MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Ministry for the Environment
Manatū Mō Te Taiao

National Policy Statement on Urban Development Capacity

Price efficiency indicators technical report: Rural-urban differentials

New Zealand Government

Acknowledgements:

MRCagney is acknowledged for the development of this technical report and the indicators within it.

Published in December 2017 by the Ministry of Business, Innovation and Employment and the Ministry for the Environment.

ISBN 978-1-98-853544-9 (print)

978-1-98-853545-6 (online)

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1. Introduction

This technical report sets out the approach to calculating land value differentials across rural-urban zoning boundaries for urban places[1] in New Zealand. It presents results for seven high-growth urban places: Whangarei, Auckland, Hamilton, Tauranga, New Plymouth, Christchurch and Queenstown.

These results, along with rural-urban differentials for other areas, are available on the dashboard on the Ministry of Business, Innovation and Employment's website.

The report should be read alongside part six of the *National Policy Statement on Urban Development Capacity: Guide to Evidence and Monitoring*, which explains how to interpret rural-urban differentials.

These tools are designed to help local authorities give effect to National Policy Statement on Urban Development Capacity (NPS-UDC) requirements to monitor market indicators and use indicators of price efficiency. The tools were developed with the assistance of technical experts in economic consultancies, central government, local authorities and Property Council New Zealand.

The underlying concept of the rural-urban differential is that it should be a 'like for like' comparison of the value of similar land parcels that have been zoned for rural or urban uses. If there are large differences in the value of similar sites with different zoning, then it may indicate that urban planning policies and/or infrastructure funding and planning policies result in insufficient development capacity for urban uses.

However, different land parcels are typically *not* identical – they differ in terms of their location and accessibility to various amenities, their physical geography, and infrastructure servicing. The methodology described and applied in this report therefore controls for a variety of differences between parcels that may affect their value to obtain a meaningful estimate of land value differentials across rural-urban boundaries.

This report consists of the following sections:

1. A section that describes the methodology and the data used to apply it, including:
    - The definition of rural-urban zoning boundaries

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[1] This analysis started with "extended urban areas", which are the largest geographic unit of analysis used for the market indicators and other price efficiency indicators on the dashboard on the Ministry of Business, Innovation and Employment's website. An extended urban area comprises the full area of territorial authorities that have jurisdiction over an "urban area" as defined by Statistics New Zealand in 2017. Some urban areas cover several territorial authority areas and so all of these are included in the extended urban area. This reflects that fact that urban settlement has created a single housing and labour market crossing the boundaries of these local authorities. So for example, the greater Christchurch extended urban area includes Christchurch city and Selwyn and Waimakariri districts.
The analysis included data on the main area of land within these extended urban areas that was zoned in District Plans for urban development, plus 10 kilometres outside of this. This ensured that peri-urban rural land and outlying towns associated with the main urban-zoned area were included (while staying within the computer data processing limits). In the case of Auckland, which has a much larger contiguous urban-zoned area than other places, computer processing limits meant that only data within eight kilometres of the main urban-zoned area were included.
The rural-urban differentials compared the values of only the land parcels 2 kilometres either side of the boundary between rural and urban zones, ie a subset of the above data.

- The identification of relevant land units either side of the zoning boundary, and their land values
- The estimation and removal of components of land value attributable to geography, amenities and subdivision costs
- The calculation of remaining differences in rural and urban land values in ratio and dollar terms.

2. One section outlining findings for each of the seven high-growth urban areas
3. Appendices that provide additional information from local authorities about geographic factors that may also affect land values (which must be controlled for in the analysis); and the results of additional model specification testing.

2. Methodology

This section sets out the approach for addressing technical issues related to the calculation of rural-urban differentials. This methodology addresses the following topics:

- The data used for the analysis
- Identification of the location of rural-urban zoning boundaries
- Identification of residential land units 2 kilometres either side of the zoning boundary
- Standardisation of land values across territorial authority boundaries within urban areas
- How a range of non-regulatory factors influencing differences in land values were estimated and controlled for, including:
    - Geographic constraints on development
    - Local amenities and proximity to centres and waterways
    - Land development costs associated with subdivision of land, on-site infrastructure, and development contributions to contribute to bulk infrastructure.
- The model calculations of the remaining difference in land values across zoning boundaries, in ratio and dollar terms.

The method builds on and refines previous calculations of rural-urban differentials for Auckland, undertaken to measure the impact of the former Metropolitan Urban Limit or MUL (Grimes and Liang, 2009; Productivity Commission, 2012; Zheng, 2013).

2.1. Underlying data

The analysis uses CoreLogic rating valuation data from the most recent valuation cycle for each territorial authority area. CoreLogic data was provided to the Ministry of Business, Innovation and Employment under a data licence arrangement for use in research and analysis of this nature.

Ratings valuation data includes rich information on the characteristics of properties, including:

- Total rateable values and land values (calculated as total rateable values minus the replacement value of improvements on the site)
- The location of the property, which has been geocoded by CoreLogic and which can be matched with Land Information New Zealand data on parcel boundaries
- Various characteristics of the property, including existing buildings on the site
- And, importantly for this exercise, the zoning that applied to the site on the valuation date, which aligns closely with local authority zoning information.

2.2. Identifying the location of zoning boundaries

This work extended the methodology previously used to calculate rural-urban differentials for Auckland, to estimate differentials for other urban areas.

The first step was to apply spatial analysis techniques to CoreLogic data to define rural-urban zoning boundaries for each urban area. Because the CoreLogic data includes information on zoning as at the most recent valuation date, this provides an indication of the location of urban and rural zones at that date. Subsequent plan changes or district plan reviews may have altered those boundaries and these have not been accounted for. This should be picked up in the next ratings valuation period.

Identification of zoning boundaries involved the following steps:

- Identification of all parcels within the main urban-zoned area plus approximately 10 kilometres outside this, which may include parcels in multiple territorial authority areas.
- Identification of the broad zoning code associated with each property centroid in the CoreLogic dataset (eg residential, industrial, commercial, rural)
    - One-digit CoreLogic zoning codes were used to identify broad zoning categories. In a limited number of cases, it was necessary to use two-digit detailed zoning codes to better align with council zoning maps.
    - Rural residential and lifestyle zones were generally classified as rural zones, as they are expected to have a significantly lower density and level of infrastructure servicing relative to urban residential zones. Future urban zones were generally classified as rural in the CoreLogic data, unless they had already been through a plan change process.
    - Some zoning categories were classified as ‘other’ zones and filled in with the zoning from nearby parcels. This was necessary to address issues such as small parks or reserves within the city that may otherwise be classified as rural land, as well as road parcels.
- Generation of space-filling polygons around each individual property centroid to enable identification of contiguous areas of urban and rural zoned land.
    - In order to do so, all the ‘other’ zoned land in the city was divided into a grid of 50 metre by 50 metre cells, and each cell was assigned the zoning of the closest rural or urban zoned land.

- Merging of contiguous areas of urban or rural land to identify the overall extent of urban and rural zoning.
- Definition of boundaries between rural and urban zones, excluding locations where zoning bordered on coastlines or inland water bodies.

Tests showed that CoreLogic zoning codes align well with council zoning maps, with the exception of property centroids that are mapped onto road zones, which does not pose a major problem for the analysis.

2.3. Identifying relevant land units 2 kilometres either side of the zoning boundary

The rural-urban differentials were calculated using only land units within 2 kilometres either side of the boundary between rural and urban zones (a total 4 kilometre band). This is consistent with the approach taken in previous rural-urban differentials calculated to measure the impact of Auckland's Metropolitan Urban Limit. . Other distance bands were also tested (see model specification tests in Appendix 2).

Property data at the most disaggregate geographic level available was used (ie the rating valuation unit). This enables the most precise estimate of the impact of zoning boundaries on land values. It is, however, a departure from the approach used in previous calculations of rural-urban differentials for Auckland, which grouped property valuation data at the Census meshblock level. Testing alternative model specifications (see the technical appendix) found that aggregating the data in this way was too coarse for smaller urban areas, and led to significantly higher estimates of rural-urban differentials.

Consistent with previous work to calculate rural-urban differentials for Auckland, the valuation data was filtered to focus on two specific types of residential properties:

- Detached dwellings (property type code RD), which comprise the majority of residential properties in and around cities
- Lifestyle blocks / rural residential properties (property code LI), which are common on the fringes of most cities and which typically coexist with farms and rural uses.

The analysis was based on urban and rural residential properties, in order to obtain a closer 'like for like' comparison of land values. Including other types of properties in the data, such as farm properties and commercial properties, would make it more challenging to robustly estimate land value differentials due to the fact that there are more differences between these types of properties that would have to be controlled for in the analysis.

As a result, it is best to think about this methodology as providing an estimate of the difference between the value of land zoned for urban or suburban residential density versus land zoned for rural residential density.[2]

[2] Lifestyle blocks typically have a higher land value, on a per hectare basis, than farmland. This reflects the cost of improving land to accommodate rural residential uses versus paddocks, and potentially also the fact that lifestyle blocks may be developed in areas of higher amenity.

2.4. Standardising the valuation data across territorial authorities

General property valuation dates differ between territorial authorities. This could in principle lead to inaccurate estimates of rural-urban land value differentials for urban areas that cross over multiple territorial authorities.

This was addressed by adjusting land values to a consistent date (2017 Quarter 1) using the sales price to appraisal ratio (SPAR) index at a territorial authority level. The SPAR index is available at a territorial authority level on the dashboard on the Ministry of Business, Innovation and Employment's website.

The following table summarises the territorial authorities included in the analysis and the date of the most recent valuation period for each territorial authority.

Table 1: The date of the most recent rating valuation for each territorial authority

Extended urban area	Territorial authority	Most recent valuation
Whangarei	Whangarei District	1/09/15
Auckland	Auckland	1/07/14
Hamilton	Hamilton City	1/09/15
	Waikato District	1/07/14
	Waipa District	1/08/16
Tauranga	Tauranga City	1/07/15
	Western Bay of Plenty District	1/07/15
New Plymouth	New Plymouth District	1/09/16
Christchurch	Christchurch City	1/08/16
	Selwyn District	1/07/15
	Waimakariri District	1/08/16
Queenstown	Queenstown-Lakes District	1/07/14

2.5. Removing the impact of geographic constraints, amenities and subdivision

Zoning is only one of many factors that affects the value of urban land. Other factors that may influence land values include the proximity of sites to amenities and employment opportunities, geographic constraints such as natural hazards, the characteristics of sites (eg slope and the direction it faces), the availability of infrastructure to serve development on the site, and improvements to land ranging from subdivision consents to earthworks.

Consequently, a simple comparison of the average value of urban-zoned land with the average value of rural-zoned land is unlikely to produce meaningful or accurate results. For instance, urban-zoned land also tends to have better access to employment opportunities than land that is far away from the edge of the city, meaning that comparing the average value of all urban zoned land with the average value of all rural-zoned land will not be meaningful.

This was addressed using the following steps:

- Conversations were held with local authority officers to identify factors that might affect land value differences at the boundary between rural and urban zones
- Tests were undertaken on the impact that geographic characteristics and challenging terrain have on land values and zoning in each extended urban area
- An econometric model was developed to remove the impact of geographic constraints and three other factors: local amenities; proximity to water bodies; and proximity to the town centre. This produced an initial set of rural-urban differentials (both ratios and dollar differences) between urban and rural land within 2 kilometres either side of the zoning boundary.
- Average section density on either side of the rural-urban boundary was estimated for each urban area using a similar econometric approach, and multiplied by national average subdivision costs (including development contributions) of $95,000 per residential section.
- The initial differentials were adjusted to account for the impact of estimated land development costs, including some development contributions for infrastructure. These produced the final differentials provided on the dashboard on the Ministry of Business, Innovation and Employment’s website.

Figure 1 illustrates the process.

Figure 1: Splitting out differences in rural and urban values caused by various factors

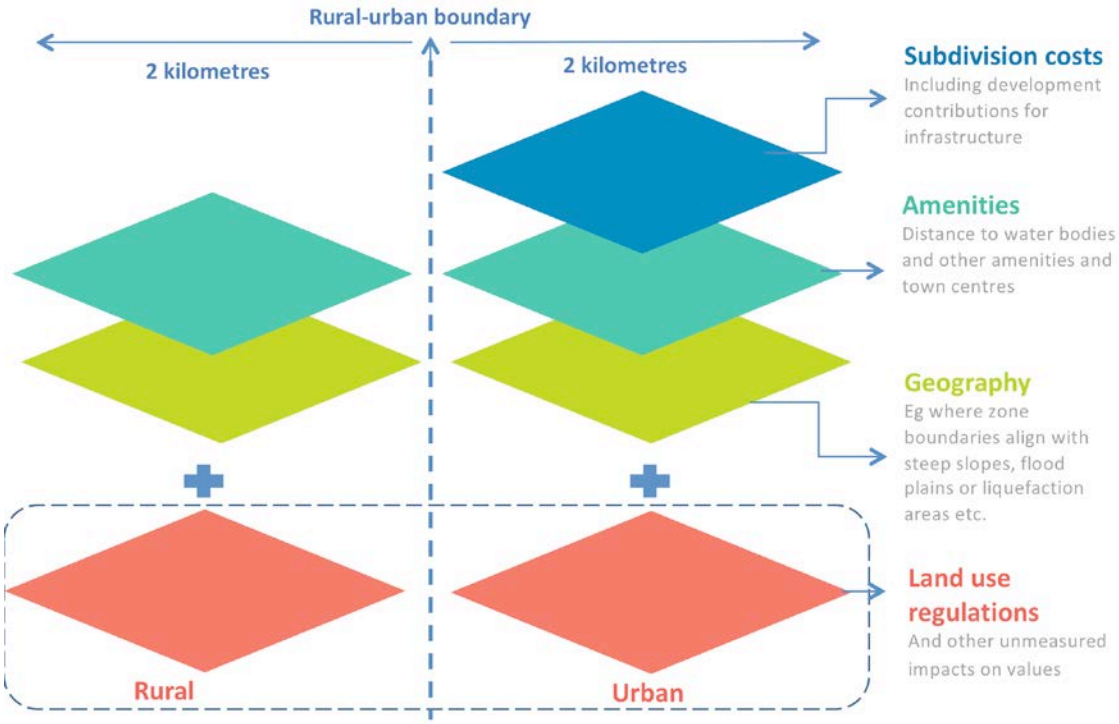


Figure 3 (section 3.2) shows the results of this process, including the initial differentials in each urban area, the relative impact of geographic constraints and amenity, versus land development costs, and the final rural-urban differentials. While the impact of these factors varies between different urban areas, in all cases removing the impact of geography and amenities significantly reduced the differential between their rural and urban land values. Removing the impact of subdivision also reduced the differential.

Further detail on the steps taken to remove the impact of geographic constraints, amenities and subdivision on differences in rural and urban land prices follows.

2.5.1. The impact of geographic constraints

Rural-urban zoning boundaries may be influenced by the physical geography of regions in a way that may bias estimates of land value differentials and result in an excessively high estimate of the impact of zoning on land values.

For instance, consider a case in which the rural-urban boundary coincides with the edge of a flood plain. The land in the flood plain is likely to be worth less than the adjacent land, but this will be due to the fact that it is costly and risky to develop. If a council responds by excluding the flood-plain from urban zoning, then there may be a drop-off in land values at zoning boundaries that occurs for reasons other than zoning.

However, zoning boundaries may not be strongly related to geographical constraints. In this case the geographic constraints will not drive differences land values along a rural-urban divide.

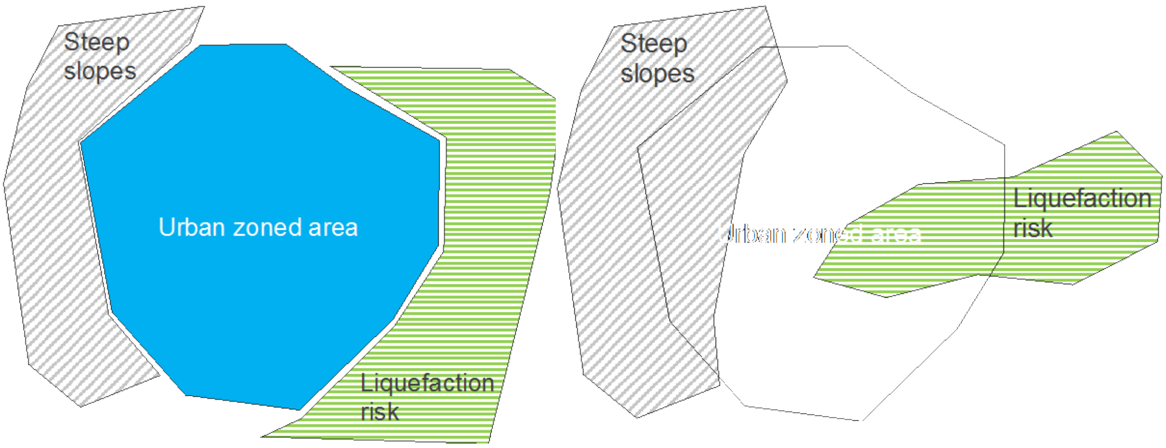
Figure 2 shows two possible scenarios, with different implications for analysis.

In the first case, there is a very close alignment between the edge of the urban-zoned area and areas with geographic constraints. There are steep slopes immediately to the west of the city, and liquefaction risk areas immediately to the east. In this case, a simple estimate of land value differentials across the rural-urban boundary will overestimate the impact of zoning. In order to estimate a reliable measure, it will be necessary to either explicitly control for geographic constraints, or to focus on the smaller areas to the north and south of the city where urban zoning does not currently abut geographic constraints.

In the second case, geographic constraints overlap across both rural and urban zoned areas. To the west of the city, there are sloping areas, some of which have already been built on or zoned for urban use. (This is a reasonably common scenario – in Wellington, for instance, many steep slopes have been developed.) To the east of the city, there is liquefaction risk in both the rural and urban zoned areas. (This is also common – for instance, significant parts of Christchurch's urban area have experienced liquefaction.) In this scenario, the presence of geographic constraints does not affect rural-urban differentials.

Figure 2: Two scenarios for challenging geography

Case 1: Geographic constraints follow the RUB **Case 2: Geographic constraints overlap the RUB**



Discussions with local authority officers (see Appendix 1) suggest there are a variety of geographic characteristics that may be relevant to consider, but there are different issues to consider in individual urban areas. Some potentially relevant issues are:

- Steep slopes, which make it costlier to develop land but which may also offer advantages in terms of views. Tests undertaken for this analysis found that in Auckland sites with an average slope of 15 percent were worth almost 30 percent less than flat sites. On the other hand steeply sloping sites experienced a larger discount in value in Auckland than in most other urban areas.
- Flood-prone land, for example, in wetlands or around rivers, which can be mitigated by spending money on flood protection measures
- Liquefaction and earthquake risk, which is difficult to mitigate or insure against
- Landslide risk – this issue was mentioned in the Queenstown context

Another geographic characteristic – high class soils – often affects council zoning decisions. This does not make land physically undevelopable for urban use. However, it is acknowledged that councils often consider soil quality when trying to address trade-offs between urban and rural uses. Unfortunately, data was not available on soil quality for already urbanised land so it was not possible to test for the impact of soil quality on urban and rural land values.

The impact of geographic constraints was accounted for in two ways:

- First, focusing the analysis on residential properties (detached houses and lifestyle blocks) significantly reduces the risk of bias due to geographic constraints or hazards. The rural-zoned properties included in the analysis are suitable for at least *some* level of residential development, as they have been developed as lifestyle blocks. This excludes challenging terrain that has been retained as reserves or low-intensity rural uses and hence ensures a closer 'like for like' comparison.
- Second, the impact of including control variables for geographic constraints was tested in several extended urban areas. More specifically, the impacts of slope plus selected natural hazards were tested for (eg in Christchurch – liquefaction risk; Queenstown – landslide risk; and Hamilton – flood risk). In all three cases, including additional variables for natural hazards and parcel slope did not significantly affect the results. This suggests that current zoning boundaries do not coincide with geographic constraints.

2.5.2. A model that excludes the impact of geographic constraints and amenities

An econometric model of land values was developed in order to control for various factors that may affect land values. This analysis uses ordinary least squares (OLS) regression, a common statistical technique for analysing the individual impact of multiple factors that affect a single outcome variable.[3]

After testing alternative model specifications (see Appendix 2) a preferred regression model was identified that optimised the trade-off between goodness of fit and model complexity.[4] The preferred model is summarised in .

Equation 1: Model of land value discontinuities with location and geographic control variables

$$\log(\mathrm{LV_i}) \sim \mathrm{DRUB2_i} + \mathrm{DRUB3_i} + \mathrm{DRUB4_i} + \log(\mathrm{DCBD_i}) + \log(\mathrm{DWater_i}) + \mathrm{MBInc_i} + Slope_i + {Slope_i}^2 + Hazard_i$$

The dependent variable in this model (on the right hand side) is the natural log of **land value per square metre**, for each individual property parcel i. This variable is log-transformed to normalise it. The explanatory variables in the model include:

- Indicator variables for whether a parcel is zoned urban and within 2 kilometres of the rural-urban zoning boundary ($\mathrm{DRUB2_i}$), zoned rural and within 2 kilometres of the zoning boundary ($\mathrm{DRUB3_i}$), or rural and far away from the zoning boundary ($\mathrm{DRUB4_i}$). (The indicator for urban-zoned parcels that are far away from the boundary is excluded from the model to prevent perfect collinearity between these indicators.)
- Three variables that control for the proximity of parcels to various amenities:

[3] More sophisticated econometric techniques such as spatial regressions or quantile regression could be used to extend this analysis; however, OLS regression has the advantage of being more straightforward to apply and interpret.

[4] As measured by Akaike's information criterion.

- o The natural log of straight-line distance to town hall ($DCBD_i$), which is a proxy for access to employment and urban amenities, which tends to be better in more central locations
- o The natural log of straight-line distance to the nearest coastline or major inland water body ($DWater_i$)
- o Median household income for people living within this neighbourhood at the time of the 2001 Census ($MBInc_i$), which serves as a proxy for other amenities, such as in-demand school zones, that may make an area more attractive for people with higher incomes and hence push up property values.

- Several controls for geographic constraints:
    - o The average slope of the longest straight line across the property ($Slope_i$), and the square of slope – this allows slope to have a nonlinear effect on land values

For selected cities, an indicator variable for whether the parcel sits within a natural hazard area, for example, a liquefaction risk area or flood risk area ($Hazard_i$)This model was applied to the CoreLogic land value data for each urban area in order to estimate a set of coefficients that provide information on the effect of each of the above factors on land values. Coefficient estimates on variables for the urban and rural-zoned parcels within 2 kilometres of the zoning boundary (the $DRUB2_i$ and $DRUB3_i$ variables) provide an estimate of the relative value of similar parcels to which different zoning applies, holding other factors constant.

Table 2 describes the variables included in the model and explains how they were calculated.

Table 2: Description of econometric model variables

Variable	**Definition and source**
Dependent variable	
1.1.1 Land value per square metre 1.1.2 $\log(LV_i)$	1.1.3 Land value per square metre, adjusted to 2017Q1 values. Transformed by taking the natural log. 1.1.4 Valuations are sourced from the CoreLogic ratings valuation data and updated to 2017Q1 values using the SPAR index.
RUB indicator variables	
1.1.5 Urban-zoned land within 2 kilometres of the zoning boundary 1.1.6 $DRUB2_i$	1.1.7 An indicator variable for urban-zoned parcels that are close to the RUB. In the base model, 'close' is defined as within 2 kilometres of the RUB. The impact of alternative distance bands was also tested (see Appendix 2). 1.1.8 Calculated using spatial analysis tools in R (programming software for statistics computing and graphics) after identifying rural-urban boundaries using CoreLogic valuation data.
1.1.9 Rural-zoned land within 2 kilometres of the zoning	1.1.11 An indicator variable for rural-zoned parcels that are close to the RUB. In the base model, 'close' is defined as within 2 kilometres of the RUB.

boundary 1.1.10 $DRUB3_i$	1.1.12 Calculated as above.
1.1.13 Rural-zoned land more than 2 kilometres of the zoning boundary 1.1.14 $DRUB4_i$	1.1.15 An indicator variable for rural-zoned parcels that are far away from the RUB. 1.1.16 Calculated as above.
Location controls	
1.1.17 Proximity to city centre 1.1.18 $\log(DCBD_i)$	1.1.19 Straight-line distance to town hall, in metres. Transformed by taking the natural log. 1.1.20 Calculated using spatial analysis tools in R. To reduce computation time, distances are measured from meshblock centroids rather than property parcel centroids.
1.1.21 Proximity to waterways 1.1.22 $\log(DWater_i)$	1.1.23 Straight-line distance to the nearest coastline or major inland water body, in metres. Transformed by taking the natural log. 1.1.24 Calculated using spatial analysis tools in R. To reduce computation time, distances are measured from meshblock centroids rather than property parcel centroids.
1.1.25 Household income (proxy for local amenity) 1.1.26 $MBInc_i$	1.1.27 Median household income (in dollars per year) for people living within this neighbourhood at the time of the 2001 Census. Sourced from Statistics New Zealand Census data.
Geographic controls	
1.1.28 $Slope_i$	1.1.29 The slope (rise over run) of the longest line across each individual property parcel. 1.1.30 Calculated by applying spatial analysis tools in ArcGIS to LINZ property parcels.
$Slope_i^2$	1.1.31 Calculated by squaring the slope variable.
1.1.32 $Hazards_i$	An indicator variable for whether the property falls within a natural hazard area, as defined by maps provided by local authority officers. 1.1.33 Calculated by applying spatial analysis tools in R to natural hazards maps (where available) and CoreLogic property parcel data.

2.5.3. Calculating the differentials using results from econometric models

The coefficients from the econometric model described above were used to calculate the ratio of land value per square metre immediately inside and outside rural-urban boundaries, controlling for other factors included in the model.

As the dependent variable is log-transformed, the ratio of land values was calculated by taking the exponent of the difference between the coefficients on the $DRUB2_i$ and $DRUB3_i$ variables. This can be calculated using Equation 2.

Equation 2: Formula for calculating the ratio of land values inside and outside the RUB

$$LV\_Ratio = \exp(DRUB2_{coeff} - DRUB3_{coeff})$$

A second measure of the rural-urban differential was also calculated: the difference in land values in dollars per square metre. In order to obtain this the RUB ratio was multiplied by the average value of land immediately inside the RUB, as shown in Equation 3.

Equation 3: Formula for calculating the dollar difference in land values inside and outside the RUB

$$LV\_Difference = E(LV_i | DRUB2_i = 1) * (1 - 1/RUB\_Ratio)$$

2.5.4. Adjusting for differences in land development costs: calculating section density

The results from the above econometric model do not control for differences in land development costs and infrastructure provision between rural- and urban-zoned parcels. However, land development and infrastructure costs are typically ‘capitalised’ into land values as they result in persistent improvements to the accessibility or developability of sites.

Accordingly, a supplemental estimate was made of the degree to which infrastructure development costs vary across the RUB. This was used to adjust the ‘raw’ land value differential calculated using the above method.

The advice of surveyors and subdivision companies was that many of the costs of subdivision scale up or down based on the number of sections created. The intended effect of zoning is often to enable councils to manage within funding constraints by focusing infrastructure spending in specific areas. In order to do so, denser urban or suburban development is discouraged in rural-zoned areas. Consequently, an estimate of land value differentials that does not take into account differences in land development costs caused by zoning decisions will be biased upwards.

It was possible to estimate the number of sections on either side of the rural urban boundary in each urban area using the CoreLogic dataset, as this also provided information on section sizes. A similar econometric analysis technique was used to estimate the average difference in section sizes across the boundary, controlling for other factors that may also affect section density. (For instance, in many cities section sizes are smaller near the centre of the city, as developers respond to higher demand to live in central locations by producing smaller sites.)

The following equation shows how the difference in section density was estimated. The dependent variable in this equation, section density, was constructed at the parcel level as the inverse of land area in square metres. The explanatory variables in this model are the same as for the first model.

Equation 4: Model of discontinuities in section density with location and geographic control variables

$$\log(\mathrm{SectionDensity_i}) \sim \mathrm{DRUB2_i} + \mathrm{DRUB3_i} + \mathrm{DRUB4_i} + \log(\mathrm{DCBD_i}) + \log(\mathrm{DWater_i}) + \mathrm{MBInc_i} + Slope_i + {Slope_i}^2 + Hazard_i$$

As above, coefficient estimates on variables for the urban and rural-zoned parcels within 2 kilometres of the zoning boundary (the $\mathrm{DRUB2_i}$ and $\mathrm{DRUB3_i}$ variables) provide an estimate of the relative density of sections immediately inside and outside the boundary, holding other factors constant. As these dependent variables were log-transformed, the ratio of section density across the boundary can be calculated by taking the exponent of the difference between the coefficients on the DRUB2 and DRUB3 variables.

This can be calculated using the formula in Equation 5.

Equation 5: Formula for calculating the ratio of section density inside and outside the RUB

$$SectionDensity\_Ratio \ = \exp(DRUB2_{coeff} - DRUB3_{coeff})$$

The numerical difference in section density across the RUB in absolute terms was then obtained by multiplying this ratio by the average density of sections immediately inside the RUB, as shown in Equation 6.

Equation 6: Formula for calculating the difference in sections per hectare inside and outside the RUB

$$SectionDensity\_Difference = E(SectionDensity_i | DRUB2_i = 1) * (1 - 1/SectionDensity\_Ratio)$$

2.5.5. Estimating land development costs

The estimate of land development costs per section drew on two BRANZ reports on the cost of new house construction, which provide data on costs in a number of locations around New Zealand.[5] This was supplemented with information on three subdivisions in south Auckland and the northern Waikato from a subdivision company.[6]

According to these sources, land development costs include all of the costs that are borne by private developers

- Site works and infrastructure, eg earthworks, electrical infrastructure, landscaping;
- Professional fees, eg infrastructure design and quantity surveying;
- Subdivision resource consents; and
- Development and financial contributions for network infrastructure – in principle, these should reflect a large share of network infrastructure costs, but in practice the degree to which they do so will depend upon individual councils' pricing policies, especially for water and wastewater infrastructure where there are large variations in council practices.

These may not include the full costs for network infrastructure which may be publicly subsidised (eg via rates).Land development costs can vary considerably by site. Table 3 provides a range of subdivision examples that illustrate this variation. In these examples subdivision costs range from $64,531 for a Northland section to $392,728 for a Queenstown section. Alternatively they range from $54 per square

[5] Page I (2008) New house price modelling. BRANZ Study Report 196(2008); Page I and Curtis M (2013) New house price model update at April 2013. BRANZ Project Report E626.
[6] The Surveying Company (2016) Personal communication with John Gasson. 1 August 2016.

metre in an Auckland subdivision to $476 per square metre for a Waikato subdivision. Table 3: Land development costs for 17 subdivisions

Location	Lots (#)	Average site area (m^2)	Land development costs per section	Land development costs per m^2
Auckland - North Shore (1)	24	2152	$115,554	$54
Auckland - North Shore (2)	22	230	$100,540	$437
Auckland - Pukekohe (3)	41	1000	$126,119	$126
Auckland - Pukekohe (3)	33	1000	$132,651	$133
Hawkes Bay (1)	149	500	$75,566	$151
Hawkes Bay (1)	128	500	$66,930	$134
Hawkes Bay (2)	26	338	$76,984	$228
Northland (1)	56	761	$64,531	$85
Queenstown (1)	89	900	$151,404	$168
Queenstown (1)	15	1400	$272,617	$195
Queenstown (1)	18	2500	$291,131	$116
Queenstown (1)	10	1200	$392,728	$327
Queenstown (1)	95	800	$90,480	$113
Southland (1)	70	800	$68,217	$85
Waikato - Tuakau (3)	21	650	$97,078	$149
Waikato (2)	71	162	$77,154	$476
Wellington (1)	170	500	$64,921	$130
Weighted average		694	$95,020	$137

Source: (1) Page (2008); (2) Page and Curtis (2013); (3) The Surveying Company (2016). All costs inflated to 2017Q1 dollars using Statistics New Zealand's Capital Goods Price Index for Land Improvements.

According to a personal communication with John Glasson (The Subdivision Company), variations in land development costs per section are more likely to reflect councils' development contributions policies and local terrain, rather than variations in lot size:

> *"Construction costs, engineering design, engineering observation and engineering completion varies from location to location. These can be considerably higher where topographical restraints are limiting and the land is steeper. The earthworks volumes in these areas significantly increase… Another limiting factor is areas prone to flooding or*

areas within a 1 in 100 year storm event area. These areas require full stormwater catchment analysis and hydraulic analysis which adds time and cost to the subdivision… Furthermore, deeper top soil depths within the Pukekohe area can often mean that the foundations for building houses can be $5,000 to $10,000 more expensive than other areas.

"The main difference [between council areas] is purely the financial contributions and development contributions. For example, the development contributions in the Waikato District Council area are approximately $15,000 plus GST cheaper per additional lot than they are in the Auckland Council area.

"Generally speaking the costs for subdivision of lots between 300sqm to 1,000sqm are very similar. This means that the price per lot is approximately the same. However, once you get lots less than 300sqm then the cost to subdivide each additional lot can decrease by up to 10 to 20%. Furthermore at the other end of the spectrum rural residential lots in excess of 2,500sqm can also be increased by 20 to 30% per lot. The reason for this is the distance for infrastructure is reduced for small lots and in turn increased for larger lots."

On the basis of this advice and using the BRANZ reports and above subdivision information, a weighted average land development cost of $95,000 per section was chosen.

This may not be representative for all urban areas. Local authorities may seek to undertake additional work to refine land development and infrastructure costs estimates if they suspect that actual land development and infrastructure costs are significantly different than the estimated averages used in this analysis. The methodology outlined here can easily be adapted to use a different estimate of per-section land development costs that also includes additional infrastructure costs that are not borne directly by developers. Higher development costs would reduce the final rural-urban differential.

2.5.6. Finalising the calculation of rural-urban differentials

The difference in sections per hectare were multiplied against an estimate of the cost of land development per section to understand how much land development costs may contribute to land values per square metre inside the RUB.

The final differentials presented in this report were obtained by:

- Subtracting estimated land development costs per square metre from the rural-urban differential, expressed in dollar terms, to obtain the dollar differential; and
- Recalculating the differential in ratio terms based on these results.

3. Summary of results for seven urban areas

3.1. The final differentials

Table 4 summarises the key results of this analysis for seven high-growth urban areas. This table reports two core measures of the differences in land values:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land

It also uses differences in dollar terms to provide an indicative estimate of the 'materiality' of these differences for a 600m^2 residential section.[7]

This analysis shows that:

- Ratios range from 1.53 to 3.15. They are lowest in Whangarei and New Plymouth, and highest in Auckland and Queenstown.
- The differences in dollar terms range from $43/m^2 to $345/m^2. They are highest in Auckland and Queenstown, and lowest in Whangarei and New Plymouth.

Table 4: Land value differentials across rural-urban zoning boundaries (2 kilometre distance band)

Geographic area	**Ratio**	**Difference ($/m^2)**	**Difference ($ per 600m^2 section)**
Whangarei	1.53	$43	$25,600
Auckland	3.15	$345	$206,700
Hamilton	2.42	$227	$136,200
Tauranga	2.02	$232	$139,200
New Plymouth	1.61	$92	$55,100
Christchurch	2.23	$150	$90,200
Queenstown	3.12	$337	$202,500

Notes: This is based on a comparison of land values between residential properties in rural and urban zoned areas. Differences in land values have been adjusted for land development costs, assuming a land development cost of approximately $95,000 per section. A 2 kilometre distance band was used to identify properties that are close to the boundary.

[7] A 600m^2 section size was chosen as an indicative benchmark and may not be representative of actual outcomes in specific locations. For instance, actual section sizes for new subdivisions in Auckland are closer to 450m^2.

3.2. How geography, amenities and subdivision affects land prices in different urban areas

Figure 3 shows how the calculation of differentials was affected by including various controls for other factors that can influence land values.

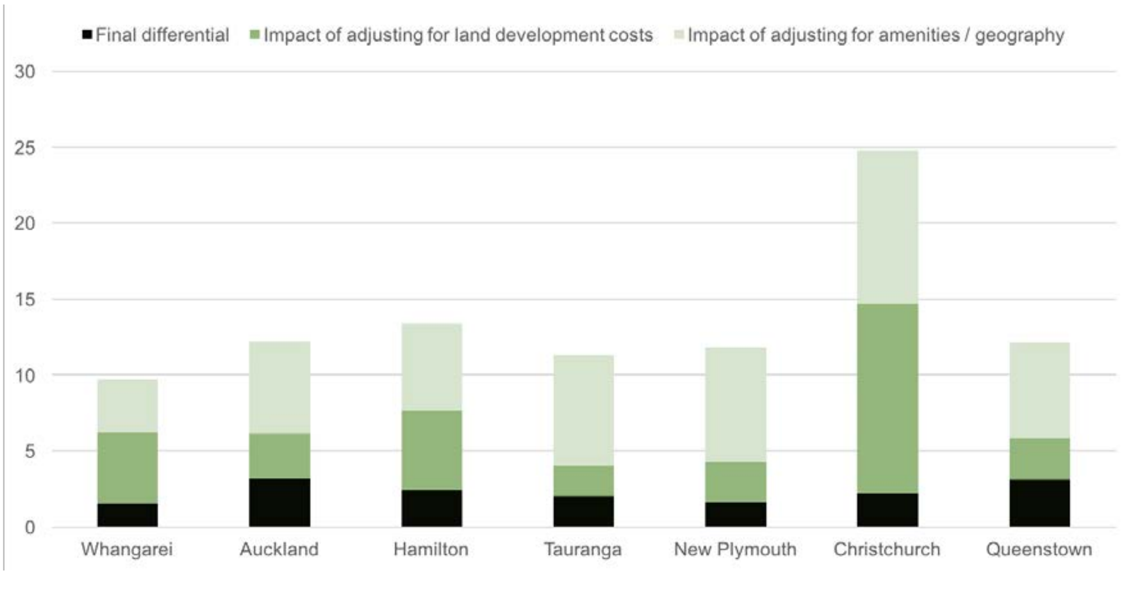
The full height of each stacked bar shows the initial differential between rural and urban land values for each urban area. This is calculated by dividing the average value of urban-zoned land close to the RUB by the average value of rural-zoned land close to the RUB. For instance, Table 8 in the following section shows that for Auckland, the average value of urban-zoned land close to the boundary was $505/m^2, compared with an average value of $41/m^2 for rural-zoned land near the boundary. This implies an initial ratio of 12.2.

Econometric models were then used to control for the impact of proximity to amenities and geography. In all cases, these models produced a lower estimate of the differential. This suggests that the initial ratios are too high due to the fact that some other explainable factors vary across the zoning boundary. In the case of Auckland, this reduced the ratio to 6.1, as shown in Table 10 in the following section.

Finally, adjusting for differences in land development costs that are borne by developers resulted in a further reduction in this ratio. For Auckland, this resulted in a final ratio of 3.15, as shown in Table 4 above.

The impact of these factors varies between urban areas. For instance, Christchurch has a very large initial ratio between rural and urban land values that is far in excess of any other city. However, this appears to primarily be the result of differences in location, amenities, and geography between urban and rural zoned parcels (which reduces the ratio by 10 points) and differences in land development expenditures (which reduces the ratio by a further 12 points).

Figure 3: How much geographic constraints, amenities and subdivision affect rural-urban differentials



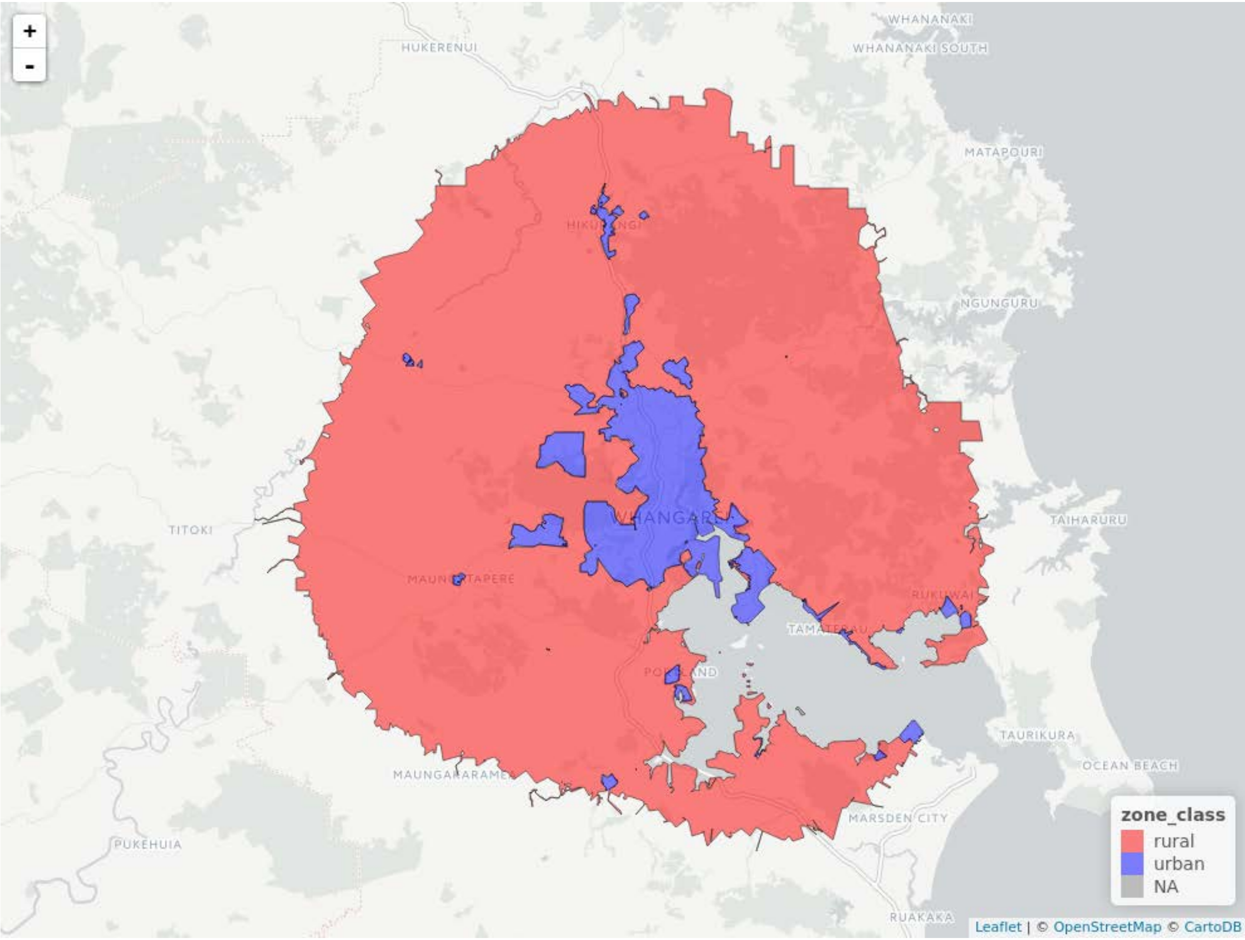
4. Whangarei urban area

This section summarises the results of the analysis for the Whangarei urban area.

4.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

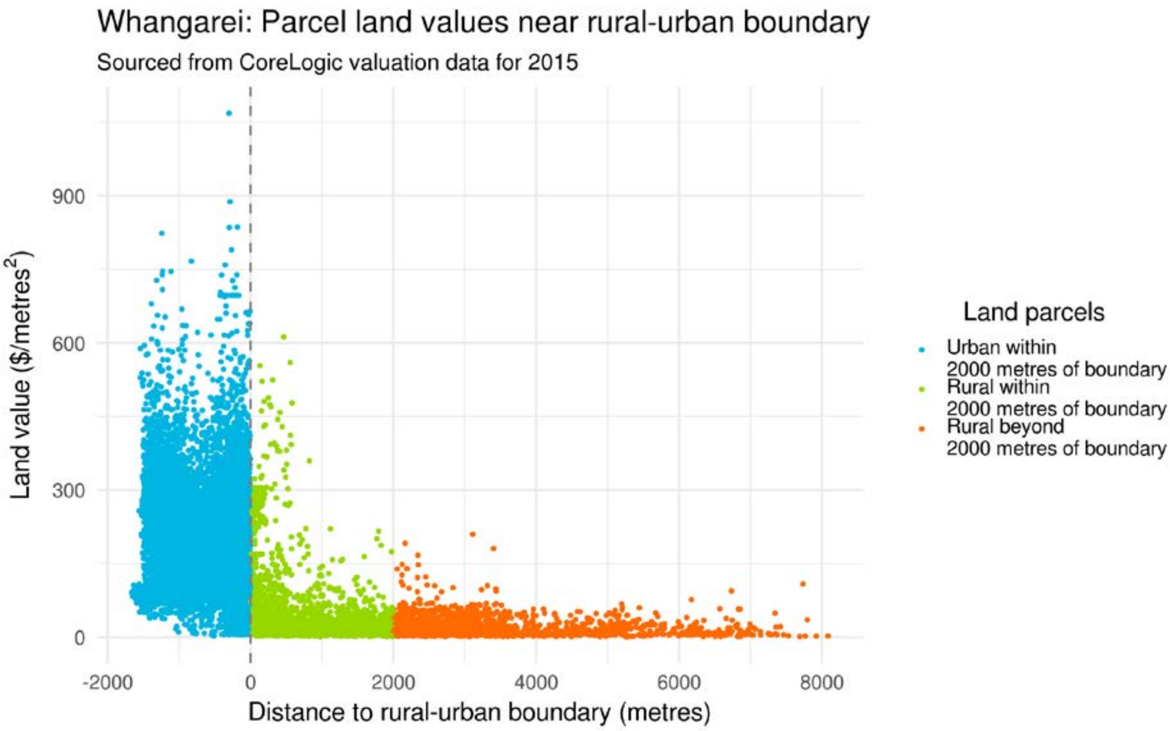
Figure 4: Estimated location of rural and urban zones



4.2. Graphing land value differences around rural-urban boundaries

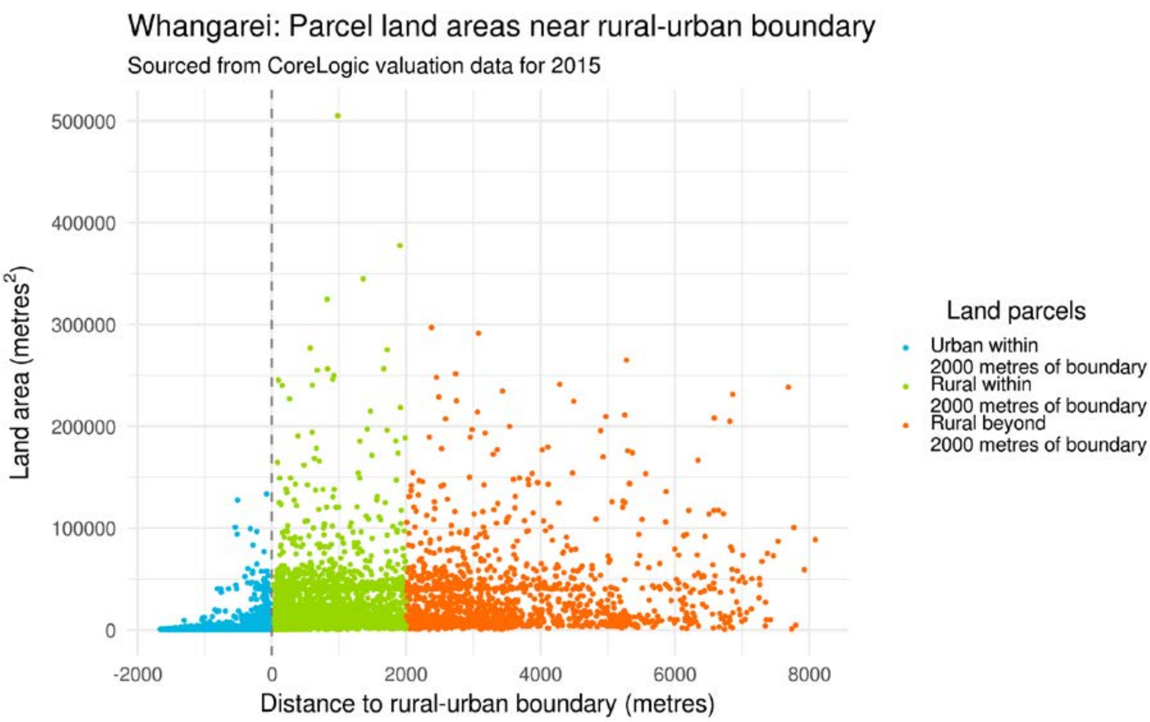
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a ‘jump’ in values that occurs at the edge of the current urban-zoned area.

Figure 5: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 6: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



4.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary. Note that in this case there are no properties more than 2 kilometres inside the boundary, and hence a summary is only reported for the remaining three categories.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 5: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m^2)
Inside urban area	Less than 2 kilometres	14,031	$123	1,397
Outside urban area	Less than 2 kilometres	2,329	$13	23,974
	More than 2 kilometres	1,491	$8	32,509

4.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a 'like for like' comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as 'close to the boundary' if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 6: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	4.49056	0.08885	0	-7.37397	0.09933	0
Rural, near boundary	0.45372	0.02284	0	0.38294	0.02554	0
Urban, near boundary	2.20914	0.02194	0	2.53964	0.02453	0
log(distance to cbd)	-0.08496	0.00797	0	-0.12518	0.00891	0
log(distance to water)	-0.10190	0.00379	0	-0.06576	0.00423	0
Median income 2001	0.00000	0.00000	0	-0.00002	0.00000	0
Average slope	-0.04024	0.00224	0	-0.03862	0.00251	0
(Average slope)^2	0.00038	0.00010	0	0.00021	0.00011	0.0578

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

4.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 7: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($\$/m^2$)	6.21	$103
Difference in parcel density (parcels/ha)	8.64	6.33
Estimated difference in land development costs ($\$/m^2$)		$60
Final difference in land values, adjusted for land development costs ($\$/m^2$)	1.53	$43

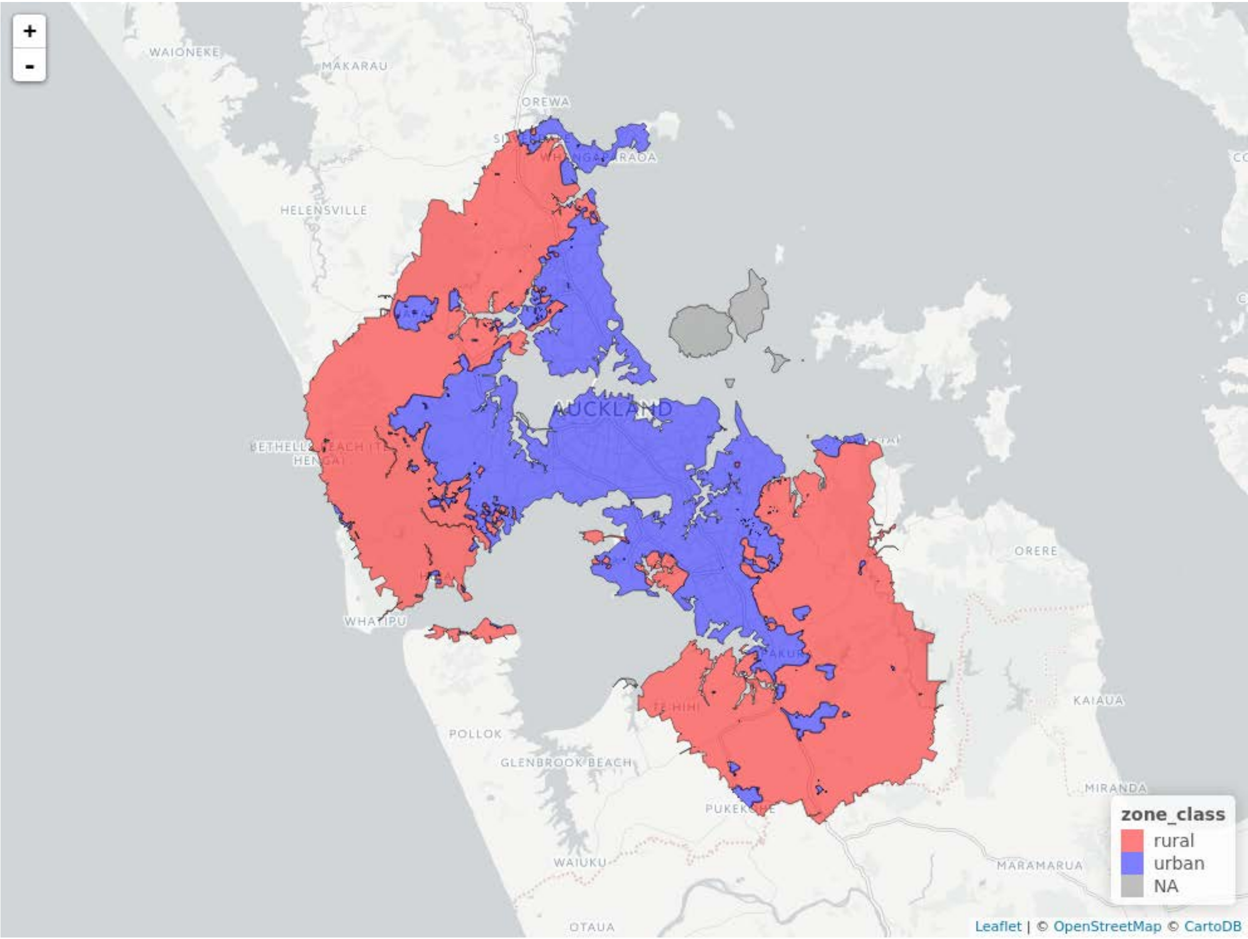
5. Auckland urban area

This section summarises the results of the analysis for the Auckland urban area.

5.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area[8], based on the most recent valuation data.

Figure 7: Estimated location of rural and urban zones

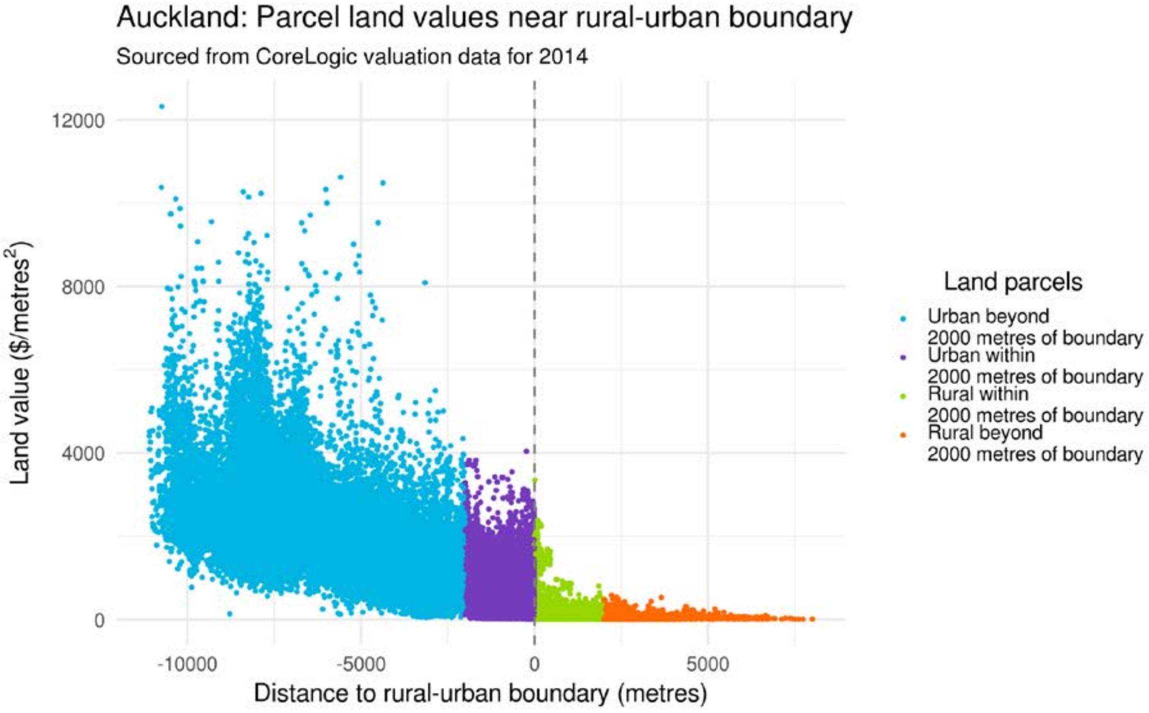


5.2. Graphing land value differences around rural-urban boundaries

The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a 'jump' in values that occurs at the edge of the current urban-zoned area.

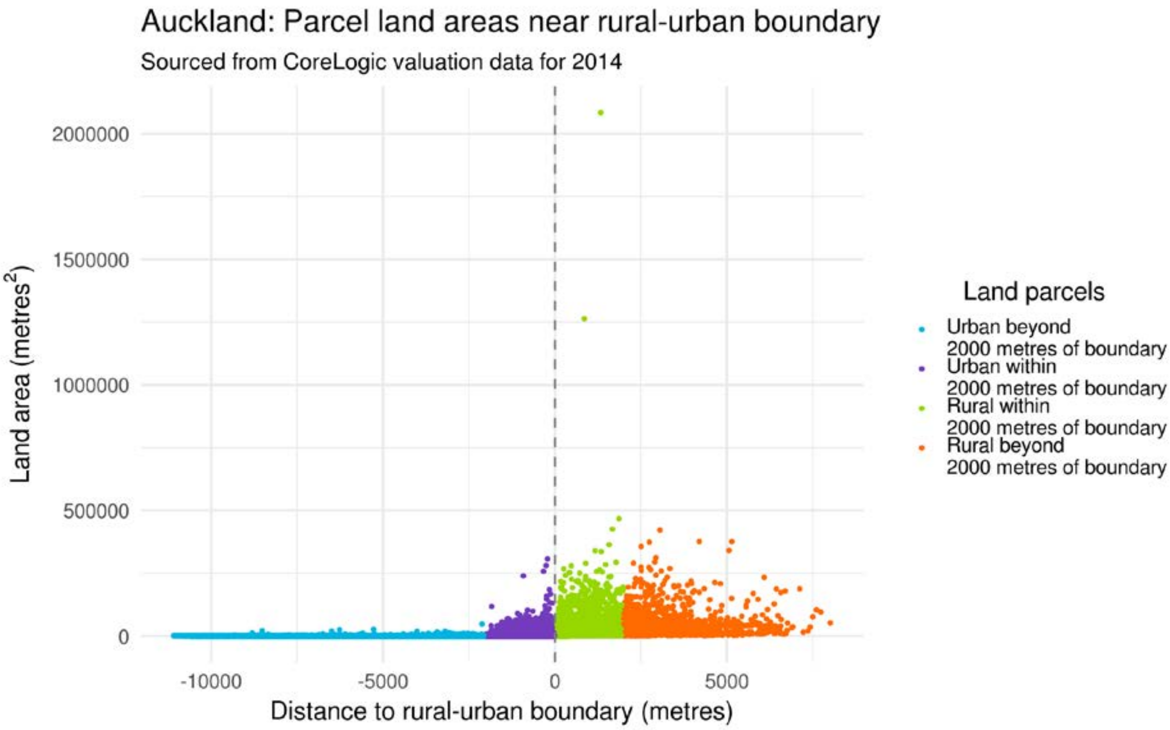
[8] However the differential only compares the values of land within 2 kilometres either side of the rural-urban zoning boundary, excluding urban land closer into the centre and rural land at the periphery of the area mapped here (such as, for example, Awhitu).

Figure 8: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 9: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



5.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 8: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m^2)
Inside urban area	More than 2 kilometres	110,436	$1,390	722
	Less than 2 kilometres	106,315	$505	1,119
Outside urban area	Less than 2 kilometres	7,584	$41	23,739
	More than 2 kilometres	2,381	$23	37,755

5.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a 'like for like' comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as 'close to the boundary' if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the model of differences in land values across the RUB, while the final three columns report outputs for the model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 9: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	10.44834	0.02934	0	-8.08779	0.03085	0
Rural, near boundary	0.65179	0.01199	0	0.73842	0.01261	0
Urban, distant from boundary	2.67191	0.01123	0	3.24467	0.01181	0
Urban, near boundary	2.55472	0.01083	0	3.24208	0.01139	0
log(distance to cbd)	-0.66680	0.00235	0	-0.16898	0.00247	0
log(distance to water)	-0.03864	0.00097	0	0.00309	0.00102	0.002
Median income 2001	0.00001	0.00000	0	0.00000	0.00000	0
Average slope	-0.01808	0.00045	0	-0.03270	0.00047	0
(Average slope)^2	-0.00011	0.00002	0	0.00038	0.00002	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

5.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

These results differ from earlier work by Grimes and Liang (2009) and Zheng (2013) due to several methodological changes that are outlined above, including the use of parcel-level land value data and adjustments for land development costs. However, they are conceptually and qualitatively consistent.

Table 10: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($/m^2)	6.15	$423
Difference in parcel density (parcels/ha)	12.23	8.21
Estimated difference in land development costs ($/m^2)		$78
Final difference in land values, adjusted for land development costs ($/m^2)	3.15	$345

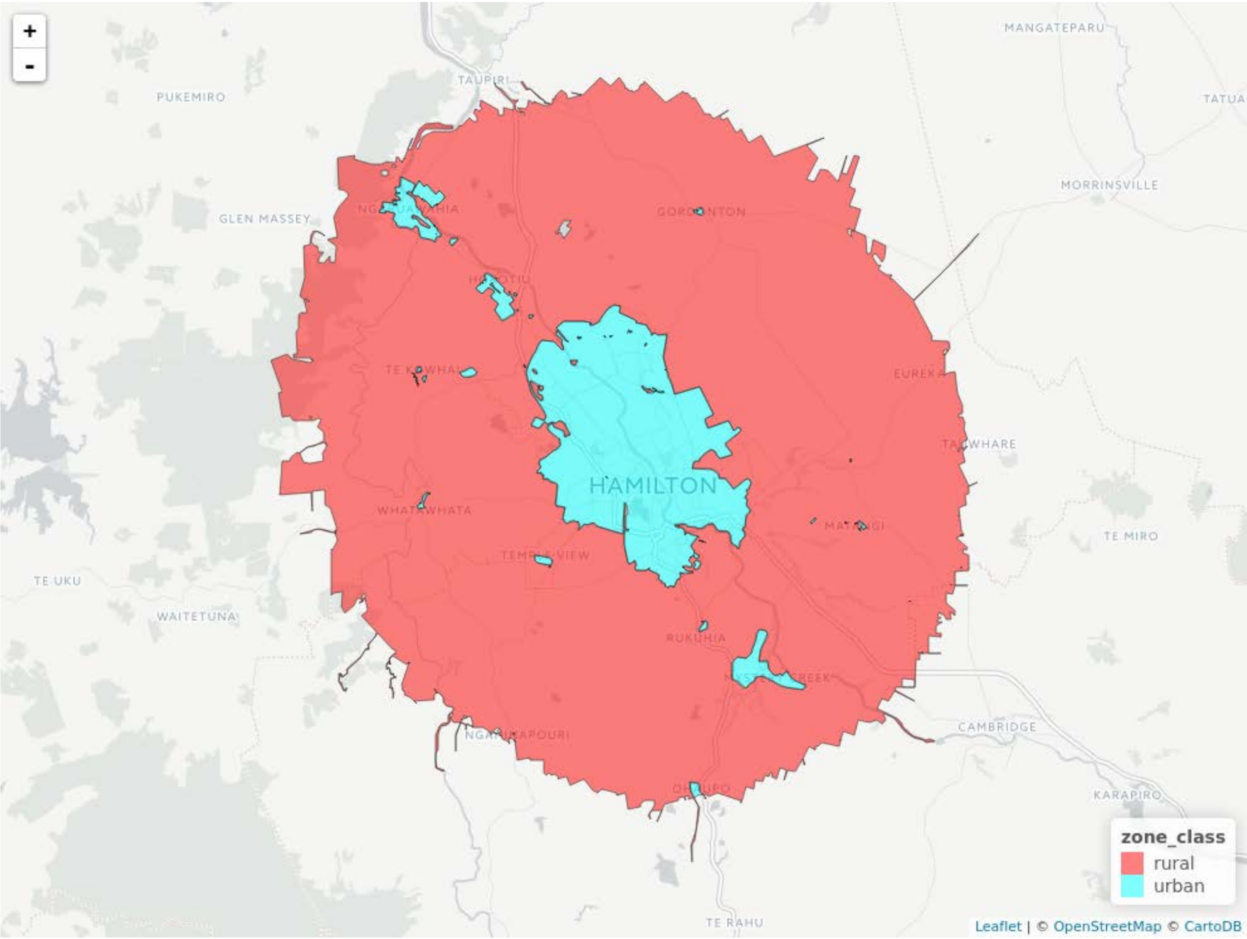
6. Hamilton urban area

This section summarises the results of the analysis for the Hamilton urban area.

6.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

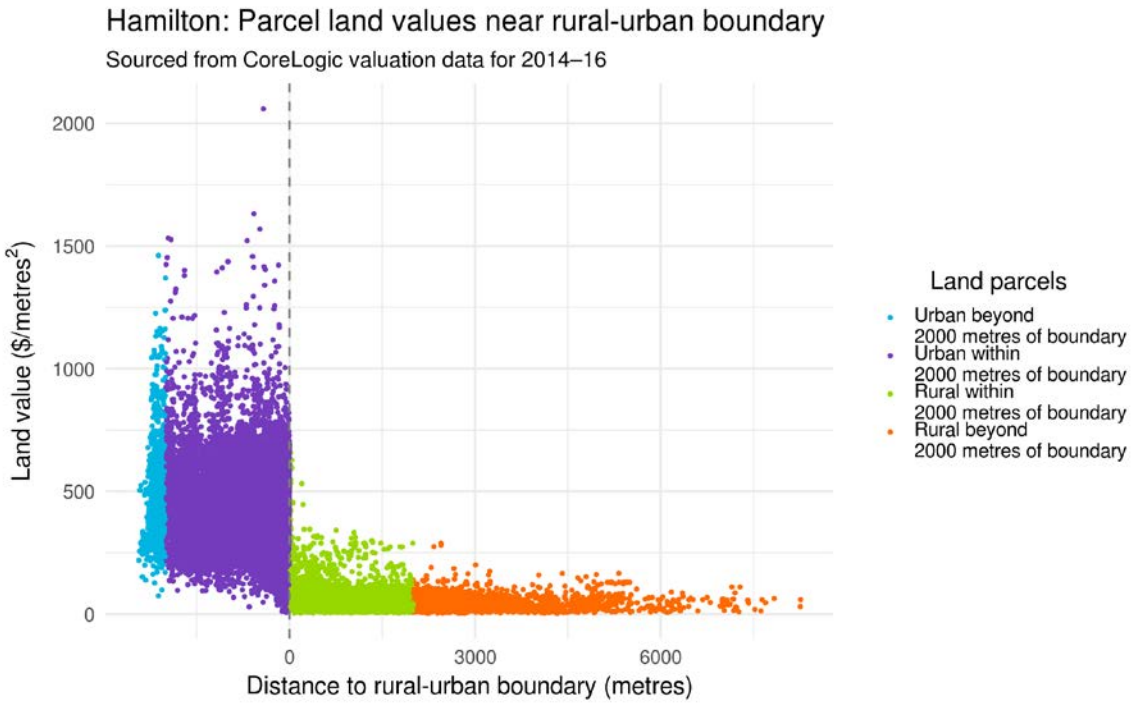
Figure 10: Estimated location of rural and urban zones



6.2. Graphing land value differences around rural-urban boundaries

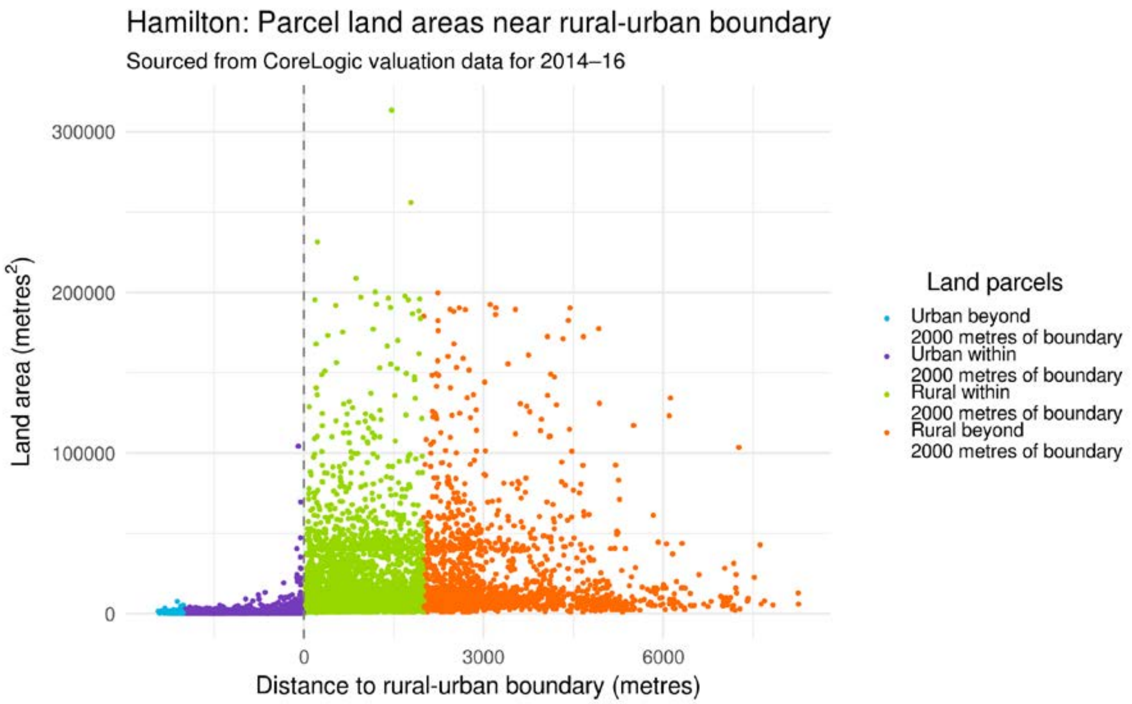
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a 'jump' in values that occurs at the edge of the current urban-zoned area.

Figure 11: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 12: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



6.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 11: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m^2)
Inside urban area	More than 2 kilometres	986	$458	812
	Less than 2 kilometres	32,912	$386	799
Outside urban area	Less than 2 kilometres	4,180	$29	16,968
	More than 2 kilometres	2,002	$22	21,751

6.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a ‘like for like’ comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as ‘close to the boundary’ if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 12: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	4.60533	0.05494	0	-8.70976	0.06753	0
Rural, near boundary	0.29355	0.01160	0	0.27815	0.01426	2.18E-84
Urban, distant from boundary	2.39127	0.01910	0	2.71344	0.02347	0
Urban, near boundary	2.31176	0.01096	0	2.74145	0.01348	0
log(distance to cbd)	-0.22530	0.00428	0	-0.09548	0.00526	0
log(distance to water)	0.06840	0.00356	0	0.02686	0.00438	0
Median income 2001	0.00002	0.00000	0	0.00000	0.00000	0.052
Average slope	0.00918	0.00211	0	-0.02592	0.00260	0
(Average slope)^2	-0.00102	0.00018	0	0.00080	0.00022	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

6.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 13: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($\$/m^2$)	7.64	$336
Difference in parcel density (parcels/ha)	11.74	11.45
Estimated difference in land development costs ($\$/m^2$)		$109
Final difference in land values, adjusted for land development costs ($\$/m^2$)	2.42	$227

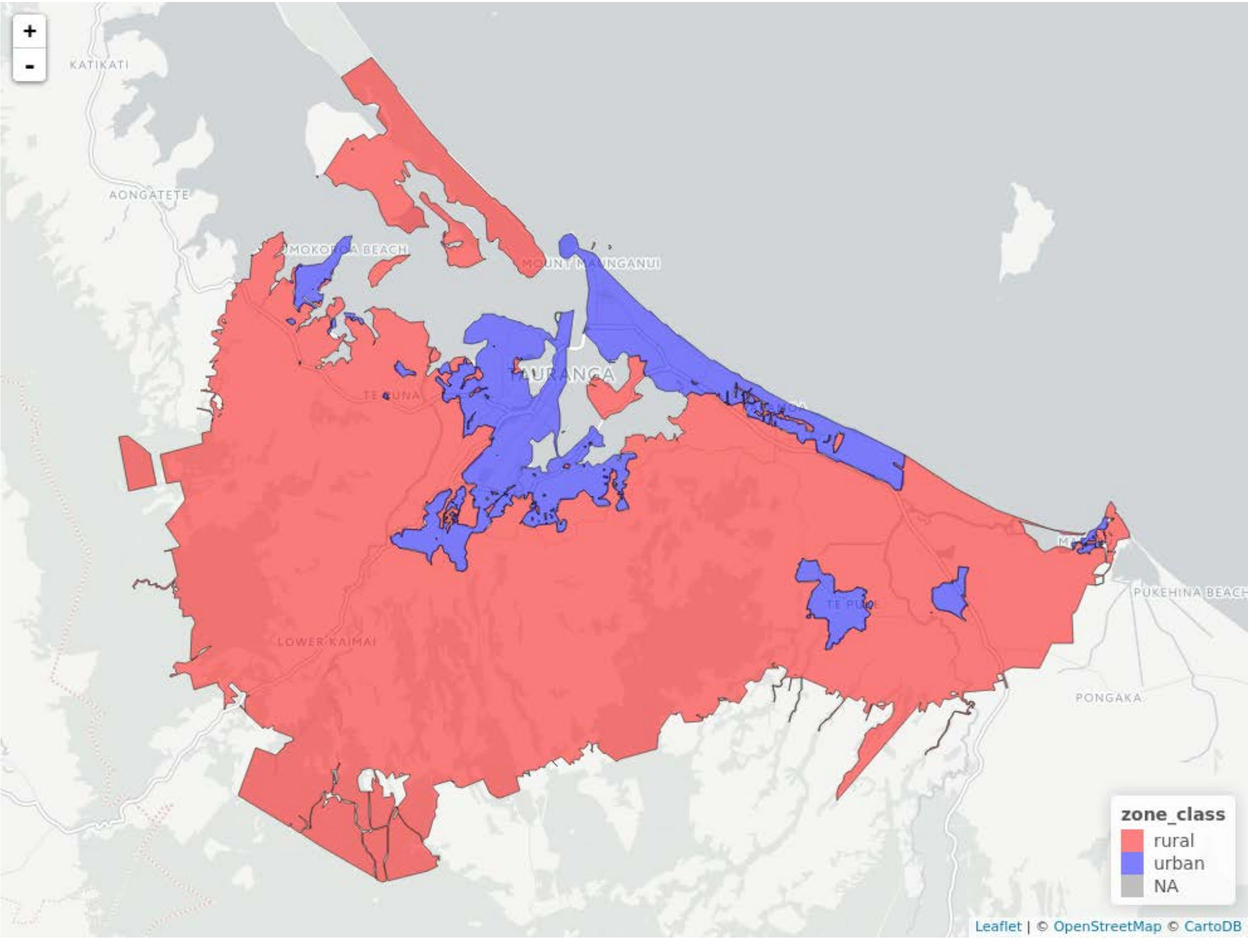
7. Tauranga urban area

This section summarises the results of the analysis for the Tauranga urban area.

7.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

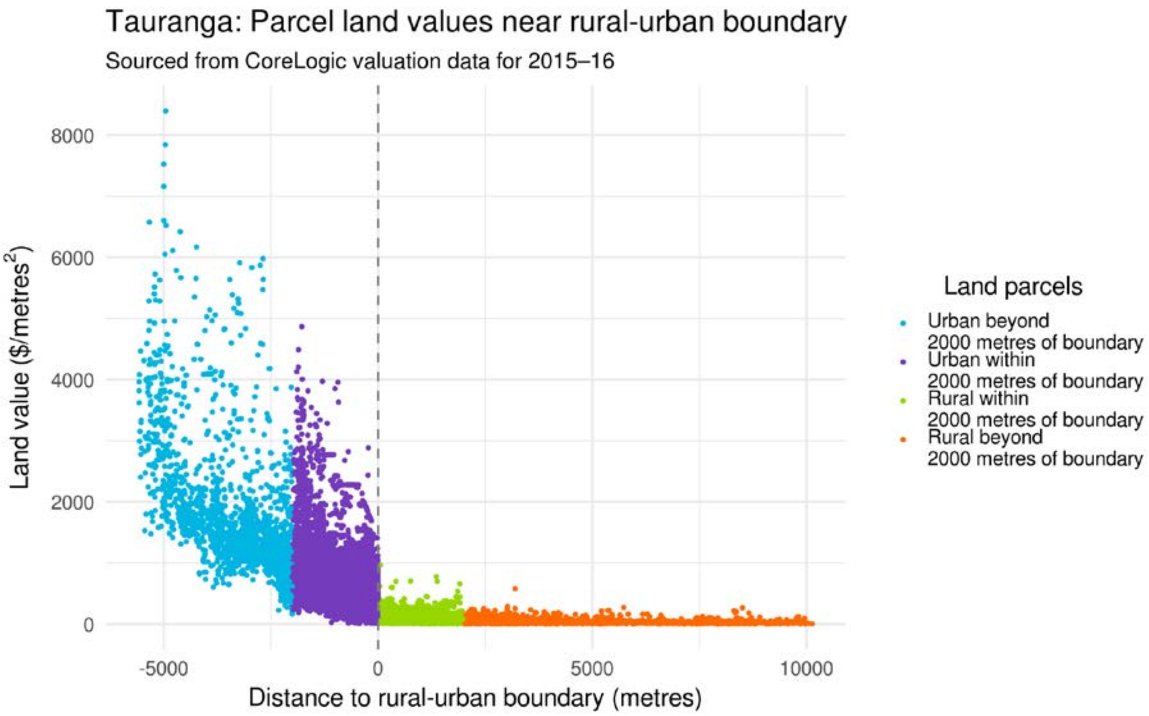
Figure 13: Estimated location of rural and urban zones



7.2. Graphing land value differences around rural-urban boundaries

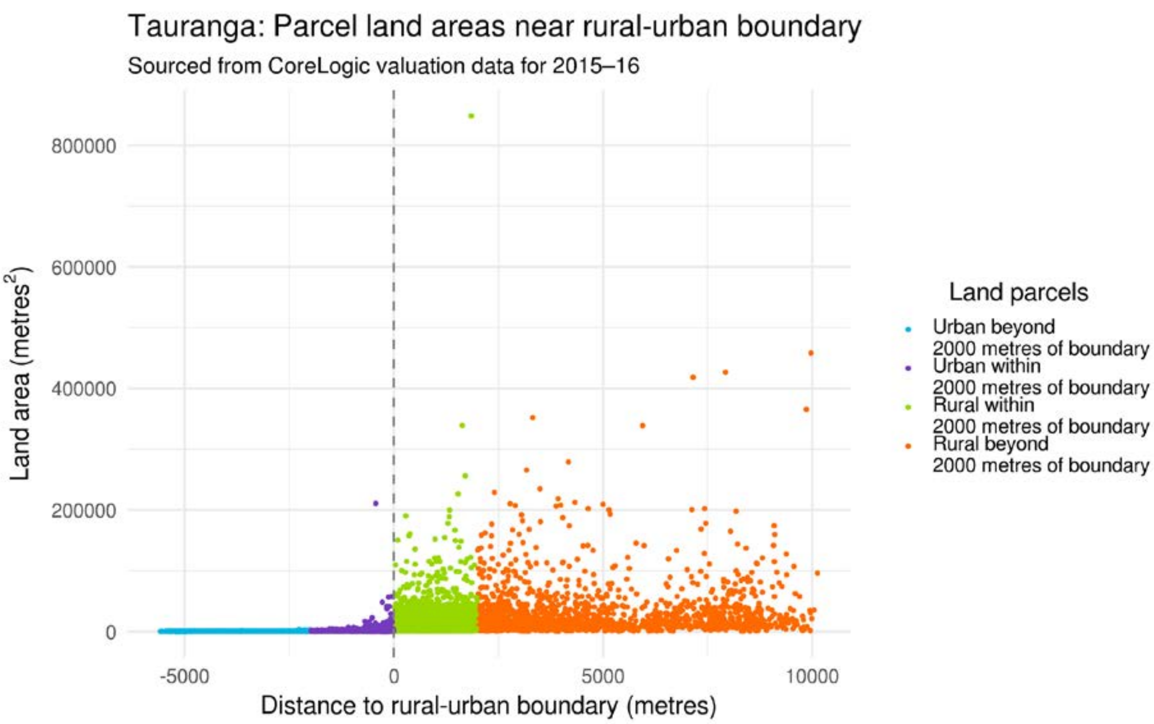
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a 'jump' in values that occurs at the edge of the current urban-zoned area.

Figure 14: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 15: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



7.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 14: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m2)
Inside urban area	More than 2 kilometres	2,112	$1,462	543
	Less than 2 kilometres	28,199	$459	751
Outside urban area	Less than 2 kilometres	2,906	$41	13,142
	More than 2 kilometres	1,700	$17	28,999

7.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a 'like for like' comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as 'close to the boundary' if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 15: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	5.97123	0.05207	0	-8.65800	0.05561	0
Rural, near boundary	0.60915	0.01629	0	0.78258	0.01740	0
Urban, distant from boundary	3.00699	0.01973	0	3.20772	0.02107	0
Urban, near boundary	2.16899	0.01483	0	2.96367	0.01584	0
log(distance to cbd)	-0.11992	0.00518	0	-0.08397	0.00553	0
log(distance to water)	-0.16365	0.00252	0	0.00689	0.00269	0.010
Median income 2001	0.00001	0.00000	0	0.00000	0.00000	0
Average slope	-0.05199	0.00167	0	-0.04292	0.00179	0
(Average slope)^2	0.00149	0.00010	0	0.00124	0.00010	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

7.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a ‘like for like’ basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 16: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($/m^2)	4.00	$344
Difference in parcel density (parcels/ha)	8.86	11.82
Estimated difference in land development costs ($/m^2)		$112
Final difference in land values, adjusted for land development costs ($/m^2)	2.02	$232

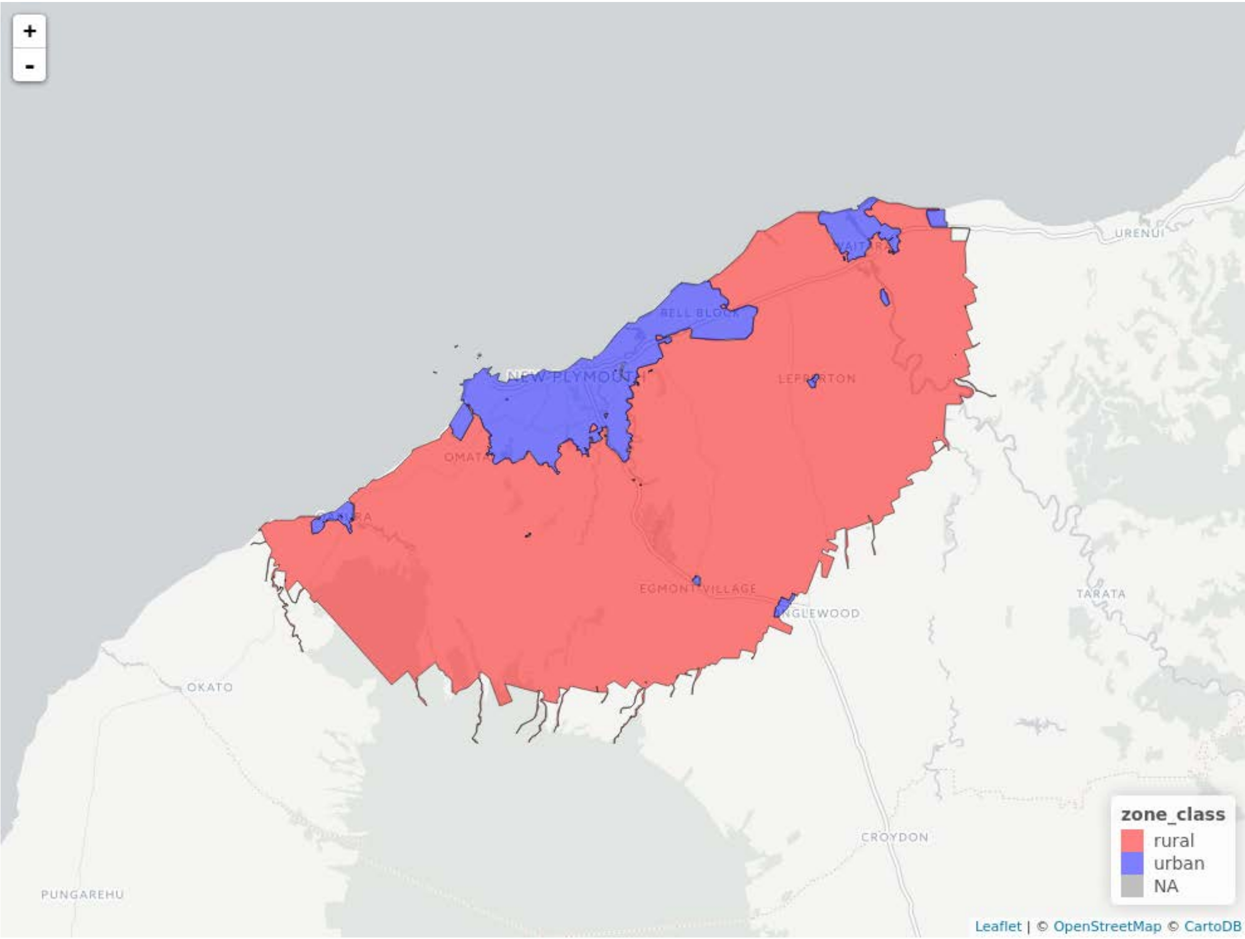
8. New Plymouth urban area

This section summarises the results of the analysis for the New Plymouth urban area.

8.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

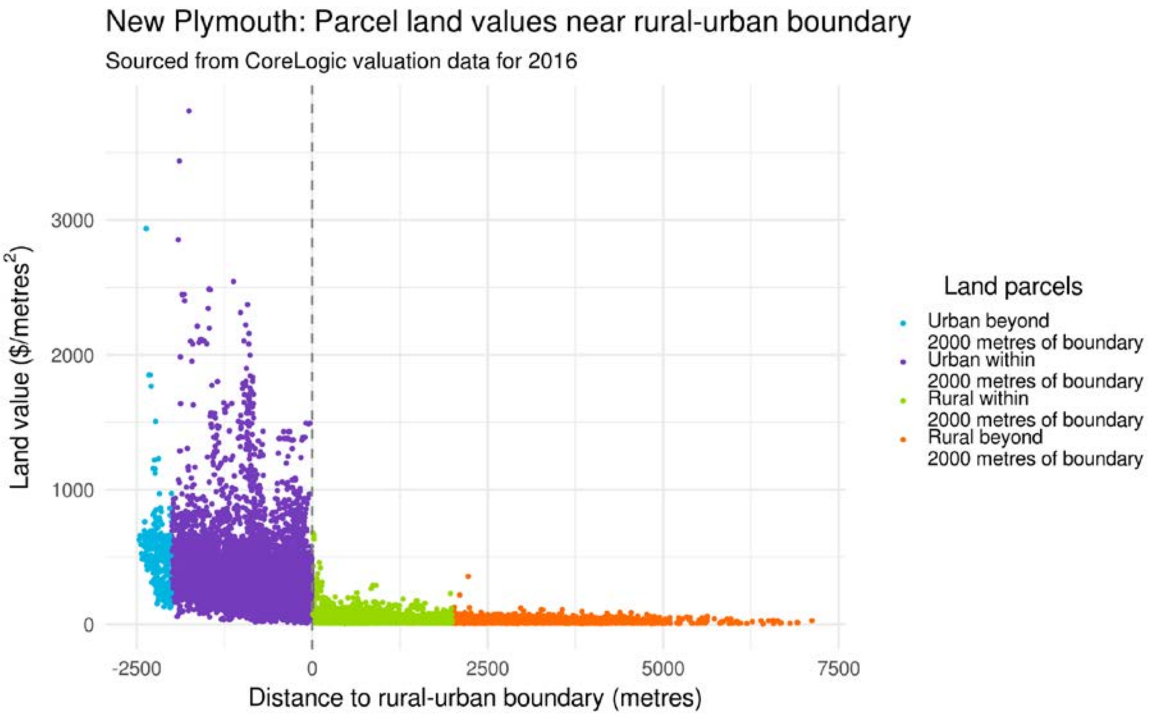
Figure 16: Estimated location of rural and urban zones



8.2. Graphing land value differences around rural-urban boundaries

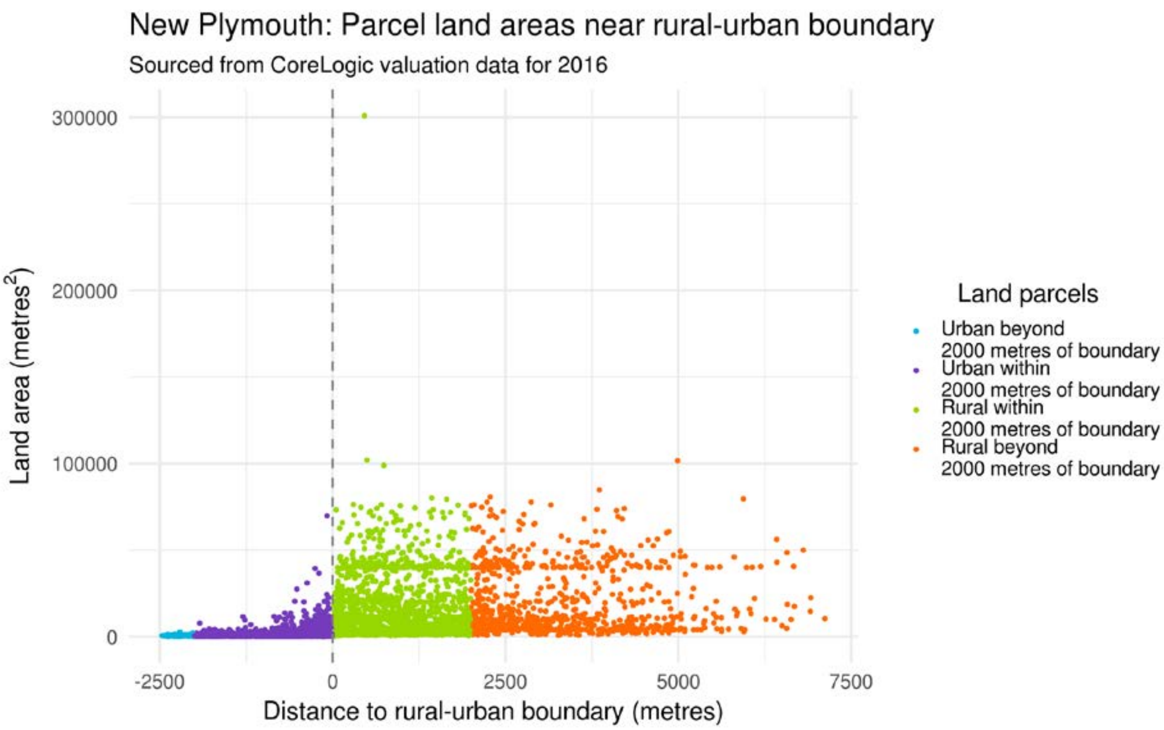
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a ‘jump’ in values that occurs at the edge of the current urban-zoned area.

Figure 17: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 18: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



8.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 17: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m^2)
Inside urban area	More than 2 kilometres	394	$486	638
	Less than 2 kilometres	17,135	$243	896
Outside urban area	Less than 2 kilometres	1,551	$21	15,941
	More than 2 kilometres	813	$16	19,750

8.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a ‘like for like’ comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as ‘close to the boundary’ if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 18: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	8.03326	0.06631	0	-7.45586	0.07543	0
Rural, near boundary	0.15334	0.02168	0	0.25115	0.02467	0
Urban, distant from boundary	1.65938	0.03517	0	2.46185	0.04001	0
Urban, near boundary	1.69794	0.02041	0	2.41080	0.02321	0
log(distance to cbd)	-0.31588	0.00490	0	-0.08020	0.00558	0
log(distance to water)	-0.23181	0.00439	0	-0.09913	0.00499	0
Median income 2001	0.00001	0.00000	0	-0.00001	0.00000	0
Average slope	-0.02383	0.00194	0	-0.02379	0.00220	0
(Average slope)^2	0.00050	0.00010	0	0.00059	0.00011	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

8.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 19: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($/m^2)	4.25	$186
Difference in parcel density (parcels/ha)	8.67	9.87
Estimated difference in land development costs ($/m2)		$94
Final difference in land values, adjusted for land development costs ($/m^2)	1.61	$92

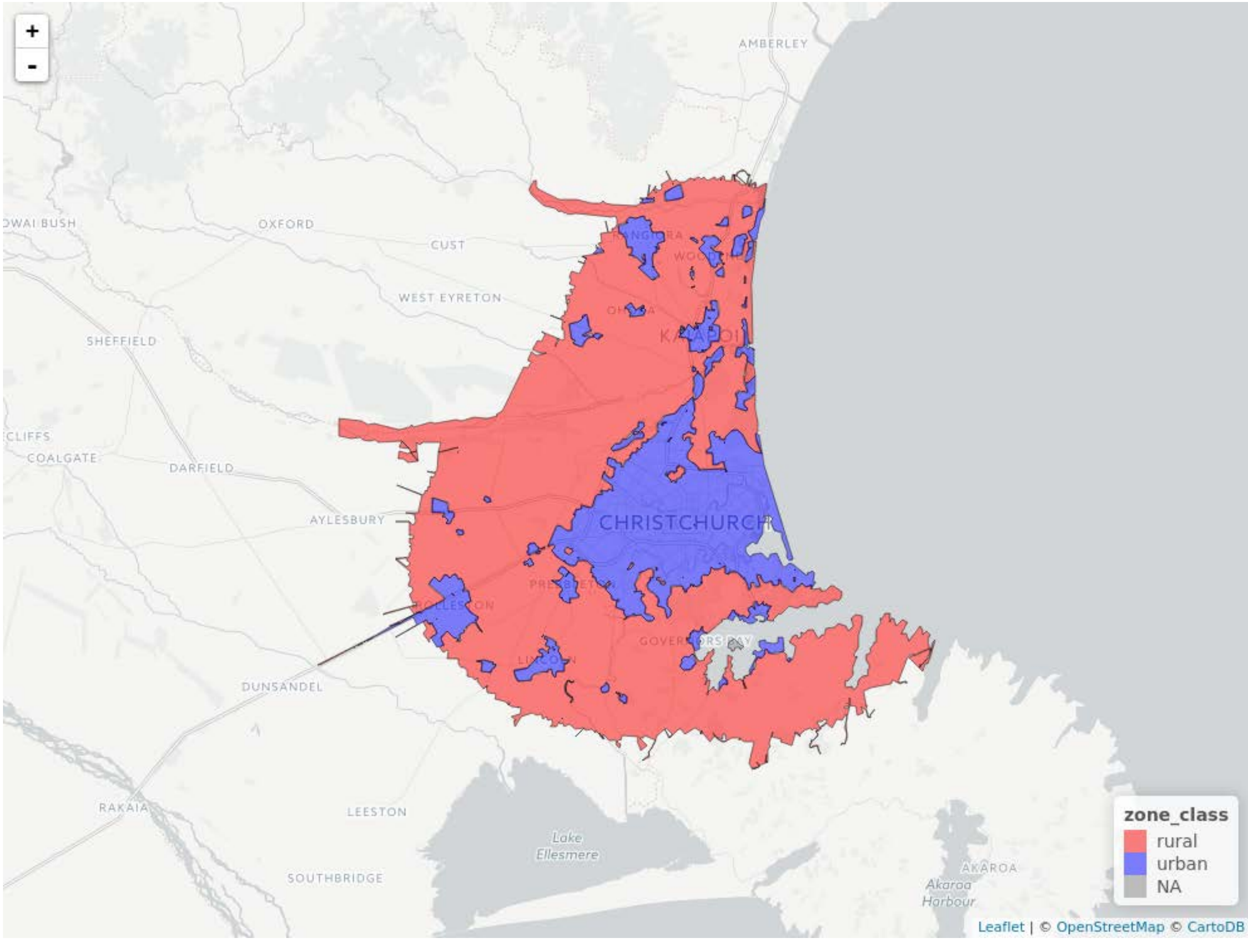
9. Christchurch urban area

This section summarises the results of the analysis for the Christchurch urban area.

9.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

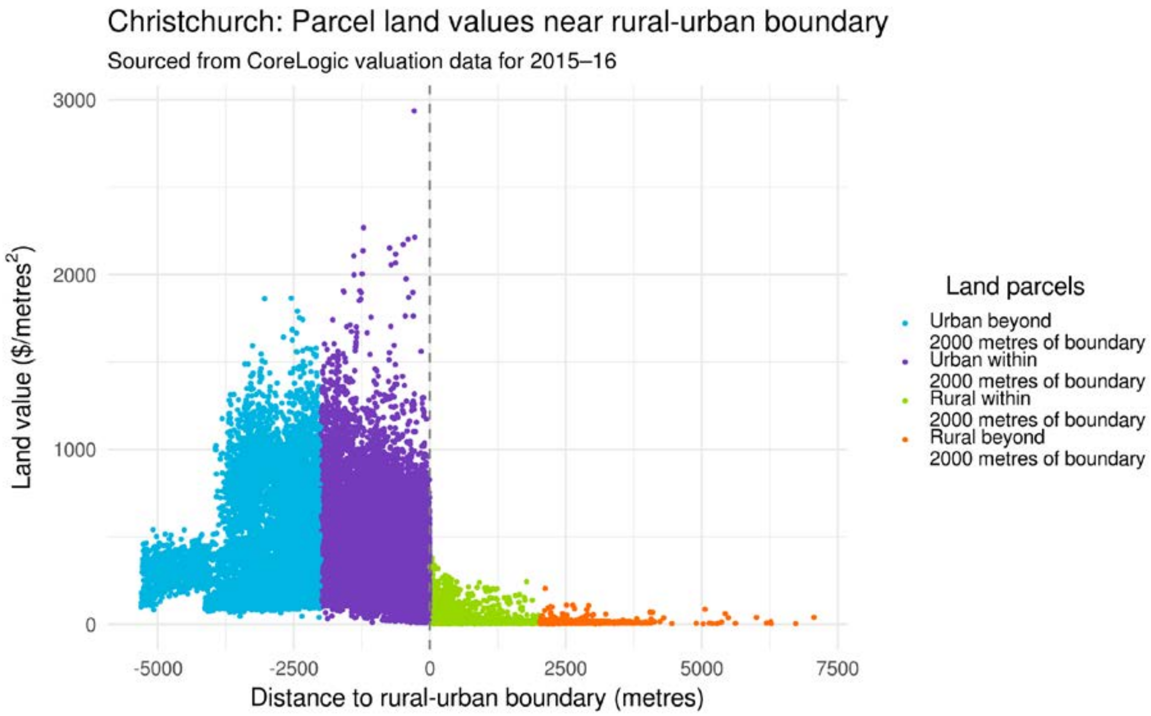
Figure 19: Estimated location of rural and urban zones



9.2. Graphing land value differences around rural-urban boundaries

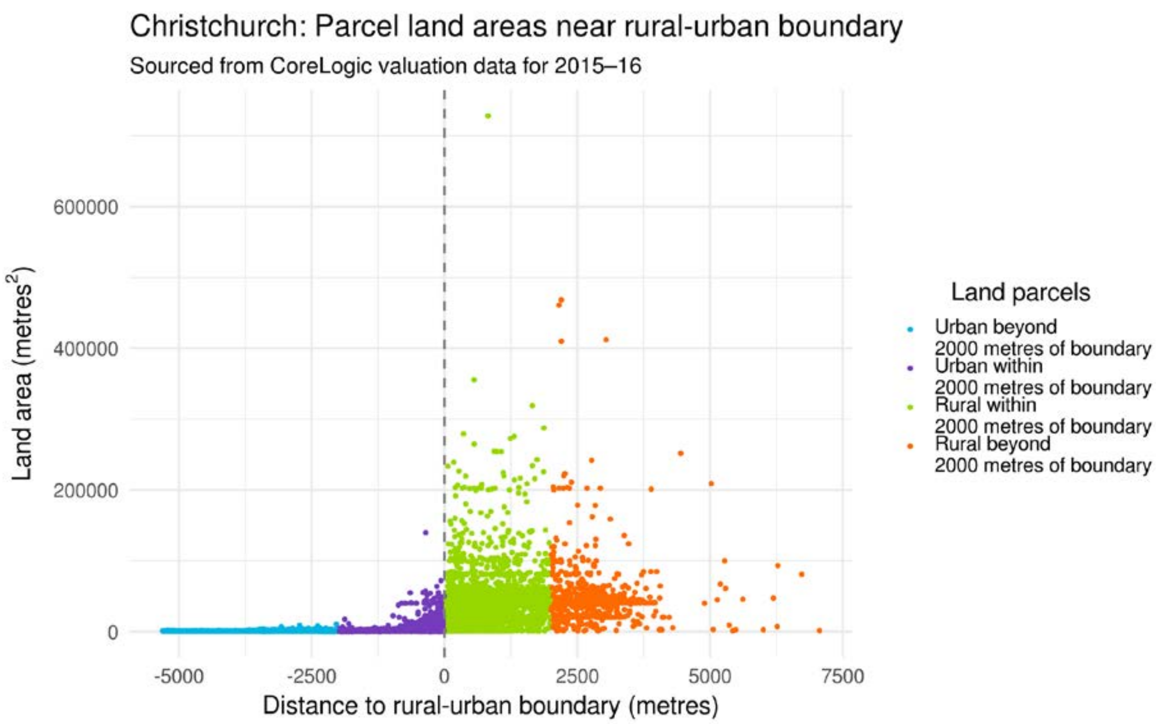
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a 'jump' in values that occurs at the edge of the current urban-zoned area.

Figure 20: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 21: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



9.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 20: Average land values and parcel areas for different categories of properties

Category	Distance to RUB	Number of properties	Weighted average land value ($/m^2)	Average parcel area (m^2)
Inside urban area	More than 2 kilometres	18,597	$366	680
	Less than 2 kilometres	78,236	$272	884
Outside urban area	Less than 2 kilometres	3,867	$11	37,022
	More than 2 kilometres	869	$8	47,032

9.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a 'like for like' comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as 'close to the boundary' if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 21: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	5.03006	0.02834	0	-8.68502	0.02959	0
Rural, near boundary	0.47595	0.01744	0	0.49490	0.01822	0
Urban, distant from boundary	3.08211	0.01645	0	3.77851	0.01718	0
Urban, near boundary	3.18175	0.01595	0	3.79323	0.01666	0
log(distance to cbd)	-0.65254	0.00335	0	-0.14401	0.00350	0
log(distance to water)	0.35135	0.00300	0	-0.02553	0.00314	0
Median income 2001	0.00001	0.00000	0	-0.00001	0.00000	0
Average slope	0.00289	0.00088	0	-0.01958	0.00091	0
(Average slope)^2	-0.00021	0.00003	0	0.00033	0.00003	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

9.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 22: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($/m^2)	14.69	$254
Difference in parcel density (parcels/ha)	27.07	10.89
Estimated difference in land development costs ($/m^2)		$103
Final difference in land values, adjusted for land development costs ($/m^2)	2.23	$150

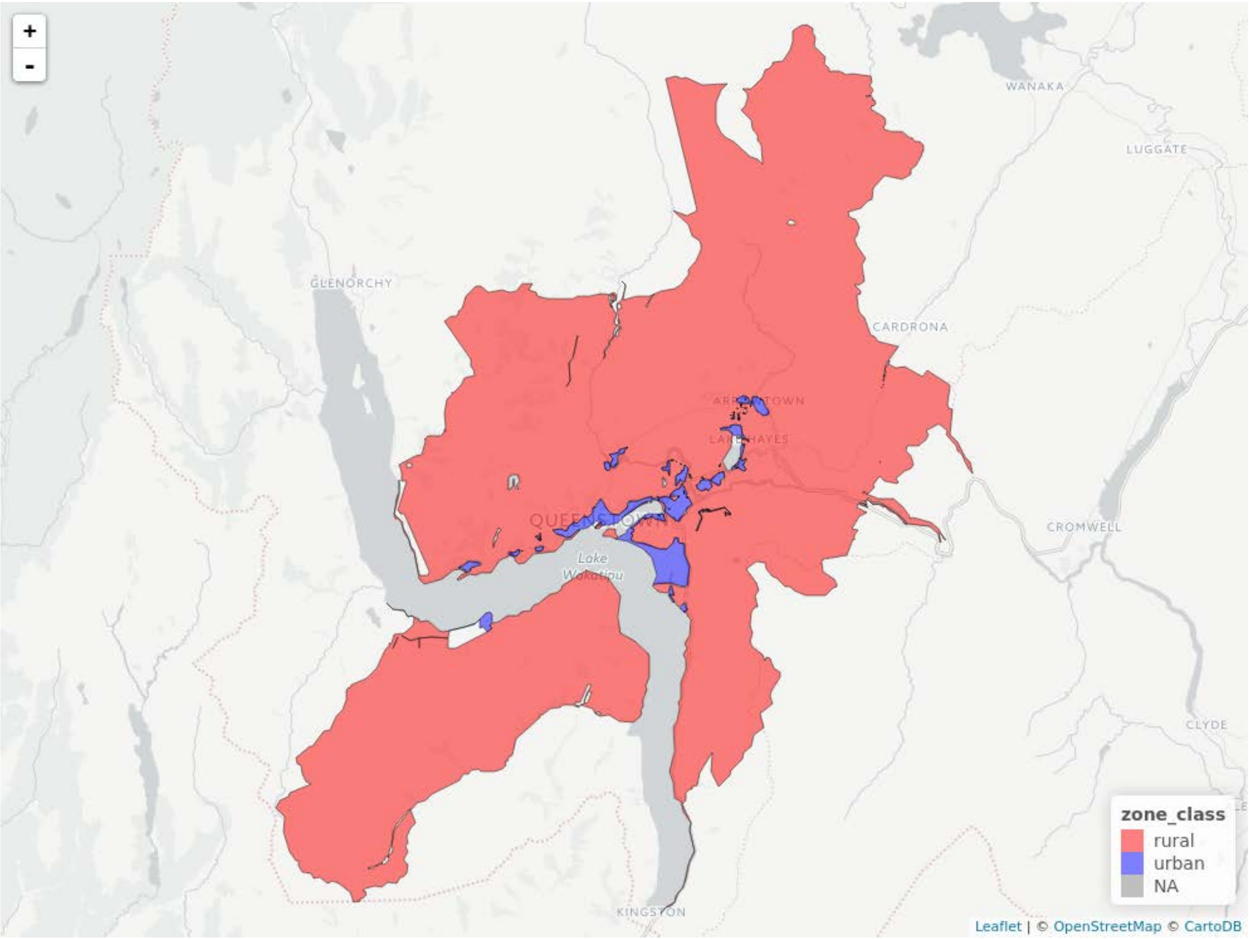
10. Queenstown

This section summarises the results of the analysis for Queenstown.

10.1. Location of rural and urban zones

The following map shows the estimated location of rural and urban-zoned land in this urban area, based on the most recent valuation data.

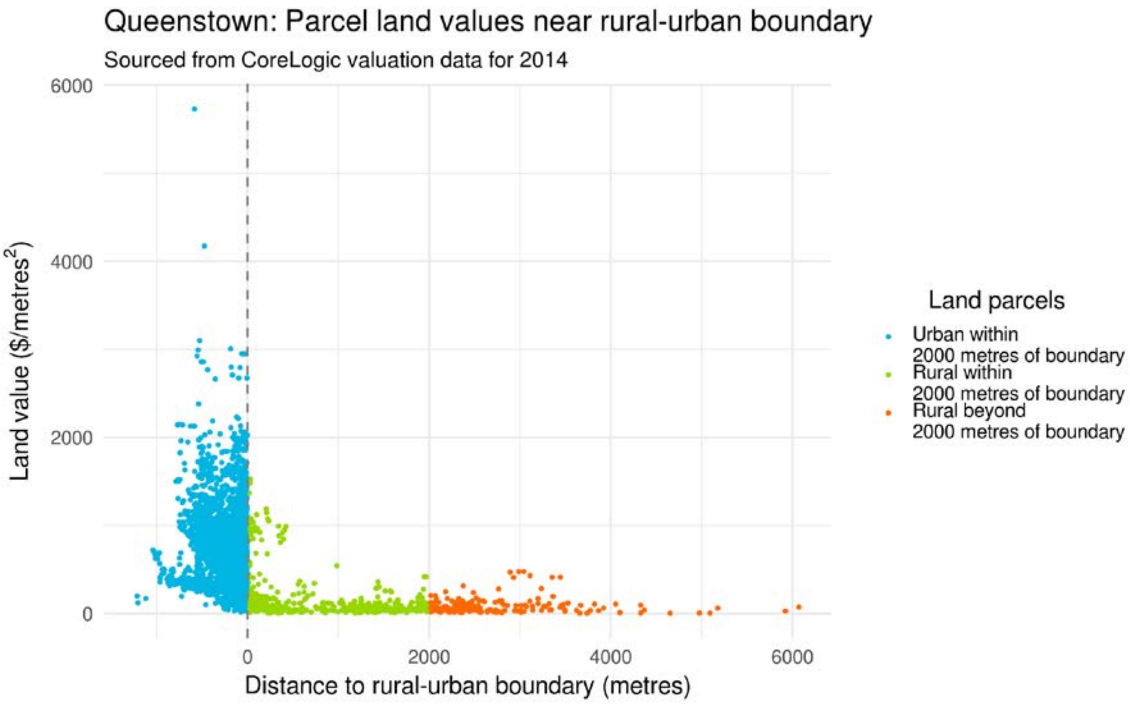
Figure 22: Estimated location of rural and urban zones



10.2. Graphing land value differences around rural-urban boundaries

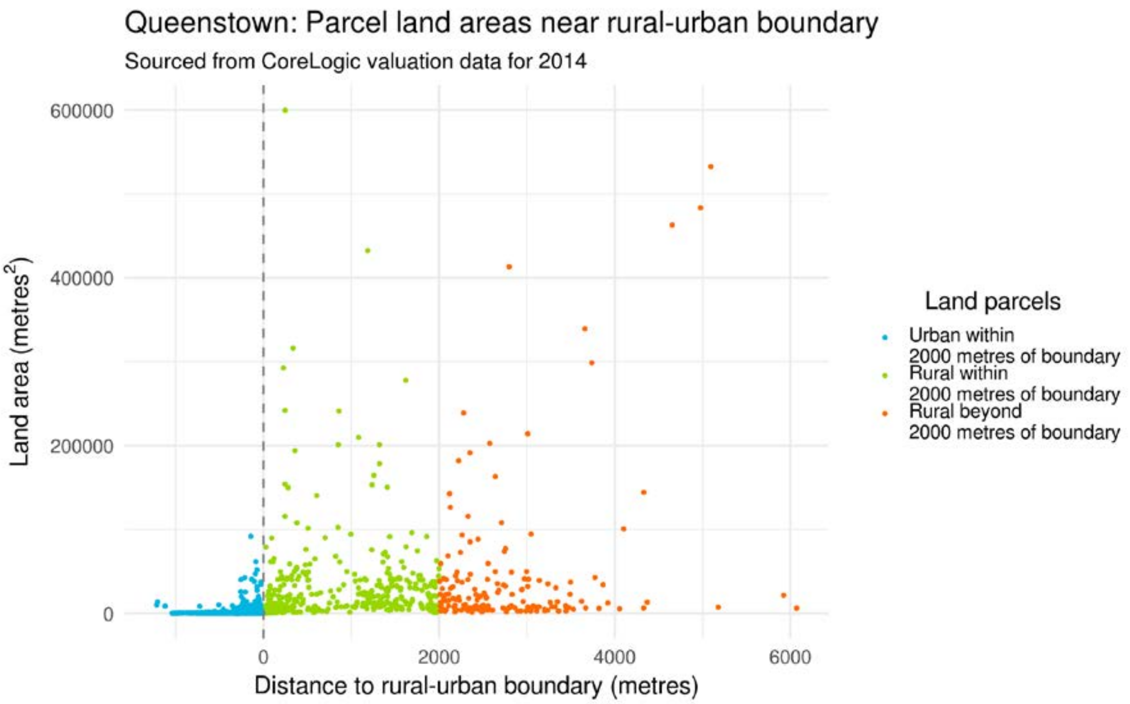
The following graph shows the distribution of land values around the rural-urban boundary. Each individual point is an individual property parcel, plotted according to distance to the boundary. This chart provides a simple, at-a-glance perspective on how land values change across the rural-urban boundary. While there is variation in land values both inside and outside of the boundary, this clearly shows a 'jump' in values that occurs at the edge of the current urban-zoned area.

Figure 23: Distribution of land values immediately inside and outside of the rural-urban boundary



The next graph shows the distribution of parcel sizes around the rural-urban boundary. This shows that urban land parcel sizes increase near the boundary, reflecting the fact that some land is not developed to urban intensities yet. Parcel sizes increase further outside the boundary, which reflects the zoning restrictions and the absence of urban infrastructure as well as increased prevalence of lifestyle blocks and rural uses.

Figure 24: Distribution of parcel areas immediately inside and outside of the rural-urban boundary



10.3. Summary statistics

The following table presents summary statistics for land values and parcel areas for this urban area, categorised by whether properties are inside or outside the urban zoned area, and whether they are close to the boundary. Note that in this case there are no properties more than 2 kilometres inside the boundary, and hence a summary is only reported for the remaining three categories.

This table simply summarises data from the above scatterplots in a different format. It confirms that there are differences in average land values and parcel sizes across the boundary.

Table 23: Average land values and parcel areas for different categories of properties

Category	**Distance to RUB**	**Number of properties**	**Weighted average land value (\$/m^2)**	**Average parcel area (m^2)**
Inside urban area	Less than 2 kilometres	4,283	\$497	1,179
Outside urban area	Less than 2 kilometres	478	\$41	28,328
	More than 2 kilometres	141	\$24	47,666

10.4. Econometric analysis of differences in land values and parcel sizes

While the scatterplots and summary tables above suggest that there are differences in land values across the rural-urban boundary, further analysis is needed to ensure that these differences are not solely driven by differences in proximity to employment or amenities, geographical constraints, or differences in the level of land development and infrastructure costs across the boundary.

As outlined in the methodology, econometric models were estimated to control for these factors and hence to obtain a 'like for like' comparison of land values for similar urban-zoned and rural-zoned residential properties. Properties are defined as 'close to the boundary' if they are within 2 kilometres of the boundary. This is consistent with previous work for Auckland that also used a 2 kilometre distance band.

The first three columns report outputs for the econometric model of differences in land values across the RUB, while the final three columns report outputs for the econometric model of differences in the density of parcels across the RUB. The coefficient estimates for the indicator variables for parcels that are close to the RUB and just inside or just outside are used to obtain estimates of differences in land values, controlling for the other variables in the model.

These econometric models also provide information on the impact of other control variables on land values. For instance, the coefficient on the variable for distance to the CBD provide

information on the degree to which land values decline for properties that are further away from the centre of the city.

Table 24: Econometric model outputs using a 2 kilometre distance band to identify sites close to the RUB

Model type	**Land value model**			**Parcel density model**		
Dependent variable	log(land value per m^2)			log(parcels per unit land area)		
term	Coefficient	Std error	p value*	Coefficient	Std error	p value*
(Intercept)	7.18003	0.13522	0	-7.32265	0.15579	0
Rural, near boundary	0.40716	0.05792	0	0.38774	0.06674	0
Urban, near boundary	2.14988	0.05124	0	2.89883	0.05904	0
log(distance to cbd)	-0.12940	0.01272	0	-0.18957	0.01466	0
log(distance to water)	-0.13197	0.00884	0	0.02244	0.01019	0.028
Median income 2001	-0.00002	0.00000	0	-0.00002	0.00000	0
Average slope	-0.01828	0.00322	0	-0.03526	0.00371	0
(Average slope)^2	0.00014	0.00009	0.128	0.00067	0.00011	0

** Lower p-values indicate that the null hypothesis that the coefficient is equal to zero can be rejected at a higher level of statistical significance. In other words, lower p-values indicate a high probability that land values or parcel density will be affected by the dependent variable to the extent indicated by the relevant coefficient.*

10.5. Estimated differences in land values

To conclude the analysis, these results are used to estimate the difference in land values across the rural-urban boundary on a 'like for like' basis. These estimates control for a wide variety of factors that might be related to land values and zoning decisions, including:

- The proximity of parcels to amenities such as coastlines and major inland water bodies, and central areas of the city that tend to offer better access to employment and retail
- An adjustment for land development costs that are borne by developers, including subdivision costs, earthworks, on-site infrastructure, and development contributions (which may or may not fully cover bulk infrastructure costs)
- Some geographic control variables, including (in this case) the slope of the longest line through the parcel.

The following table reports results based on the econometric models above. The bottom row (in bold) shows the final estimate of the difference in land values, adjusted for land development costs. The rural-urban differential is reported as both:

- The ratio of land values immediately inside the rural-urban boundary relative to similar sites just outside the boundary
- The estimated difference in dollar terms – ie the difference in terms of dollars per square metre of land.

Table 25: Estimated differences in land values across the rural-urban boundary

	Ratio	**Difference**
Initial difference in land values, not adjusted for land development costs ($\$/m^2$)	5.82	$412
Difference in parcel density (parcels/ha)	12.32	7.79
Estimated difference in land development costs ($\$/m^2$)		$74
Final difference in land values, adjusted for land development costs ($\$/m^2$)	3.12	$337

Appendix 1: Local authority information about geographic constraints and other variables

To develop a credible estimate of land price differentials across rural/urban zoning boundaries, it is necessary to ensure that the results are not 'biased' by other factors that also affect land values, independently of the effect of zoning boundaries, and which may coincide with the location of zoning boundaries.

These include:

- Infrastructure provision and land development costs, which may be borne by either developers or councils / public infrastructure providers
- Geographic factors that may make development costly or risky, such as steep slopes, flood hazards, or liquefaction risk.

To the extent possible given the available data, this report has investigated these factors to understand what, if any, impact they have on results.

This section summarises feedback from meetings with council staff from four of five high-growth urban areas, excluding Christchurch, regarding what control variables should be included in the analysis.

Auckland

Attendees: David Norman and Harshal Chitale (Auckland Council), David Taylor (MBIE), Peter Nunns (MRCagney)

Key comments:

- Infrastructure and land development costs, whether borne by private developers or public infrastructure providers (eg Auckland Council) are capitalised into land values. It is important to account for this in order for estimates of rural/urban land value differentials to be credible.
- Development contributions may understate the true cost of infrastructure, an issue that Auckland Council is grappling with. It is important to account for this possibility.
- Geographical features such as steep slopes and flood risk may affect land values or developability, but this was not seen as the primary factor affecting the location of rural and urban zones. Hard volcanic rock may also affect the cost of developing land, but most areas with volcanic rock have already been developed.
- Proximity to amenities, including major employment centres, coastlines, schools, parks, etc, will affect land values and should be controlled for.

Key actions:

- Account for differences in infrastructure / land development costs using a two-stage process. This will entail estimating the difference in the intensity of development across the rural/urban boundary and using this estimate to calculate the magnitude of land development / infrastructure costs that have been capitalised into land values inside urban zones.

- As infrastructure costs to council may exceed the value of development contributions paid by developers, ensure that it is clear that councils may seek to undertake additional analysis to quantify public infrastructure costs that are capitalised into land values. Clarify how this can be incorporated into the analysis by councils.
- Variables for slope and flood risk should be investigated but not as a first priority. Auckland Council can provide flood risk shapefiles.
- If including meshblock-level variables for median income as a proxy variable for other localised amenities, use 2001 Census data to reduce simultaneous causality problems between land values and incomes of people living in areas.
- Test different specifications of indicator variables for proximity to the RUB – eg 3 kilometre bands vs 2 kilometre bands. (Tests were undertaken on various distance bands ranging from 100 metres to 3 kilometre: these tests and their results are outlined in Appendix 2).

Hamilton

Attendees: Keith Hornby, Stacy Mahon, Mark Roberts and Upa Paragahawewa (Hamilton City Council), Peter Nunns (MRCagney)

Key comments:

- Hamilton (and the neighbouring Waipa and Waikato District Councils) have few geographic features that would prohibit development.
- Flood risk and peat soils raise the cost of development as they require mitigation but do not prevent development. The cost of mitigation may be on the order of $10,000 per dwelling, which is minor in the context of overall development costs. Peat soils may also raise infrastructure supply costs due to the need to proof pipes against cracking when peat soil dries out and subsides.
- Flood risk is concentrated around the Waikato River and in gullies. Generally speaking, gullies and areas with flood risk are zoned open space or subject to restrictions on further development.
- Waikato Regional Council has mapped flood risk throughout the region.
- Infrastructure supply and boundary adjustments to bring new urban land in from neighbouring (rural) councils are seen as key factors that may affect land values.
- There is an interest in understanding how land values have changed following previous boundary adjustments in 2004, 2011, and 2014. When adjusting boundaries, land transitions between being outside of the city boundary to being inside the boundary but not zoned urban, to being inside the boundary and zoned urban.
- Distance to the Waikato River is seen as having positive amenity value (even accounting for flood risks on river bank), as is proximity to several centrally-located amenities (including the lake, hospital, and possibly the CBD).

Key actions:

- As Hamilton City boundaries coincide with urban zone boundaries, capture the effect of rural/urban differentials by including data from neighbouring councils. Adjust for differences in valuation year.
- Include a control variable for distance to the Waikato River, along with a control variable for distance to the CBD (which also captures the impact of proximity to other centrally-located amenities.)
- Contact Waikato Regional Council to request flood risk maps. Include an indicator for whether parcels are in natural hazard areas in the econometric model of the impact of rural/urban zoning on land values.
- Map land values at a meshblock level to allow local authority officers to interrogate effects spatially. Also map land values before and after the last three boundary adjustments (2004, 2011, 2014) to assist in assessing impact of previous changes.

Tauranga

Attendees: Andrew Mead (Tauranga City Council), Peter Nunns (MRCagney)

Key comments:

- Need to clarify what measure of the rural/urban boundary are used – ie do they measure (a) land that has been developed, (b) land that is currently zoned for urban use, or (c) land that is currently zoned plus land that has been identified in future development strategies, such as the Te Tumu and Tauriko West areas.
    - Clarification: This analysis uses the second definition. Zoning at the valuation date is identified using CoreLogic data. To clarify, the CoreLogic data does not count the Te Tumu or Tauriko West areas as urban zoned land, but it does include the Plan Change 18 and Plan Change 25 areas that have been progressed.
- Steeply sloping land and deep peat soils can significantly raise the cost of development or make development infeasible. There are a number of areas where the rural/urban boundary abuts challenging terrain. These are the main geographic barriers to development.
    - A challenge is that soil maps are not always good quality / comprehensive – eg urban soil is not measured on the LINZ datasets.
    - Tauranga City and Western Bay of Plenty District are familiar with the terrain and would be able to identify areas where terrain is very challenging.
- Flood risk often coincides with peat soils (as peat is formed in swampy areas). Bay of Plenty Regional Council is close to updating its flood risk maps, which could serve as a proxy variable for peat soils.
- Flat land beyond the rural/urban boundary is likely to be attractive for horticulture – kiwifruit / avocados – and hence can command high land values. This is a factor that will reduce the magnitude of the boundary differential.

- Infrastructure and land development costs also get capitalised into land values and should be accounted for in the analysis. These costs can vary significantly between locations, principally due to the higher cost of earthworks in some places. Tauranga City's greenfield development feasibility modelling provides information on some location-specific variations in infrastructure costs between locations.

Key actions:

- As Tauranga City boundaries generally coincide with urban zone boundaries, capture the effect of rural/urban differentials by including data from Western Bay of Plenty District. Adjust for differences in valuation year.
- Variables for slope and flood risk should be investigated. LINZ digital elevation maps can be used to identify slope, while Bay of Plenty Regional Council may be able to provide a flood risk map.
- Account for differences in infrastructure / land development costs using a two-stage process as described above. This will entail estimating the difference in the intensity of development across the rural/urban boundary and using this estimate to calculate the magnitude of land development / infrastructure costs that have been capitalised into land values inside urban zones.
- Map land values at a meshblock level to allow local authority officers to interrogate effects spatially, and identify areas where land may be unsuitable for development and which could be excluded from the analysis.

Queenstown

Attendees: Anita Vanstone, Kim Banks and Ian Bayliss (Queenstown Lakes District Council), Peter Nunns (MRCagney)

Key comments:

- Natural hazards affect the location of urban zoning. Areas with significant ongoing landslide and rockfall risk are risky to develop and hence Queenstown Lakes District Council (QLDC) is resistant to approve subdivision in these areas.
- QLDC has a GIS map of natural hazards, including landslide risk. This information is a work in progress and is updated when new information becomes available from consent applications etc.
- Proximity to the lake, water views, and north-facing sites are amenities that enhance land values. Sloping land is costly to develop but can also be more valuable if it has better views.
- The cost of infrastructure provision is a key constraint to extending zoning.
- Outstanding Natural Landscape / Outstanding Natural Feature areas are also considered undesirable to develop due to the policy direction set to protect these areas (Section 6 of RMA). This is acknowledged as a key policy consideration that may make extending urban zoning undesirable in some areas.

Key actions:

- If available from either CoreLogic data or LINZ elevation data, include measures of slope in the econometric model of the impact of rural/urban zoning.
- If available from CoreLogic data, include an indicator for water views in the econometric model. (A preliminary check suggests that this data is not available).
- QLDC to provide GIS shapefile of natural hazards to enable identification of parcels that are in hazard areas.
- Include an indicator for whether parcels are in natural hazard areas in the econometric model of the impact of rural/urban zoning on land values.

Appendix 2: Model specification tests

This Appendix reports the results of a range of model specification tests that were conducted in order to select preferred models and understand the trade-offs between alternative choices of variables.

Tests of alternative model specification

A variety of econometric model specification tests were conducted prior to selecting and estimating the final models presented in this report. A summary of the results of specification test is reported in the following table.

Table 26: Summary of model specification tests

Specification test	**Cities tested**	**Result / conclusion**
Exclude $DCBD_i$ and $DWater_i$ variables	Hamilton, Tauranga	Excluding these variables resulted in a significantly higher differential. They reduced the quality of the model (measured by Akaike's Information Criterion), suggesting that these variables are relevant control variables for explaining variations in land values even within 2 kilometre bands around the edge of the RUB. Conclusion: It is necessary to include $DCBD_i$ and $DWater_i$ control variables.
Include $DCBD_i$ and $DWater_i$ variables in quadradic form (ie $DCBD_i$ and $DCBD_i^2$) rather than logarithmic form	Hamilton, Tauranga	Including these variables in quadratic form resulted in slight differences in the differentials – slightly higher in Tauranga and lower in Hamilton. This change reduced the quality of the model slightly (measured by Akaike's Information Criterion), suggesting that the logarithmic form is preferred. Conclusion: Include $DCBD_i$ and $DWater_i$ control variables in log-transformed form.
Group land value data by meshblock rather than using parcel-level data	Hamilton, Tauranga	Grouping land value data resulted in a large increase in the raw differential, which doubled in Tauranga and tripled in Hamilton. This is due to the fact that grouping the data places more weight on large sites, which are concentrated outside the RUB and which tend to have lower land values (reflecting their generally lower level of development). Conclusion: Most of the differences between this analysis and previous work by Grimes and Liang (2009) and Zheng (2013) can be explained by the use of parcel-level data rather than meshblock-level data.
Include indicator variables for natural hazards	Hamilton (flood risk), Christchurch (liquefaction risk), Queenstown (landslide risk)	Coefficients on the natural hazard indicator variables were statistically significant and had the expected negative impact on land values. However, because natural hazards affect both urban and rural zoned land they didn't affect the difference in rural and urban land values. Accordingly, adding natural hazard variables to the model resulted in very little change in

		raw differentials. In Hamilton and Christchurch, the natural hazard variables did not affect the magnitude of the raw differential, while including these variables for Queenstown reduced the raw differential by less than $20/m^2. Conclusion: While natural hazards negatively affect land values, their inclusion or exclusion from the econometric model does not significantly affect the differential. This suggests that existing rural-urban zoning boundaries do not closely align with natural hazards.

Are differences in land values across the RUB statistically significant?

The following table reports tests of whether estimated differences in land values between sites that are just inside and just outside of the RUB are statistically significant.

An F-test was used to test the null hypothesis that the coefficient on $DRUB2_i$ (indicating parcels immediately inside the RUB) is equal to the coefficient on $DRUB3_i$ (indicating parcels immediately outside it). Tests were conducted with both a 2 kilometre distance band around the RUB and a considerably smaller 100 metre distance band. In each urban area, the F-statistic from these tests was large, indicating that there is a statistically significant difference in land values across the boundary at the 1 percent confidence level.

These results suggest that the observed differences in land values do not simply reflect random variation in the land value data.

Table 27: F-tests for whether there is a statistically significant difference in land values across RUBs

Geographic area	**2 kilometre distance band**		**100 metre distance band**	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Whangarei	9,838	<0.001	408	<0.001
Auckland	92,089	<0.001	1,921	<0.001
Hamilton	67,875	<0.001	2,859	<0.001
Tauranga	20,933	<0.001	1,346	<0.001
New Plymouth	11,327	<0.001	763	<0.001
Christchurch	118,309	<0.001	4,302	<0.001
Queenstown	2,911	<0.001	255	<0.001

The impact of different distance bands

A single distance band of 2 kilometres either side of the boundary between rural and urban zones was used to calculate the rural-urban differentials for all of the urban areas. This is the same distance band as has previously been used to calculate rural-urban differentials in Auckland.

However alternative distance bands were also tested, and sensitivity tests were conducted to understand the impact of choosing a narrower or wider distance band around the RUB. The aim of these sensitivity tests was to understand whether choosing a different definition of parcels that are close to the RUB resulted in qualitatively different results, relative to the baseline specification of a 2 kilometre band.

The following charts present information on how the magnitude of the final differential, which is adjusted for estimated differences in section development costs, differs if a narrower or wider distance band is selected. They also show how the model fit (measured by the coefficient of determination, or R^2) varies for different choices of distance band. The R^2 value indicates how much of the variation in the underlying land value data is 'explained' by the data. For instance, an R^2 of 0.1 would indicate that the model only explains 10 percent of the variation in the underlying data, while an R^2 of 0.8 would indicate that it explains 80 percent of the variation.

The following table summarises the R^2 values for the preferred model with a 2 kilometre distance band. It compares this value against the minimum and maximum R^2 values across the full range of models that were tested, which use distance bands ranging from 100 metres to 3 kilometres. This table shows that:

- The preferred econometric models 'explain' between 57 percent and 79 percent of variations in parcel-level land values in these cities. This suggests that these models are successful in accounting for a wide variety of factors that affect land values, including both the impact of zoning boundaries and other control variables.
- These results also suggest that there are also other unobserved factors that influence land values.
- An alternative choices of distance band would not result in a significant increase in the R^2 in any city, suggesting that the preferred 2 kilometre distance band generally performs well to capture variations in land values that are related to the RUB.

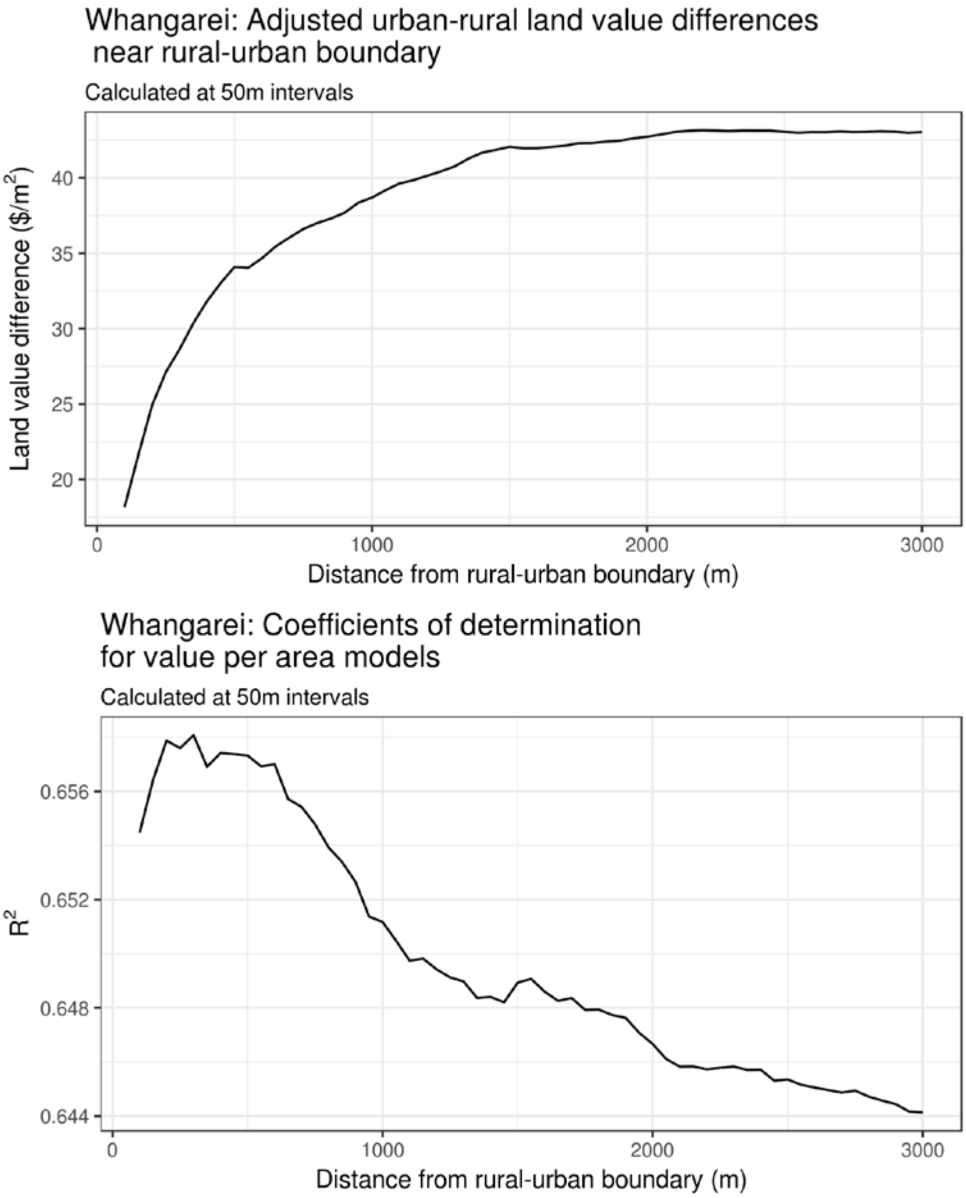
Table 28: R^2 values for alternative econometric models of land value discontinuities

Geographic area	**R^2 of model with 2 kilometre distance band**	**Minimum R^2**	**Maximum R^2**
Whangarei	0.647	0.644	0.658
Auckland	0.666	0.665	0.676
Hamilton	0.794	0.792	0.798
Tauranga	0.730	0.690	0.734
New Plymouth	0.700	0.700	0.703
Christchurch	0.661	0.656	0.664
Queenstown	0.573	0.570	0.597

The following charts show how the Whangarei RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.647 to around 0.658, suggesting that a shorter distance band may result in a model that explains an additional 1 percent of variation in land values. This is a negligible difference, suggesting that there is little gain in precision from a shorter distance band.

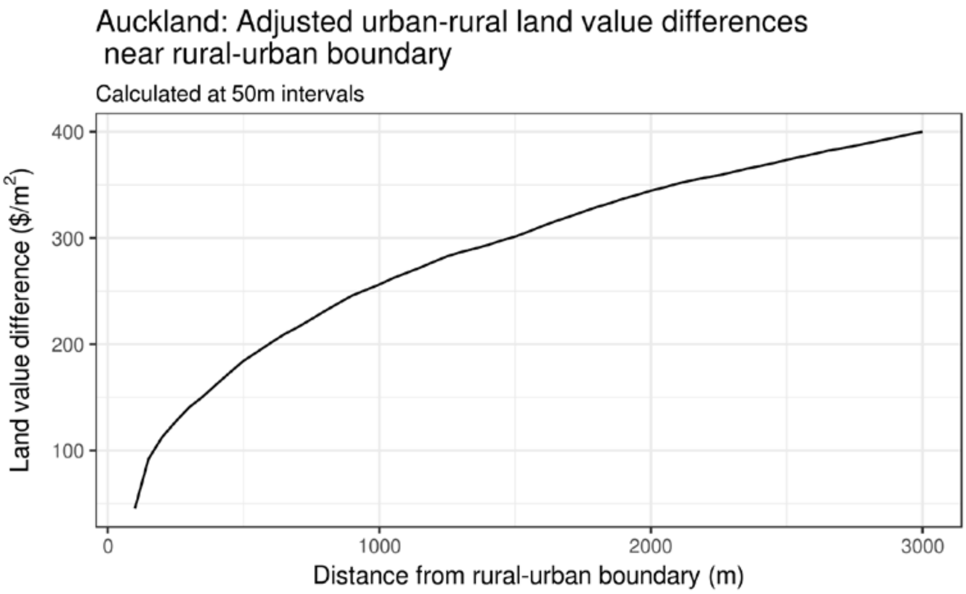
Figure 25: The impact of different distance bands on the Whangarei RUB differential

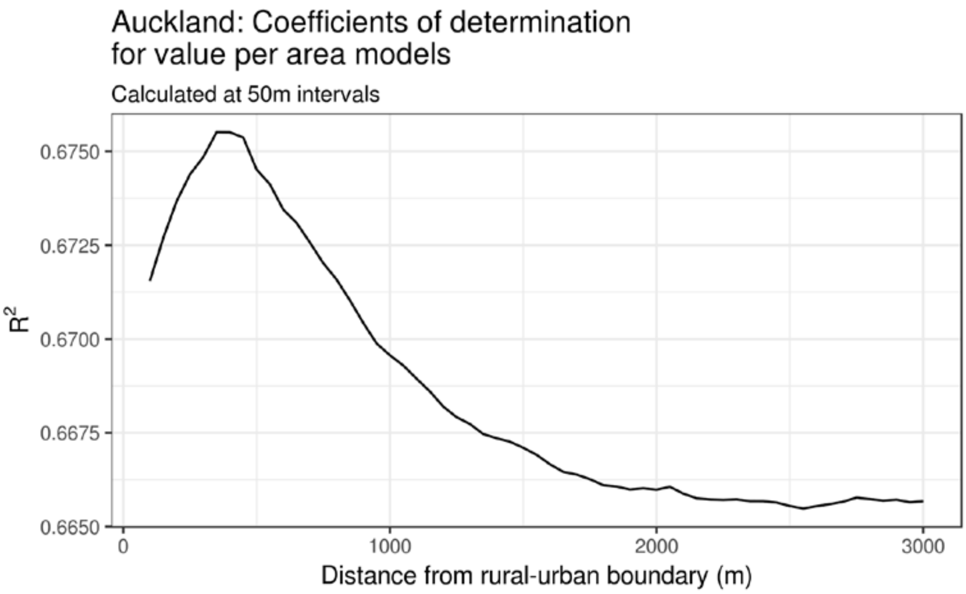


The following charts show how the Auckland RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is substantially larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.666 to around 0.676, suggesting that a shorter distance band may result in a model that explains an additional 1 percent of variation in land values. This is a negligible difference, suggesting that there is little gain in precision from a shorter distance band.

Figure 26: The impact of different distance bands on the Auckland RUB differential

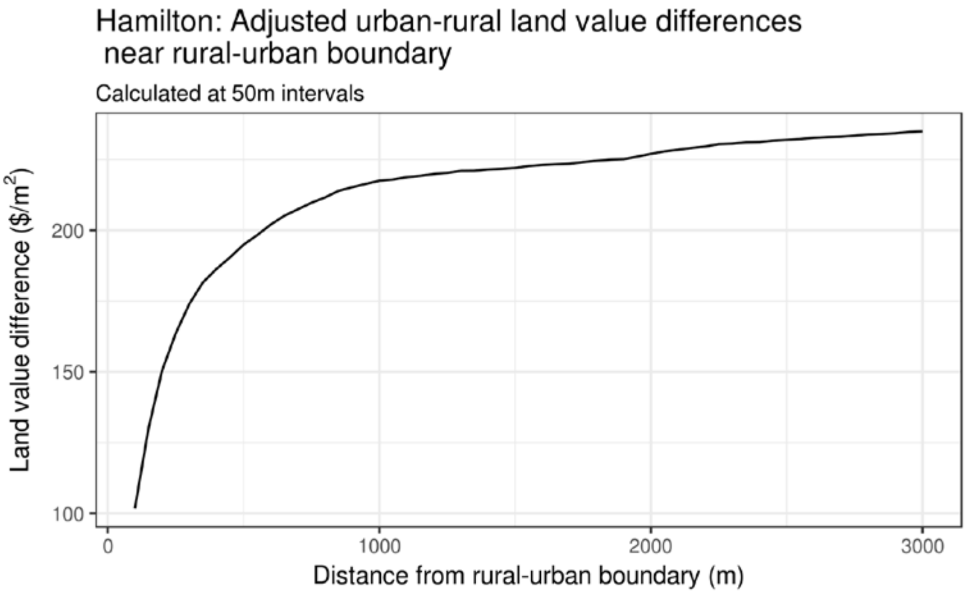


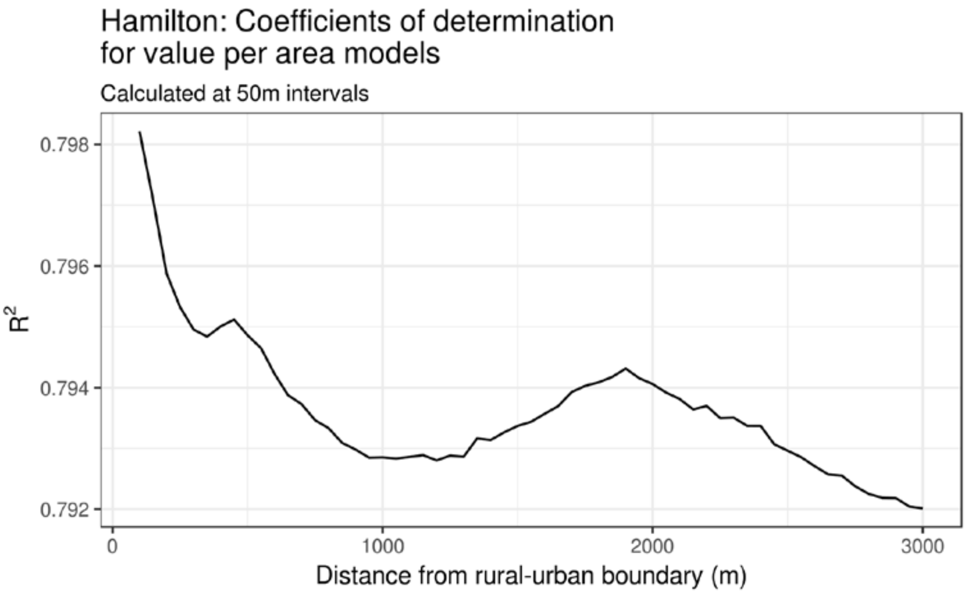


The following charts show how the Hamilton RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.794 to around 0.798, suggesting that a shorter distance band may result in a model that explains an additional 0.4 percent of variation in land values. This is a negligible difference, suggesting that there is little gain in precision from a shorter distance band.

Figure 27: The impact of different distance bands on the Hamilton RUB differential

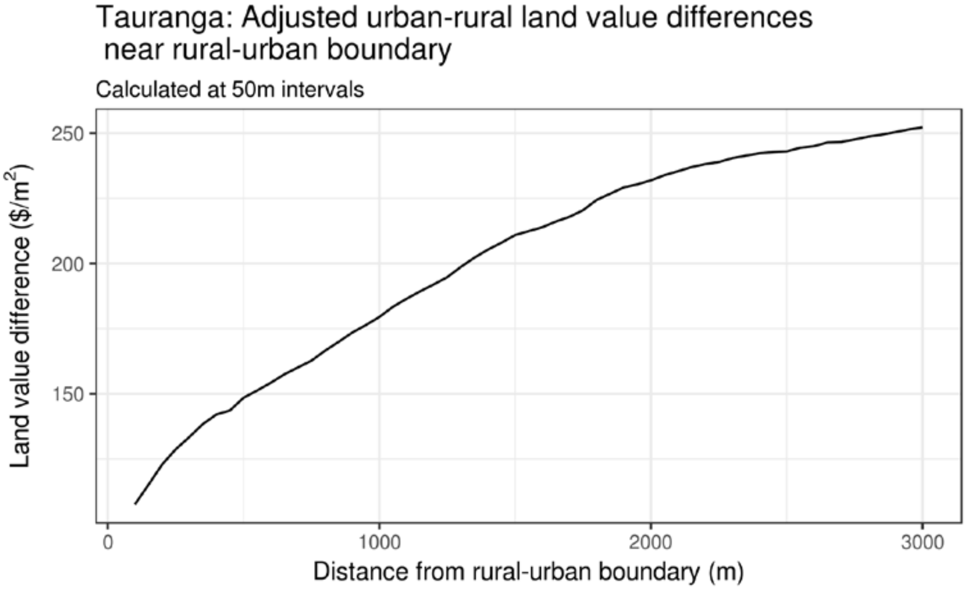


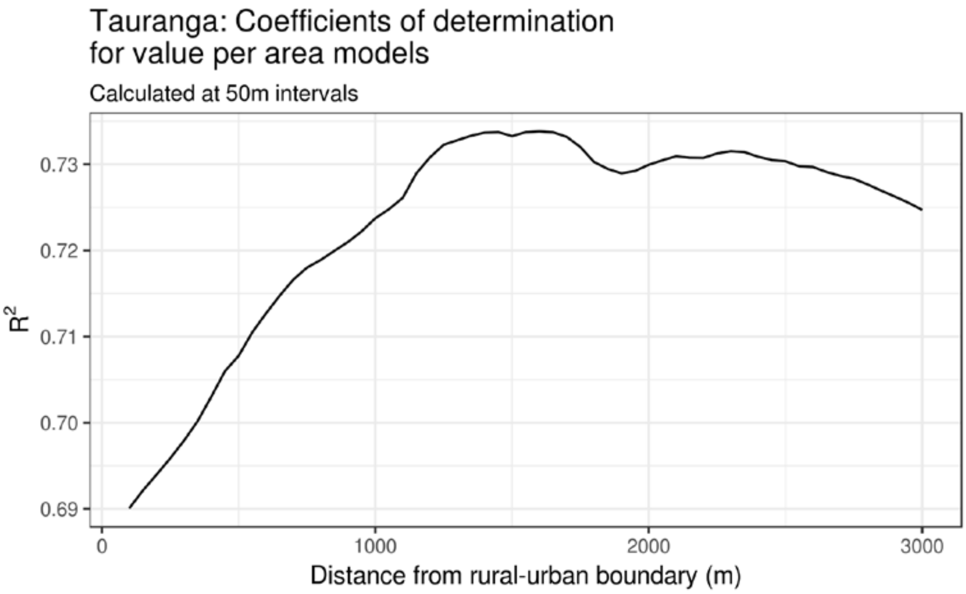


The following charts show how the Tauranga RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is larger than zero even if a 100 metre distance band is used. The R^2 declines from 0.730 to around 0.690, suggesting that a shorter distance band may result in a model that less of the observed variation in land values. This suggests that there is little rationale to use a shorter distance band for analysis in Tauranga.

Figure 28: The impact of different distance bands on the Tauranga RUB differential

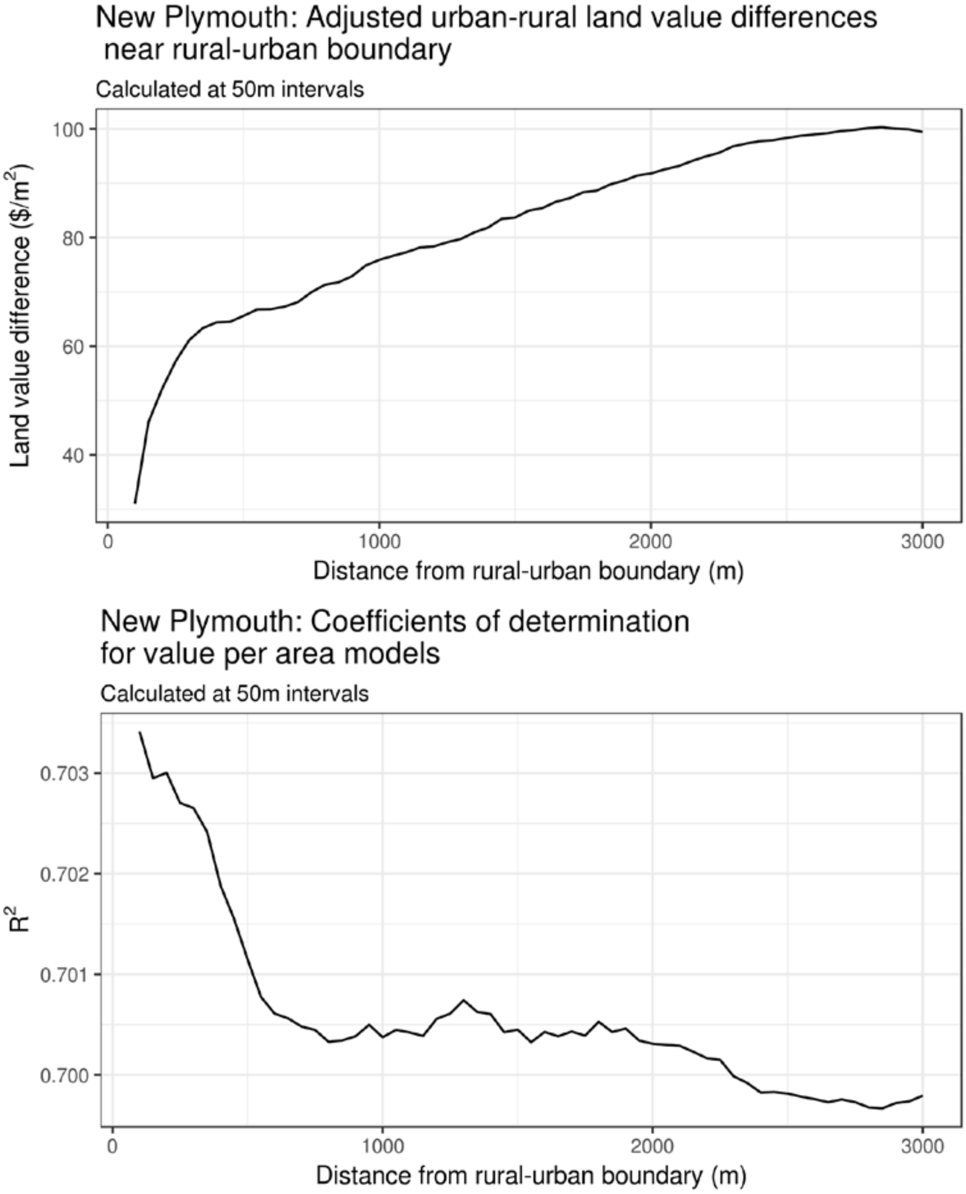




The following charts show how the New Plymouth RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.700 to around 0.703, suggesting that a shorter distance band may result in a model that explains an additional 0.3 percent of variation in land values. This is a negligible difference, suggesting that there is little gain in precision from a shorter distance band.

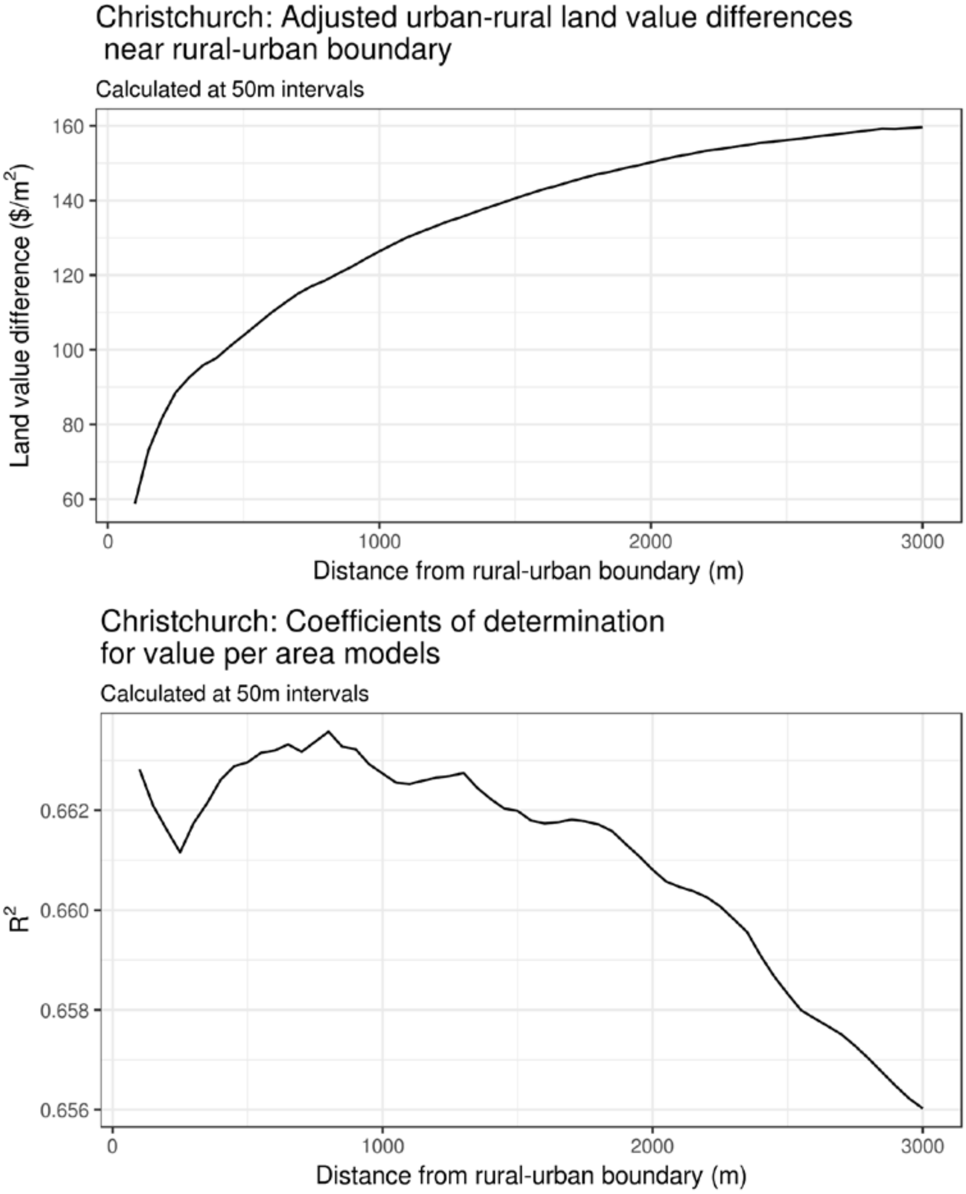
Figure 29: The impact of different distance bands on the New Plymouth RUB differential



The following charts show how the Christchurch RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.661 to around 0.664, suggesting that a shorter distance band may result in a model that explains an additional 0.3 percent of variation in land values. This is a negligible difference, suggesting that there is little gain in precision from a shorter distance band.

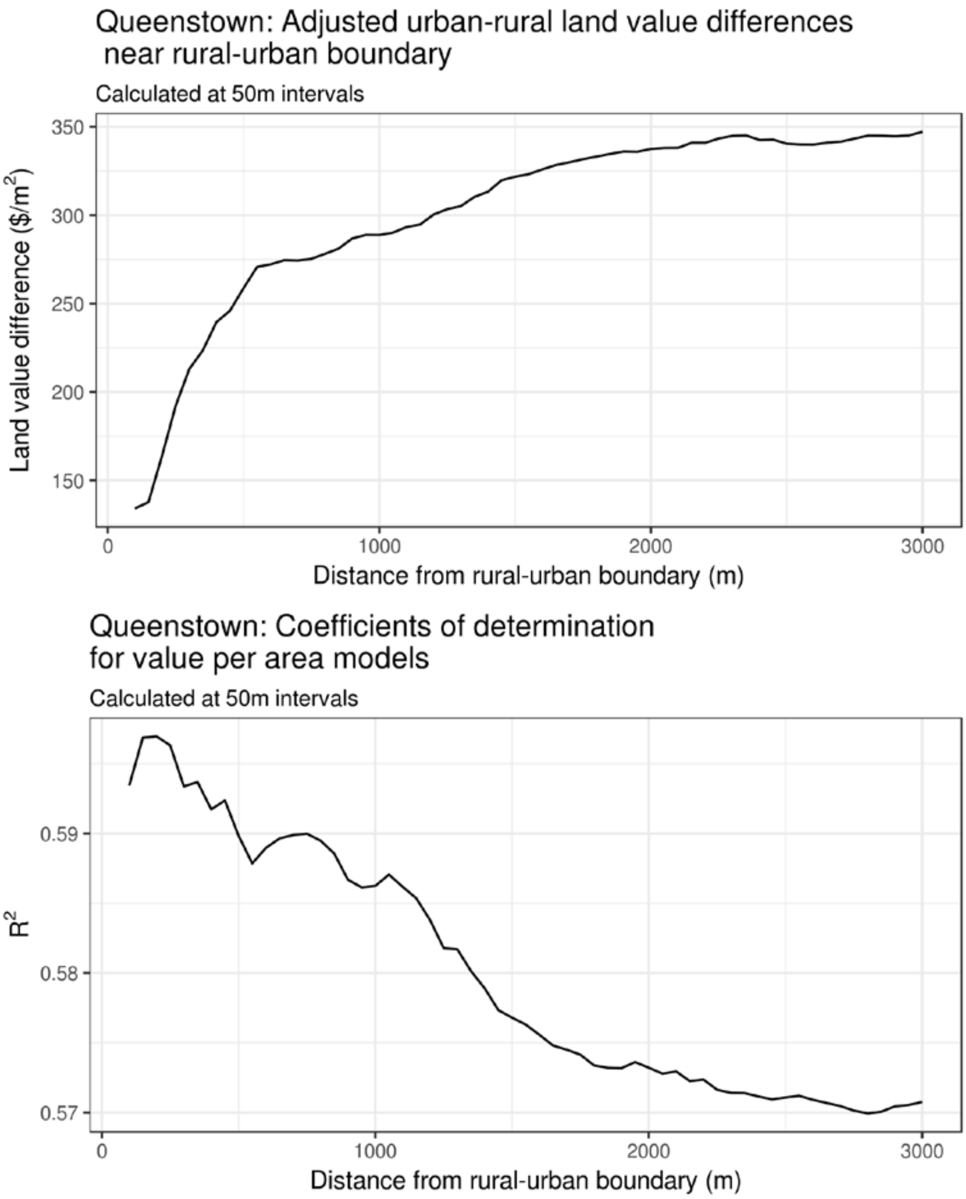
Figure 30: The impact of different distance bands on the Christchurch RUB differential



The following charts show how the Queenstown RUB differential varies if different distance bands are used. The horizontal axis of the charts indicates the width of the distance bands used to identify properties that are close to the RUB, which range from 100 metres to 3 kilometres.

The estimated differential declines as the distance band shrinks in width, although it is substantially larger than zero even if a 100 metre distance band is used. The R^2 rises slightly, from 0.573 to around 0.597, suggesting that a shorter distance band may result in a model that explains an additional 2.4 percent of variation in land values. This is a larger increase in R^2 than is observed in other cities, which is a finding that may bear further investigation. It may, for instance, reflect the smaller size of Queenstown relative to other cities.

Figure 31: The impact of different distance bands on the Queenstown RUB differential



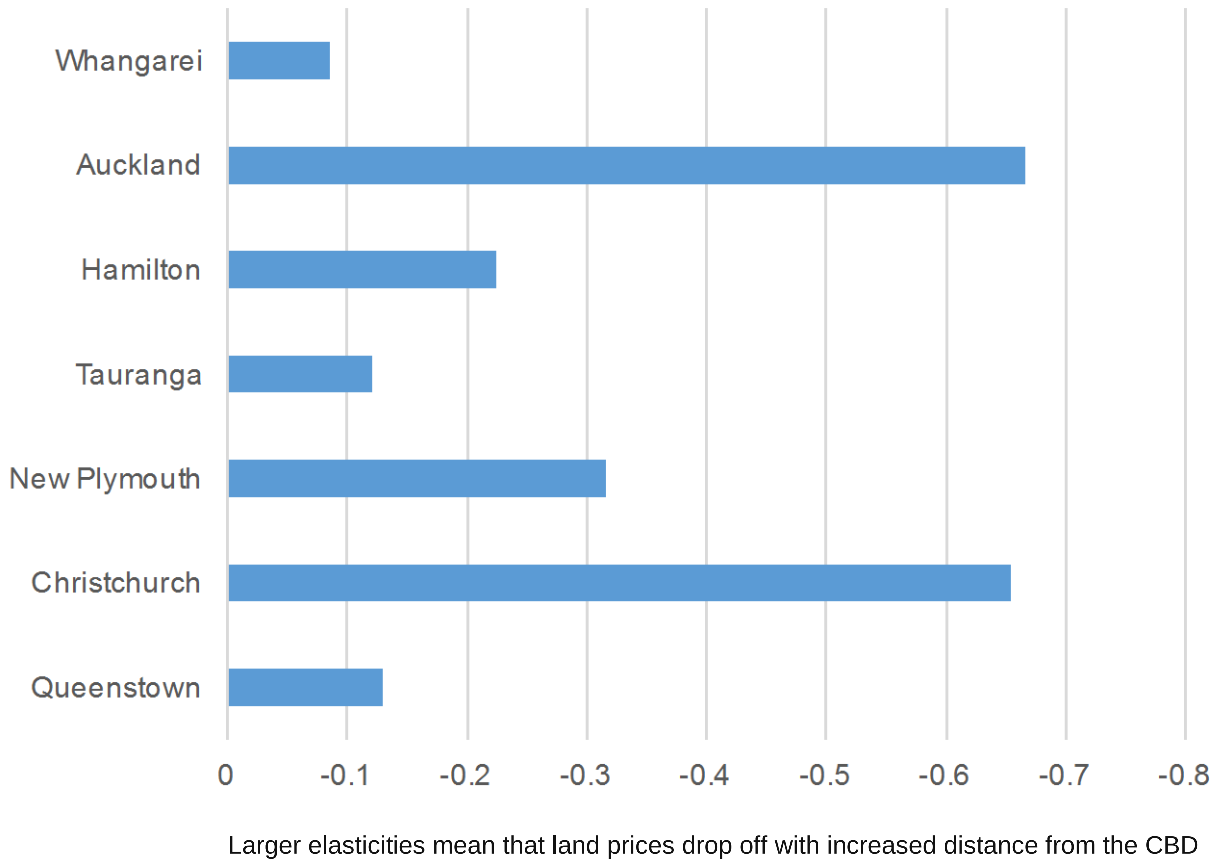
Appendix 3: the impact of amenities on land values

The results in this report can also be used to estimate the impact of different amenities or locations on property values in different cities. In particular, control variables for proximity to the city centre and proximity to coastlines or inland water bodies can be used to understand the degree to which buyers in different cities value different types of locations.

The following chart shows the impact of proximity to the CBD on land values. The bars show the econometric model coefficients on the $DCBD_i$ variable, which estimate the elasticity of price with respect to increased distance to the CBD. Larger values indicate that there is a steeper price gradient as distance from the CBD increases.

These results suggest that Auckland and Christchurch have steeper price gradients, while Whangarei, Tauranga, and Queenstown have flatter price gradients. This aligns with intuitions: Auckland and Christchurch are larger cities where living further out may mean significantly longer travel distances or exposure to congestion, while the other cities are smaller waterfront cities where there may be less variation in travel distances.

Figure 32: Impact of proximity to the CBD on land values

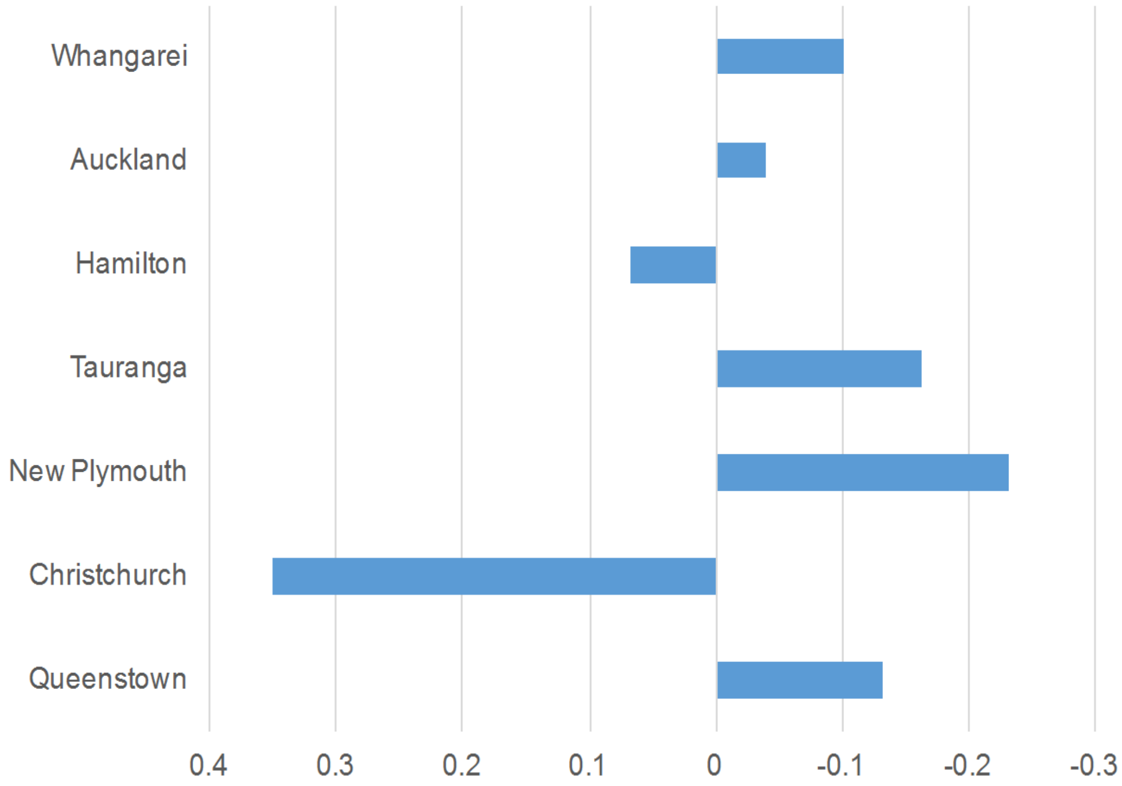


The next chart shows the impact of proximity to the coastline or major inland water bodies on land values. The bars show the econometric model coefficients on the $DWater_i$ variable, which estimate the elasticity of price with respect to increased distance to the CBD. Larger values indicate that there is a steeper price gradient as distance from water increases.

These results suggest that Tauranga, New Plymouth, and Queenstown have steeper price gradients, while Christchurch has a substantial negative price gradient. Again, this aligns with intuitions: Tauranga, New Plymouth, and Queenstown are coastal cities, while coastal areas in Christchurch are more exposed to natural hazards such as flooding and liquefaction.

The coefficient for Auckland is small but still indicates that prices are higher near the coast, while the coefficient for Hamilton is small but indicates that prices are lower near the river. These results may reflect variations in the quality of different coastal / river areas. For instance, in Auckland, proximity to the Waitemata Harbour has a stronger positive impact on prices than proximity to the Manukau Harbour, due both to different levels of natural amenity and different built environments around the harbour.

Figure 33: Impact of proximity to coastlines or inland water bodies on land values



Larger elasticities mean that land prices drop off with increased distance from coastlines or inland water bodies