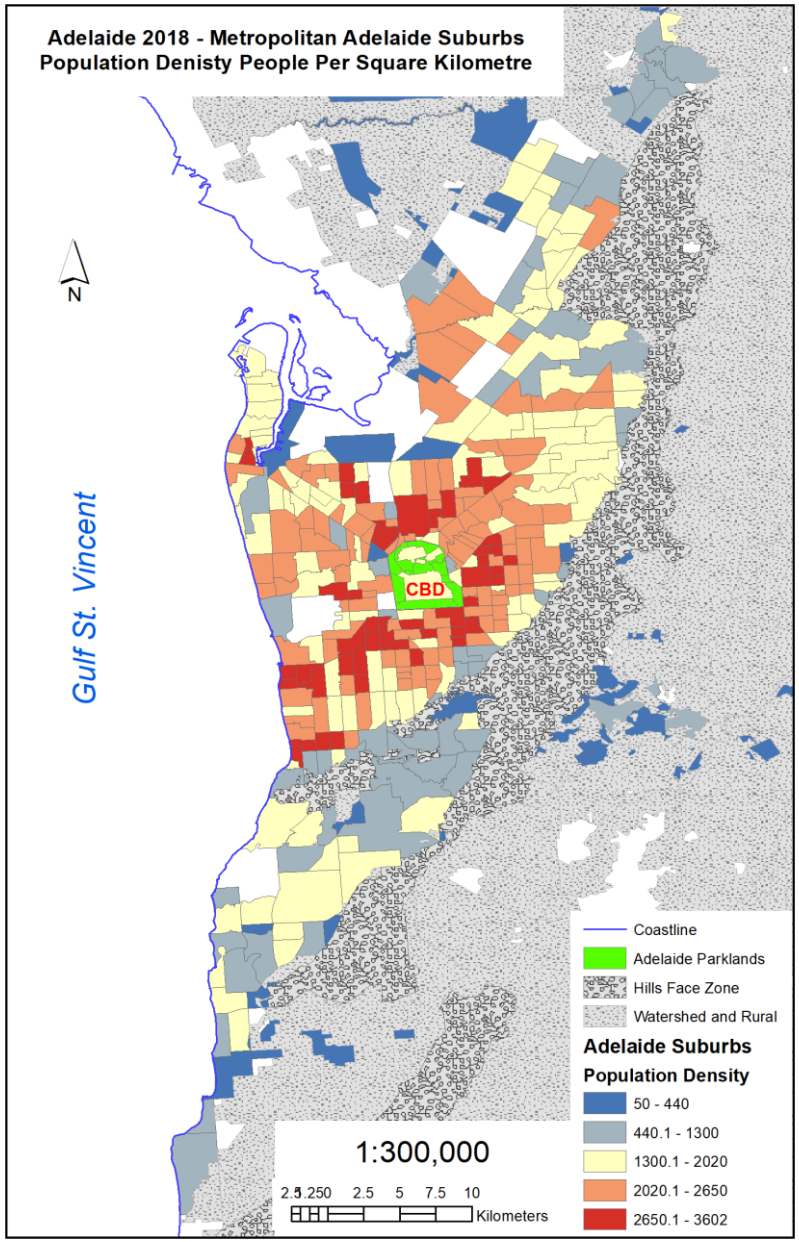


Figure 6 - Metroplitan Adelaide Population Densities 2018



Source: Author Analysis of South Australian Valuer Generals Data, 2016 ABS Census Data, South Australian Government Land Use Controls

Figure 8 – Residential Land Values/sqm – Adelaide 2018

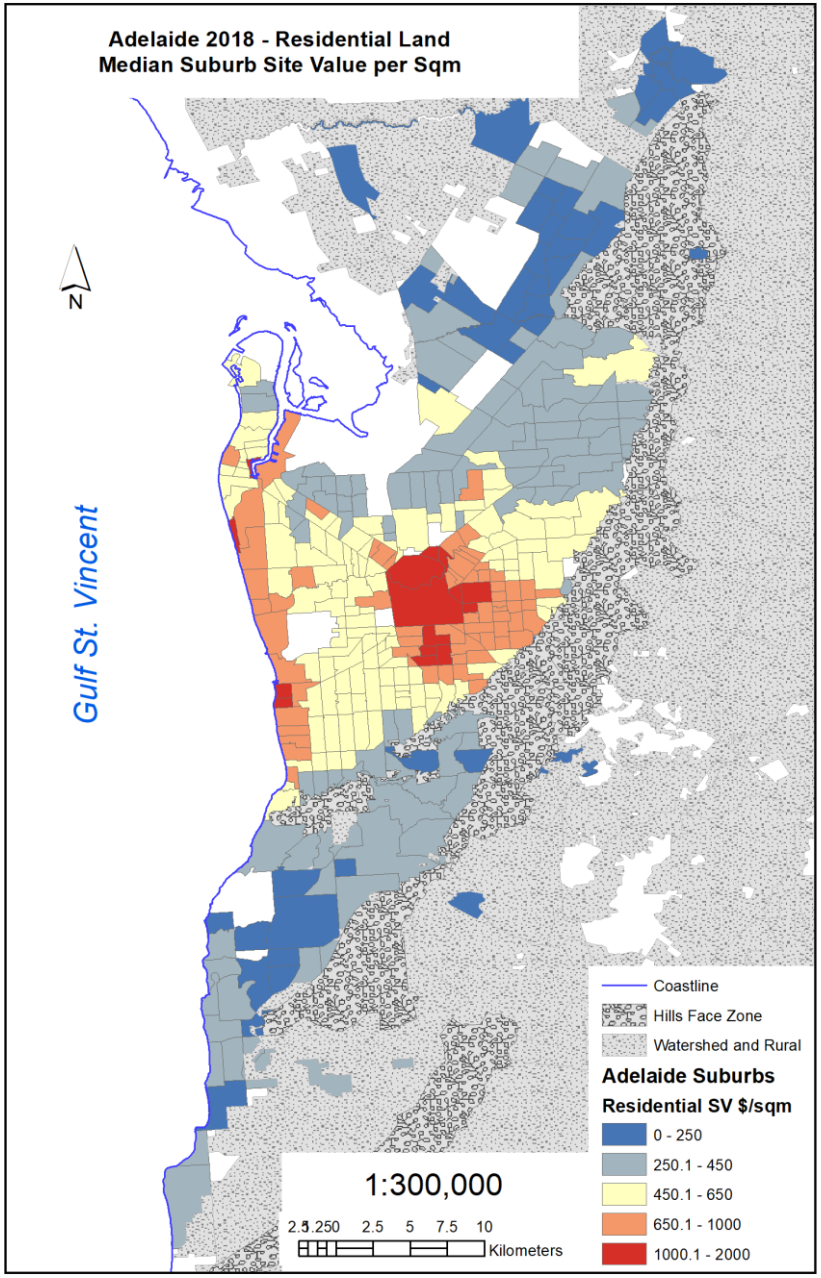
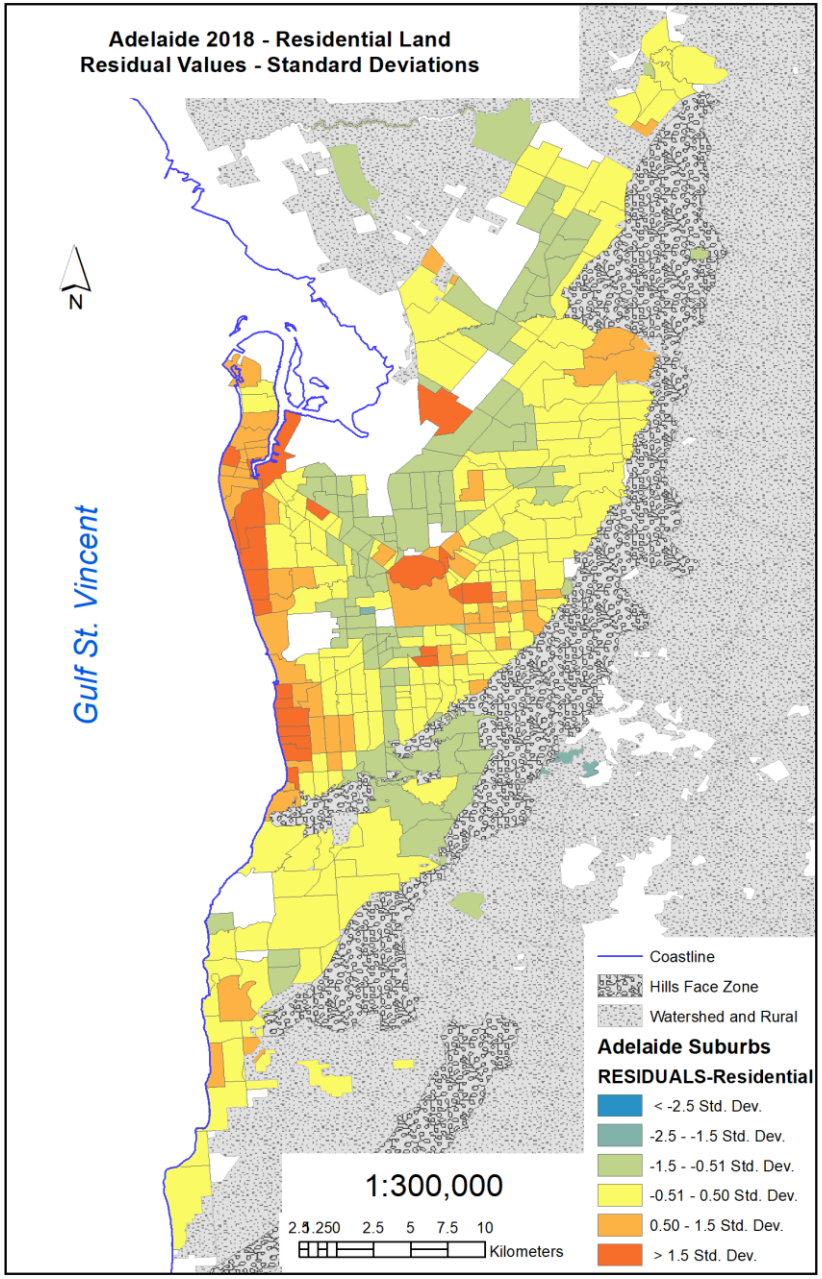


Figure 7 – Residantial Land - Residuals from Land Rent Curve



Source: Author Analysis of South Australian Valuer Generals Data

Figure 10 – Commercial Land Values/sqm – Adelaide 2018

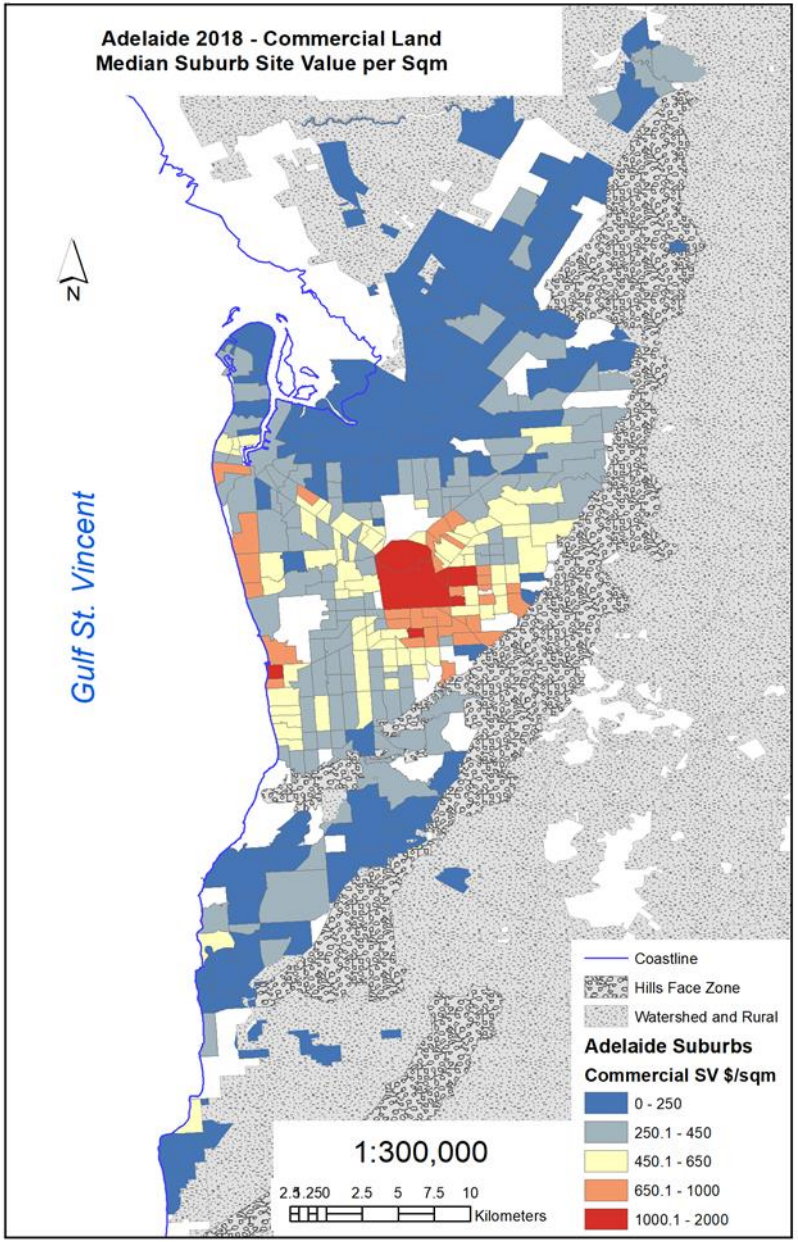
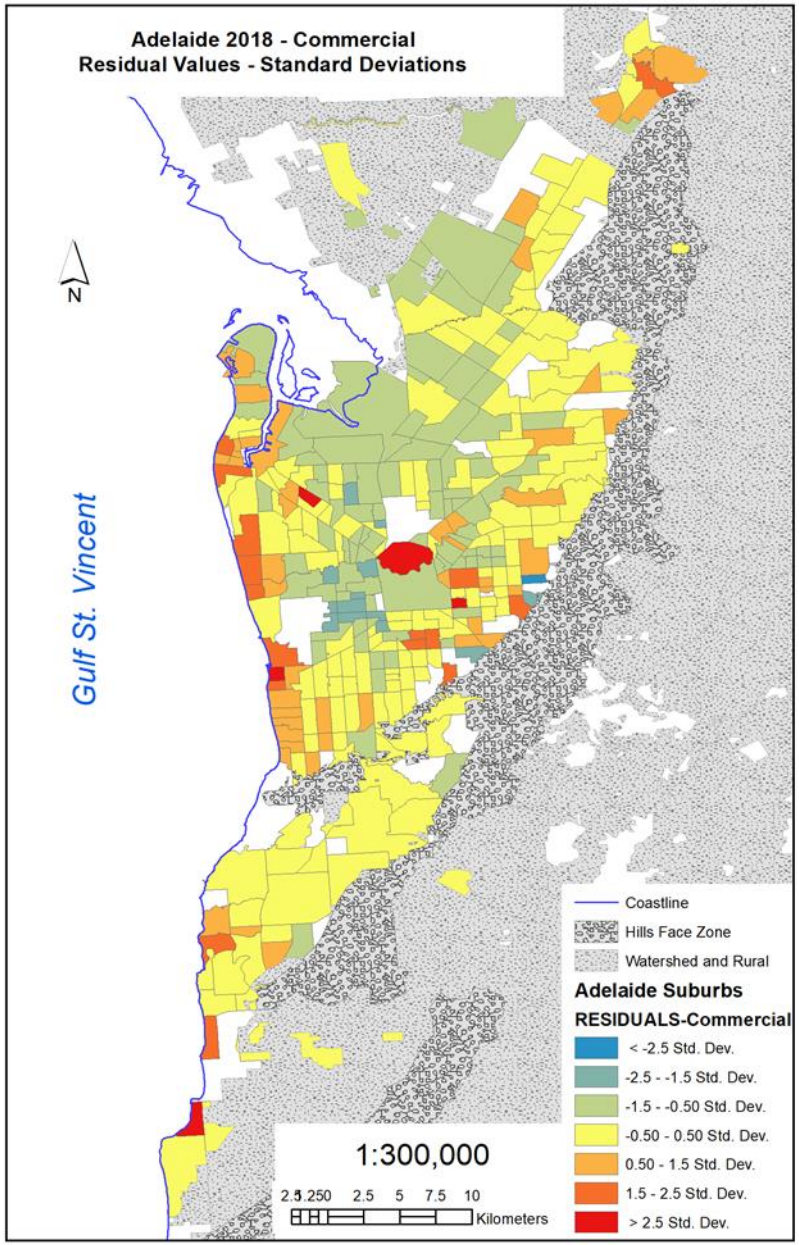


Figure 9 – Commercial Land - Residuals from Land Rent Curve



Source: Author Analysis of South Australian Valuer Generals Data

Figure 12 – Retail Land Values/sqm – Adelaide 2018

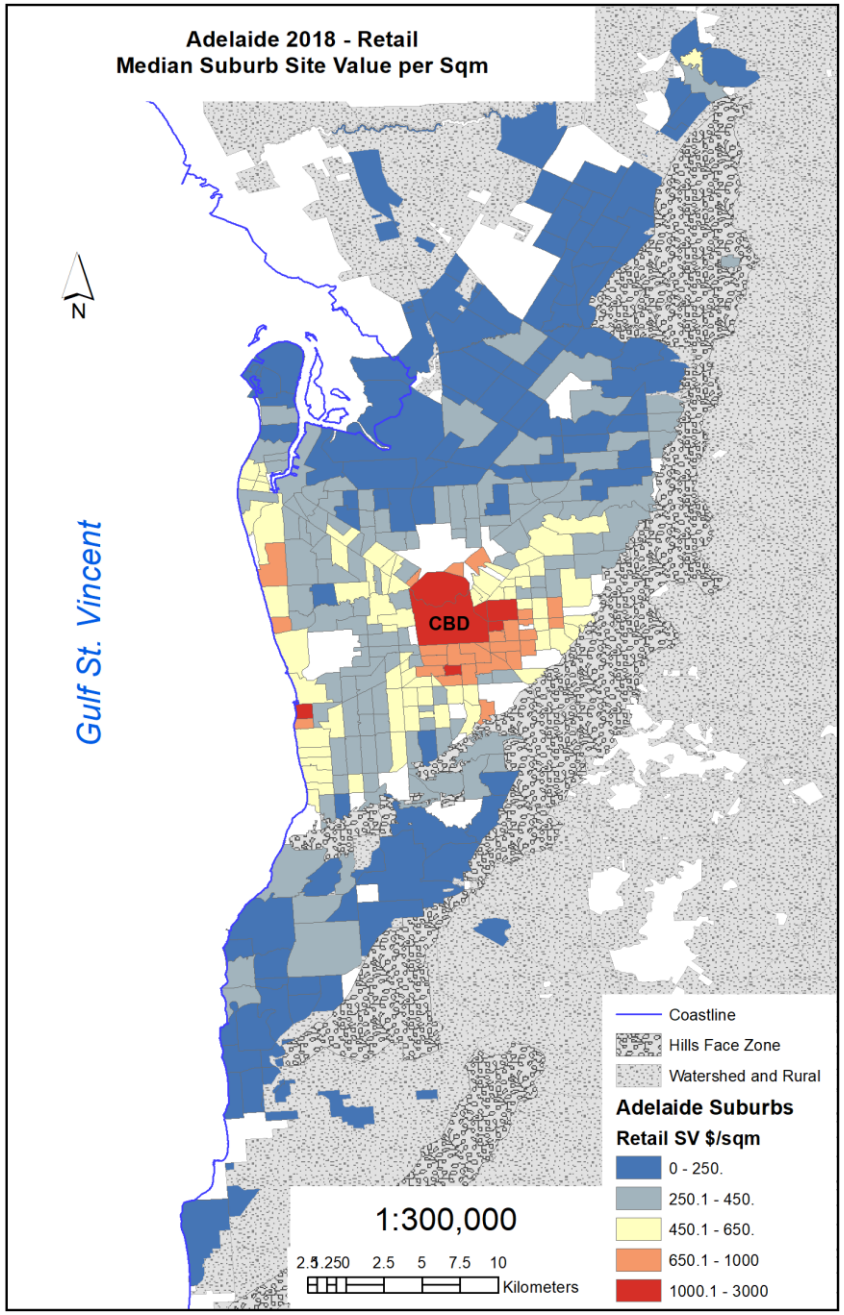
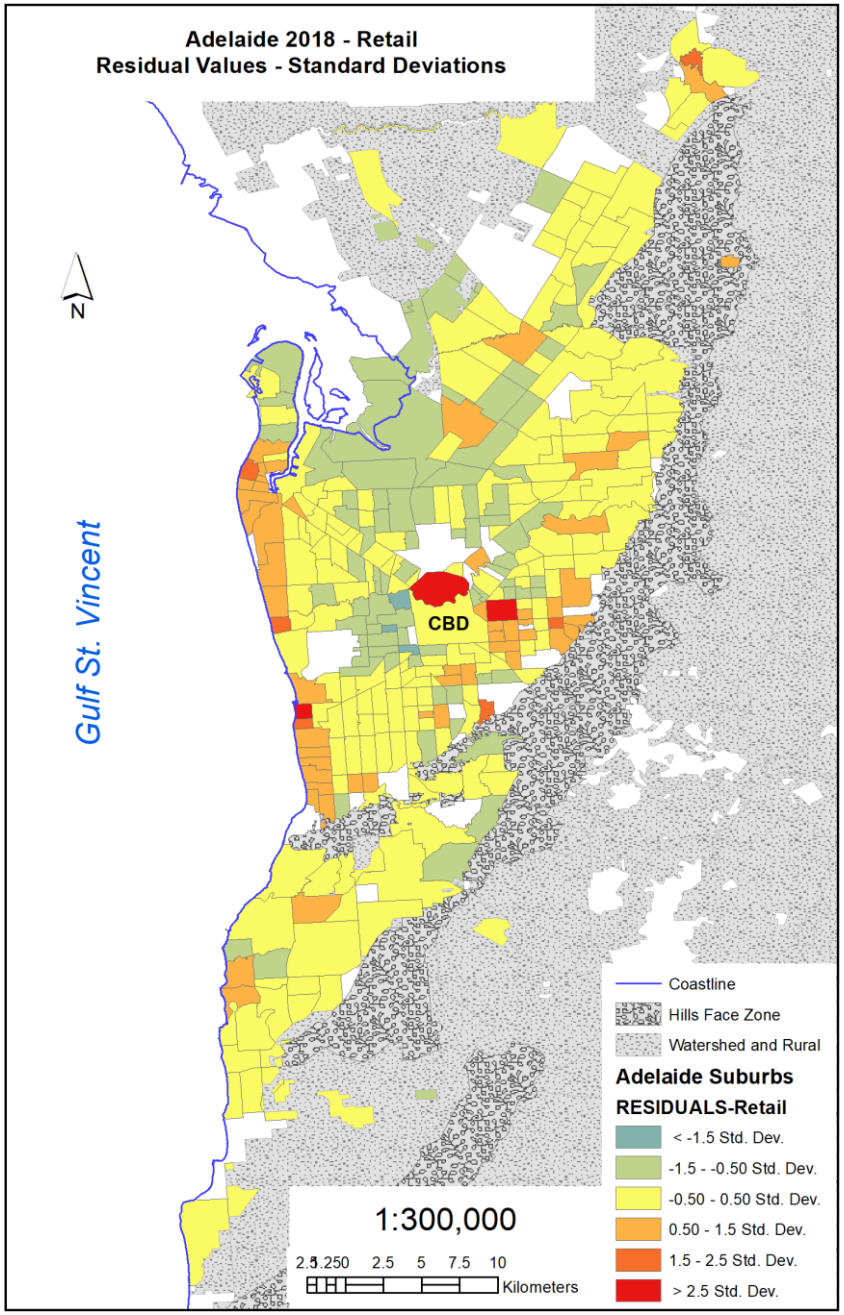


Figure 11 –Retail Land - Residuals from Land Rent Curve



Source: Author Analysis of South Australian Valuer Generals Data

Figure 14 – Industrial Land Values/sqm – Adelaide 2018

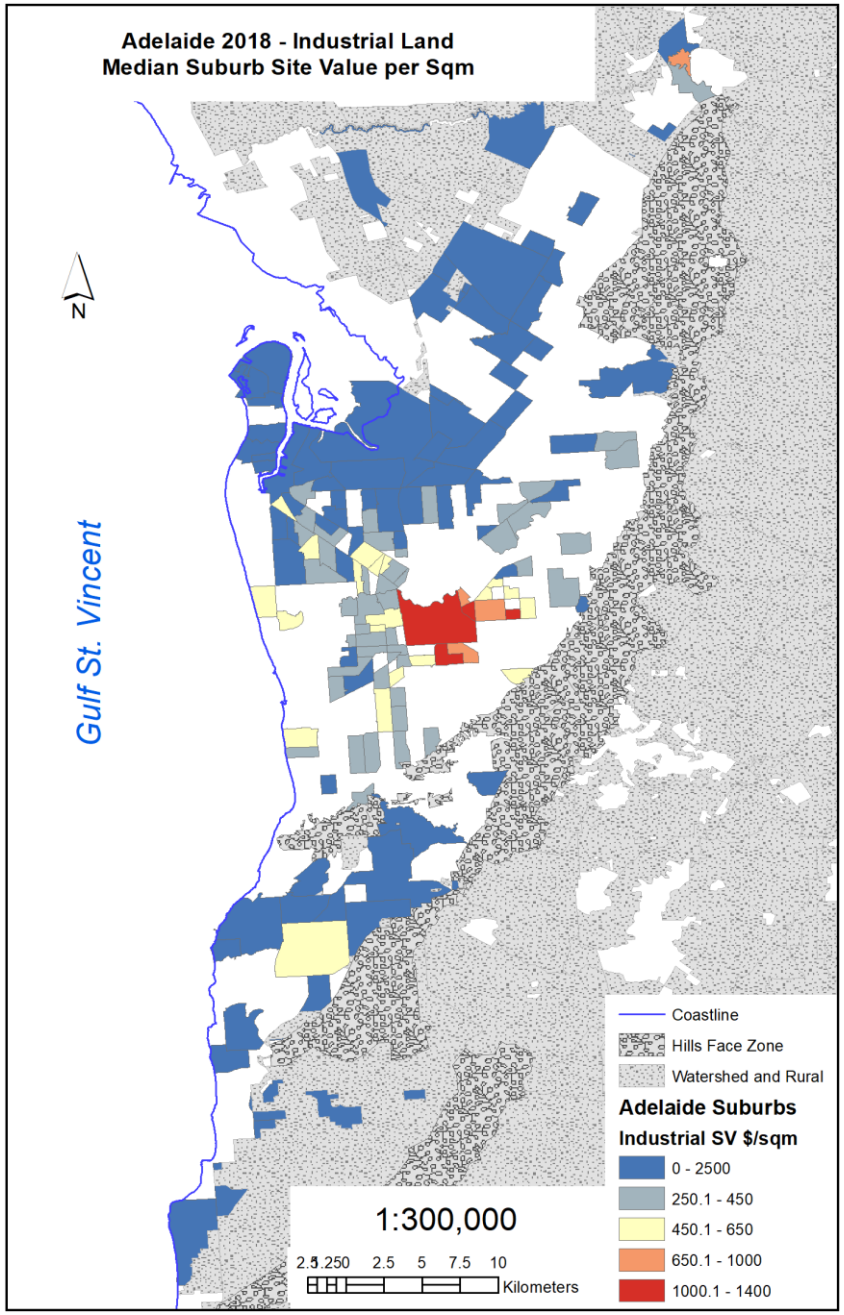
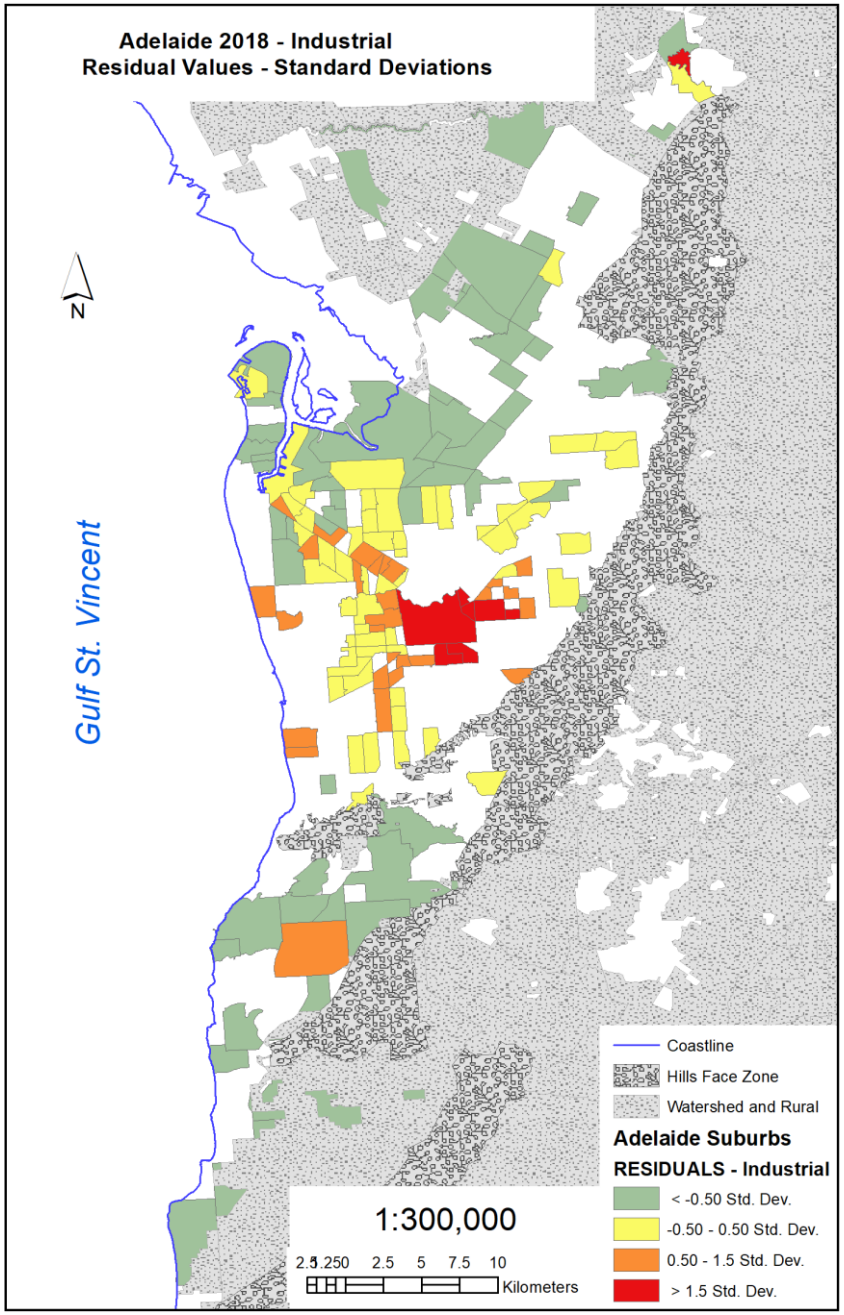


Figure 13 – Industrial Land - Residuals from Land Rent Curve



Source: Author Analysis of South Australian Valuer Generals Data

Figure 16 - Rural Land Values/sqm – Adelaide 2018

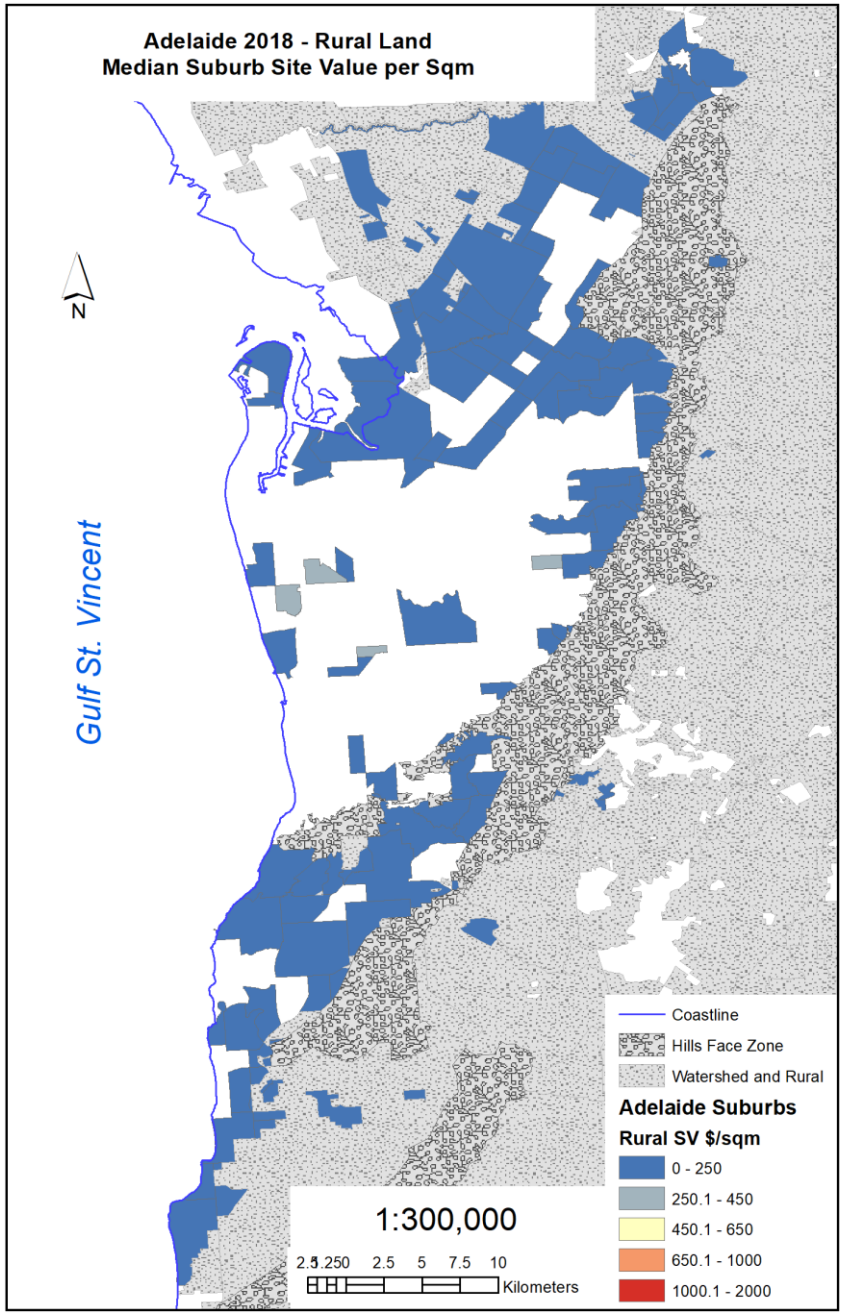
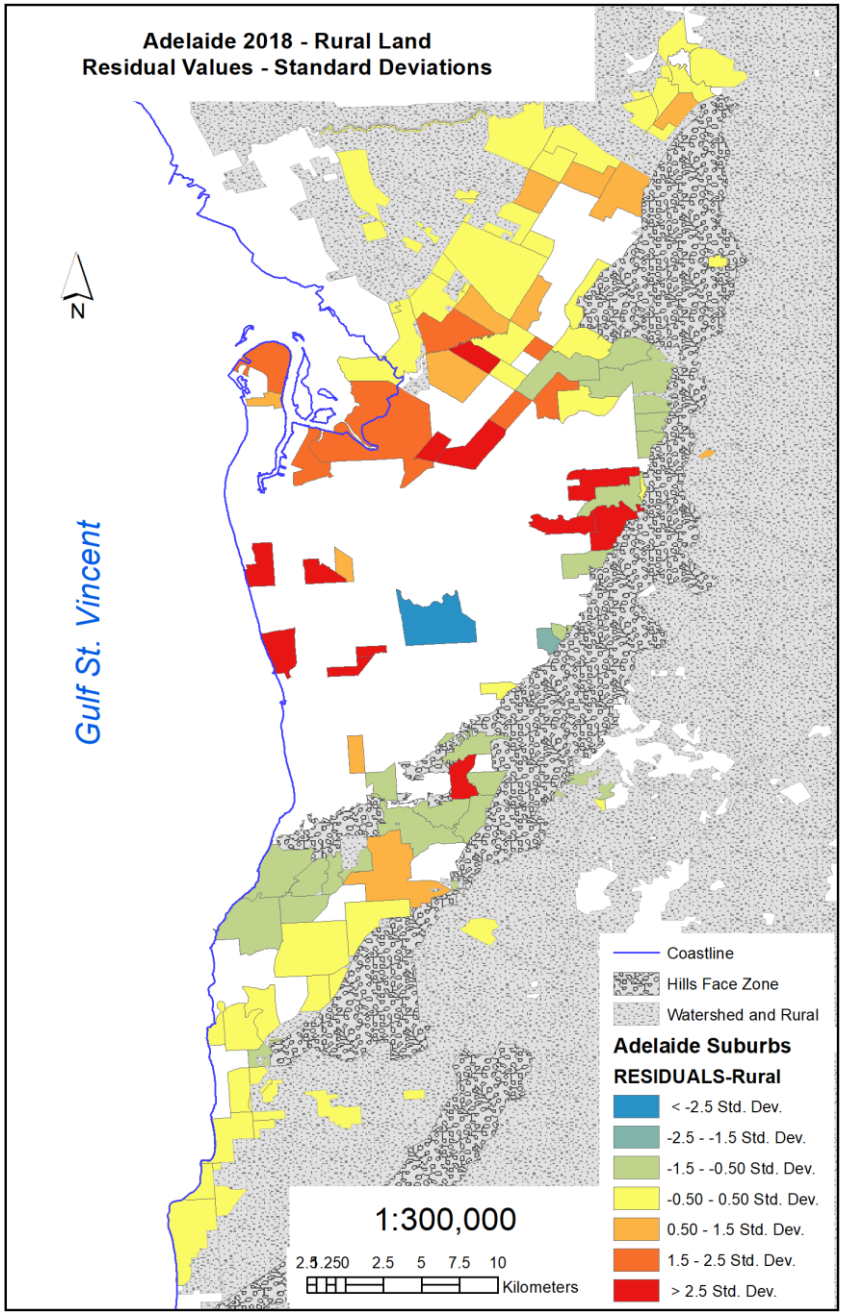


Figure 15 – Rural Land - Residuals from Land Rent Curve



Source: Author Analysis of South Australian Valuer Generals Data