The Medium Density Residential Standards under the Resource Management Act

Estimates of development impacts at the Statistical Area 2 level

Prepared for

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pwc

Context

In response to housing supply shortages, the Ministry for the Environment required cost-benefit analysis (CBA) of two amendments to the Resource Management Act that require councils to up-zone:

- Implement a new default Medium Density Residential Standards (MDRS) in their residential areas.
- Bring forward the timing of implementation for the intensification policies of the National Policy Statement on Urban Development (NPS-UD), to enable denser housing close to jobs, transport options and areas of high demand.

Now local councils are updating their district plans to comply with the Resource Management (enabling housing supply and other matters) Amendment Act 2021 ('the Act'). Part of this process involves making applications for "qualifying matters" under the Act – exceptions to the policy in areas that would otherwise be subject to its MDRS. Applications for qualifying matters require, among other things, that councils provide an assessment of the costs and impacts of the implied reduction in development capacity (Section 77J).

However, the CBA for the Act provided aggregate totals for each urban area. The Ministry of Housing and Urban Development is seeking an estimate of the expected development impact of the MDRS within individual Territorial Authority boundaries. The purpose of this estimate is to support local authorities in selecting and preparing their applications for qualifying matters under the Act.

This report provides an estimate of the expected development impact of the MDRS within individual Territorial Authority boundaries, and within each Statistical Area 2 (SA2) area.

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1 Executive summary

The Government introduced a new default Medium Density Residential Standard (MDRS) to reduce barriers to housing supply and improve housing affordability

In late 2021, Government passed the Resource Management (Enabling housing supply and other matters) Amendment Act 2021 ('the Act'). The amendment requires councils in Tier 1 urban environments to up-zone in two ways:

1. Bring forward the timing of implementation for existing intensification policies of the National Policy Statement on Urban Development (NPS-UD).
2. Implement a new default Medium Density Residential Standard (MDRS) in residential areas.

The costs and benefits of the intensification policies in the NPS-UD are estimated elsewhere,[1] but the timing implications are important.

The MDRS is new and:

a) allows three-storeys and three-units as of right per site

b) enables:

- more flexible heights in relation to boundary standards to enable three storeys on average sized sites
- smaller private outlook spaces (that is, space between windows and other buildings) and private outdoor spaces (for example, balconies)
- development closer to side boundaries
- more planning consents (when needed) to proceed on a non-notified basis without neighbour approvals.

The MDRS applies to all existing residential zones, with minor exemptions. The MDRS also applies to new residential zones, such as when rural land is urbanised, as a minimum enablement. It does not apply to land zoned for recreation, open space, or business.

The change implied by the MDRS amounts to a permanent shift in the responsiveness of housing supply to rising prices. This means the impacts of the policy will begin slowly, but continue to build as long as the MDRS remains in place.

A spatial estimate of impact is needed to support local authorities

The purpose of this report is to provide a spatial estimate of the development impact of the MDRS. We aim to do this at a level of granularity that can assist local authorities in meeting their obligations under the NPS-UD as they prepare plan changes in response to the Act. To do this, we build on a proprietary spatial-econometric model originally developed for the cost-benefit analysis that supported the Act during its parliamentary process. We achieve this by using existing parcel-level redevelopment probabilities to simulate 1,000 likely outcomes for each urban area.

[1] See PwC 2020.

The CBA model assesses impacts on the supply of dwellings by understanding the impact of the Auckland Unitary Plan

Our analysis of development impact relies on a spatial econometric model to generate forecasts for Auckland and then adapts the model to data from the wider urban areas of Christchurch, Wellington, Hamilton, and Tauranga for application to those cities.

Our modelling is based on a standard theoretical framework, calibrated to the housing market in each city to arrive at a forecast. The increase in dwelling supply in Auckland following the 2016 enactment of the Auckland Unitary Plan (AUP) provides a natural experiment. The changes under the MDRS create a new city-wide minimum allowable density level similar to the building constraints for one of the AUP zones (Residential Mixed Housing Urban or MHU). We use this recent observed increase in response to a similar policy change to calibrate our forecasts.

However, there are important ways with what happened under the AUP that are different from what we expect to happen under the MDRS. The AUP favoured development at the urban fringe over intensification near the city centre and left in place other constraints to development beyond zoning rules, resulting in some measured results that do not align with the demand patterns predicted by theoretical frameworks for urban spatial equilibrium. The MDRS is intended to alter this. To align our forecasts with that intent, we adjust our model to neutralise the AUP bias toward urban fringe development, allowing demand and opportunity cost characteristics to drive the response to up-zoning instead. When we adjust the model to neutralise the AUP bias toward urban fringe development, we find the most intensive development moving much closer to the city centre. Our base-case scenario shows development closely hugging the NPS-UD walkable catchments around public transport and metropolitan centre areas. This bodes well for the NPS-UD intensification policies, suggesting that previous estimates of their impact may have been understated.

Table 1 shows the estimates from the original MDRS CBA of the additional new dwelling consents in residential areas subject to the MDRS policy during the *five to eight years* following policy enactment. Additional dwellings are those dwellings **over and above** what would be expected to have otherwise occurred without the MDRS. The MDRS is estimated to result in nearly 75,000 additional dwellings above what would otherwise take place in New Zealand's fastest growing cities in the medium term.

Table 1: Five-to-eight-year additional dwellings added forecasts with sensitivity range

	Base estimate
Auckland	39,200*
Hamilton	8,300
Tauranga	5,800
Wellington	9,800
Christchurch	11,500
Totals	74,600

Source: CBA of the proposed MDRS (2021).

** This base estimate was adjusted downward to 37,500 in subsequent analysis following a change to the policy requirements after the second reading in Parliament. The change concerned the minimum height-in-relation-to-boundary (HIRB), adjusting down from 6m and 60 degrees to 4m and 60 degrees.*

Our original CBA did not consider where these development sites are within each city. In this report, we generalise the initial CBA by analysing where these development sites might be within each urban area. We provide an average expected development for each Territorial Authority (TA), at the Statistical Area 2 (SA2) level.

Table 2 below shows the estimates of additional new dwelling consents in residential areas subject to the MDRS policy during the *five to eight years* following policy enactment for each TA. Estimates at the SA2 level are presented in Appendix A. As noted above, the additional dwellings shown in Table 2 are those **over and above** what would be expected to have otherwise occurred without the MDRS.

These estimates are based on various assumptions and a custom metric called the *quality score*. The quality score incorporates the interaction between zone and demand characteristics. We also assume that the average rate of participation in the development market among homeowners, including participation by selling to developers (holding our model variables constant), is similar over time between cities. In addition, wider factors that are not included in the modelling, such as capacity of the construction sector, will influence the actual number of additional dwellings that are realised in this timeframe. Our key model features and assumptions are described in Box B (see page 25).

Table 2: Five-to-eight-year additional dwellings added forecasts by TA

Territorial Authority	Mean Impact	Median Impact	25th Percentile[2]	75th Percentile[3]
Auckland	45,839	45,478	37,810	53,429
Waikato District	-425	-429	-619	-232
Hamilton City	10,166	10,142	9,136	11,190
Waipā District	-445	-452	-638	-253
Western Bay of Plenty District	886	880	722	1,038
Tauranga City	3,931	3,906	3,350	4,486
Kapiti Coast District	1,632	1,617	1,382	1,871
Porirua City	474	466	253	690
Upper Hutt City	589	584	458	713
Lower Hutt City	2,087	2,062	1,674	2,470
Wellington City	4,134	4,068	3,414	4,769
Waimakariri District	269	255	45	476
Christchurch City	9,419	9,350	7,521	11,232
Selwyn District	669	661	447	880

Source: Author's analysis

[2] The 25th percentile is the value that 25% of all estimates lie below, or 75% of all estimates lie above.
[3] The 75th percentile is the value that 75% of all estimates lie below, or 25% of all estiamtes lie above.

We forecast that all but two areas will see an increase in additional dwellings as a result of the MDRS. However, some smaller areas have a negative expected impact due to a reduction in demand as more development occurs in more attractive areas in the wider region. For example, some of the increase in development in Hamilton City is at the 'expense' of development in Waipā District (which may see a lower level of development compared with what would have otherwise occurred without the MDRS).

The range of additional dwellings added in each TA reflects the nature of the model being based on probabilities and the model being run 1,000 times (with different results each time). In reality, predicting the exact occurrence of development is impossible, and we would expect a range of future results across the different TAs, and then again at the SA2 level. The use of a probabilistic approach also means there may be a difference when comparing the aggregate estimates in the original CBA with the sum of our new SA2 estimates for the same corresponding areas (though these estimates are within the same range of uncertainty). We wish to point out that the modelling undertaken in this report is not intended as a revision to the original CBA estimates, which were determined using a different methodology designed for estimating overall regional impacts (in aggregate).

2 The Medium Density Residential Standards

2.1 Overview

2.1.1 The MDRS is estimated to have a significant effect on supply

The new MDRS will affect about 33,600 hectares of residential land in Auckland, including all of the four major residential zones established by the AUP. This is comparable in size to the total area zoned for 3 dwellings or more per site under the AUP, but on average allows for significantly more intensification than the AUP did. In the four other Tier 1 urban areas, the policy will affect most of the residential land.

We have a fortunate alignment of timing with the AUP and post-AUP data that allows us to form a robust estimate of the supply response to a policy change that was a lot like the MDRS. We have high quality data on what happened under the AUP and can use it to inform a forecast for what the MDRS is expected to do in Auckland and other Tier 1 cities. This helps us understand how closely Auckland's case aligns to theoretical predictions, despite the many real-world factors that theoretical models ignore. In other New Zealand cities, we can use local data where it is available, and triangulate between theory and observations of Auckland where it is not.

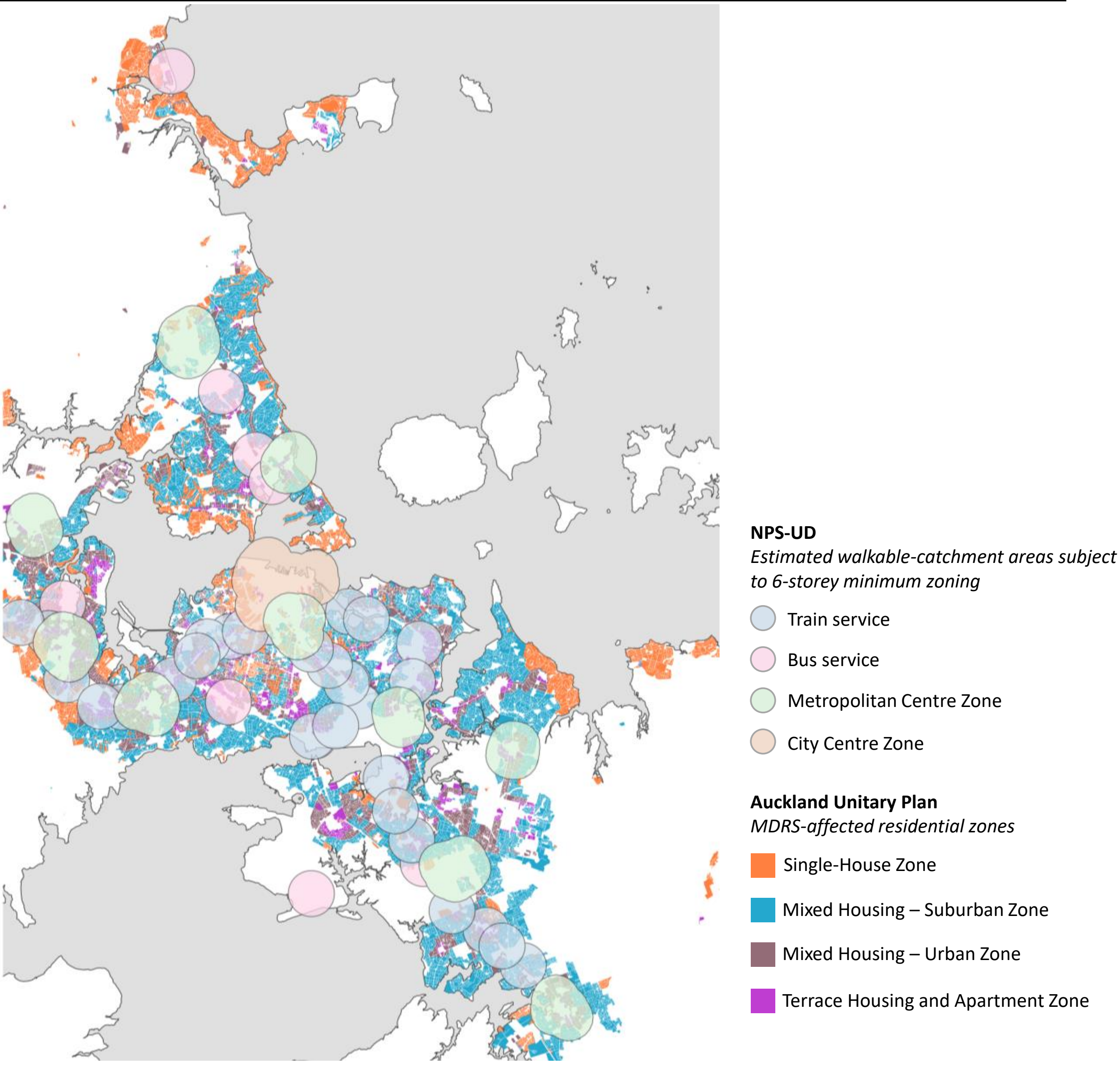
Beyond the AUP, our without-policy forecasts must incorporate another recent and significant departure from past trends—the impact of the NPS-UD. The NPS-UD aims to remove some of the barriers to urban intensification and attempts this using several instruments.

One of these instruments is to mandate a minimum enabled development intensity of 6-storeys within a walkable catchment of rapid transit stops and City Centre and Metropolitan Centre Zones. Figure 1 shows these NPS-UD affected zones, as well as the AUP residential zones for Auckland's core urban area.

The walkable catchment areas shown in Figure 1 are excluded from our estimates of the MDRS impact on housing supply. This is to avoid double-counting effects in those areas that were estimated as part of the benefits of the NPS-UD in the CBA for that policy. However, MDRS rules still apply in these areas. While the MDRS allows for a lower minimum intensity than required by the NPS-UD, it also allows development up to that lower level to proceed 'as of right', without a resource consent (building consents are still required). In this sense, the MDRS may have additional impact inside these NPS-UD catchment areas. These impacts are not included in our modelling.

Of the policy-affected area of 33,600 hectares, we estimate about 12,300 hectares will fall into the walkable catchment areas required to be up-zoned to at least 6-storeys by the NPS-UD. This impact assessment focuses on housing supply effects in the residential land outside of those catchments, where the MDRS represents the greatest departure from the zoning rules that would otherwise prevail. For Auckland, this is an area of 21,300 hectares, or 56 percent of the four major residential zones.

Figure 1: Areas affected by the MDRS policy



Source: HUD data, Auckland Council, authors' analysis.
Note: Walkable catchments are authors' estimates based on Auckland Council Planning Committee proceedings (July 2021).

2.2 Utilising the AUP as a natural experiment

Our model approach and estimates are built on a common theoretical foundation to those used for the CBAs of the NPS-UD and the National Policy Statement on Urban Development Capacity (NPS-UDC), but differ in important ways:

- The CBA for the NPS-UD assessed the benefits of the policy under the assumption that it achieves its stated intent of increasing the responsiveness of housing supply to price increases. To do this, the authors chose to model the implied costs and benefits of a deliberately conservative supply impact, to avoid optimism bias in their estimates.
- The chosen and assessed impact was small enough that it was within the range of observed historical variation in supply response to price increases in each of the six urban areas assessed. In other words, it was assumed to be much lower than the market-transforming

levels to which the policy aspired, as data constraints and the policy's complexity prevented a more robust estimate. As the authors of the CBA for the NPS-UD note:

> "…our assumed policy impacts are well within the scope of historical variation in elasticity for New Zealand cities as a starting point…an impact of this magnitude would be unremarkable if it happened by mere chance. Our high and low estimates…do not represent the extremes of possibility, but two unremarkable outcomes within a much larger range. We intend this conservative choice for potential benefits to guard against undue optimism and ultimately to emphasise the mismatch in orders of magnitude between the potential benefits and costs of the policy."[4]

- Now, with the benefit of five years of building consent data since the enactment of the finalised AUP and a more tightly scoped policy to assess, we have what we need for a higher-quality forecast of actual supply and price responses to a relaxation of zoning constraints in these cities.

Our method builds on the NPS-UD models for calculation of benefits but replaces the assumption of a modest supply response with this forecast. As we will show below, the evidence suggests that:

- the actual impact of the NPS-UD may be significantly greater than assumed for that policy's CBA
- the AUP shows a responsive market, but also a bias toward development at the urban fringe compared to theoretical expectations.

Our model is based on the theoretical framework provided by the Alonso-Muth-Mills model of urban spatial equilibrium (Alonso 1964, Muth 1969, Mills 1967), with parameters fitted to empirical data taken from the up-zoning under the AUP as a natural experiment.

2.2.1 Theoretical framework

Historical data – AUP as a natural experiment

The AUP guides Auckland's natural and physical resources, including land development. It determines what can be built, where, and how much of it. The AUP is both simpler and more permissive than the fragmented plans it replaced, and it has allowed thousands more property owners across Auckland to develop their land through zoning changes (up-zoning), increasing the potential number of dwellings. However, not all land parcels were up-zoned, and constraints in some areas were relaxed less than in others. This forms a natural experiment as there are natural control and treatment groups.[5]

We can look at historical data on how land values changed after the enactment of the AUP to determine how the up-zoning affected land values, and on how zone changes predict building consents to estimate the likelihood and quantity of residential development.

However, there are important ways with what happened under the AUP that are different from what we expect to happen under the MDRS. The AUP favoured development at the urban fringe over intensification near the city centre and left in place other constraints to development beyond zoning rules, such as around 17,000 residential properties under 'special character overlays'—areas

[4] PwC 2020, pages 32-33.

[5] Ideally the assignment of parcels into these groups would be random. In areas where very similar properties were allocated to different zones, say on either side of the same street, we can consider the allocation to be 'pseudo-random'. However, we expect a significant portion of the allocation of zones in older areas of the city to have aligned loosely with the levels of development that were already present under the 90-odd zones that existed before the AUP. This would bias our results toward underestimating the policy's effect in terms of the general level of response to up-zoning.

subject to much stricter conditions for redevelopment. The post-AUP period also has yet to reveal the results of the NPS-UD, which introduced large-scale changes to all Tier 1 urban areas. The NPS-UD was enacted in August 2020, and originally planned to take full effect by 2024, so the data to date does not capture the significant changes in underlying trends it will likely create.

Both the MDRS and the NPS-UD are designed with an intention to reverse the bias toward urban-fringe development observed under the AUP. To inform our assumptions about how future development might occur both with and without the MDRS, we need a theoretical framework for how market forces act on urban spatial arrangements in both the presence and absence of policy constraints. For this, we rely on the Alonso-Muth-Mills (AMM) model, introduced in the next section. Box A describes the key insights from the AUP that inform our forecasts.

Box A: Key insights from the AUP inform our forecasts

Properties up-zoned under the AUP increased in value in subsequent years more than properties that remained at pre-AUP constraint levels. The more permissive the new zone, the more the value increased, all else equal. This observation aligns with the theoretical expectation for high-demand areas—more permissive development implies greater potential revenue from built floor area, which is capitalised into land values. Measurements of these patterns allow us to simulate land value shocks following the MDRS.[6]

The land value and improvement value characteristics of residential properties before the AUP show a strong relationship to how zoning affected the probability of adding at least one dwelling after the AUP. We find:

- for properties in the AUP zone most similar to the MDRS (the MHU zone), there was a 20% probability of houses adding at least one dwelling if they have high relative land value and low opportunity cost of development,
- this probability drops to below 10% for properties with average relative land value and average opportunity cost of development.

Zoning changes strongly predicted the amount of floor area increase for properties that added at least one dwelling. The more permissive the new zone, the more floor area a property added on average (for those that added at least one dwelling), in ratio to land area. This implies that, on average, zoning rules worked as intended, leading to more intense development in the more permissive zones.

Since we have data on land and improvement values at the individual property level, we can analyse development likelihood based on these results with high granularity. However, the AUP released constraints by much more on the outskirts of the city than in the high-demand areas. Following the AUP, adding dwellings was statistically more likely the further away a parcel is from the city centre after controlling for land and improvement values, zone, and special character status.

This does not align with the demand patterns predicted by theoretical frameworks for urban spatial equilibrium. Further analysis reveals that while the zones themselves are distributed widely across distances, areas where the zones increased the permissible development capacity beyond the existing improvements by enough to add at least one dwelling were much less common as we approach the centre. In other words, the AUP effectively dispersed development to the city fringes.

When we adjust the model to neutralise the AUP bias toward urban fringe development, allowing demand and opportunity cost characteristics (linked with low value of existing improvements) to drive the response to up-zoning instead, we find the most intensive development moving much closer to the city centre.

Where the unadjusted AUP-based scenario shows the hubs of development projected in Flat Bush, Howick, Half-Moon Bay, Warkworth, Omaha, Algies Bay, and Whangaparāoa, our base-case scenario shows development closely hugging the NPS-UD walkable catchments around public transport and metropolitan centre areas. This bodes well for the NPS-UD intensification policies, suggesting that previous estimates of their impact may have been understated.

[6] See Greenaway-McGrevy et al. 2020 on the impact of the AUP on intensification, land values and house prices.

The Alonso-Muth-Mills Model

The AMM model is a depiction of urban spatial structure that explains the economic substitutions associated with spatial choices that individuals make regarding where to live and work within the urban landscape. It is one of the most widely used spatial models in urban economics.

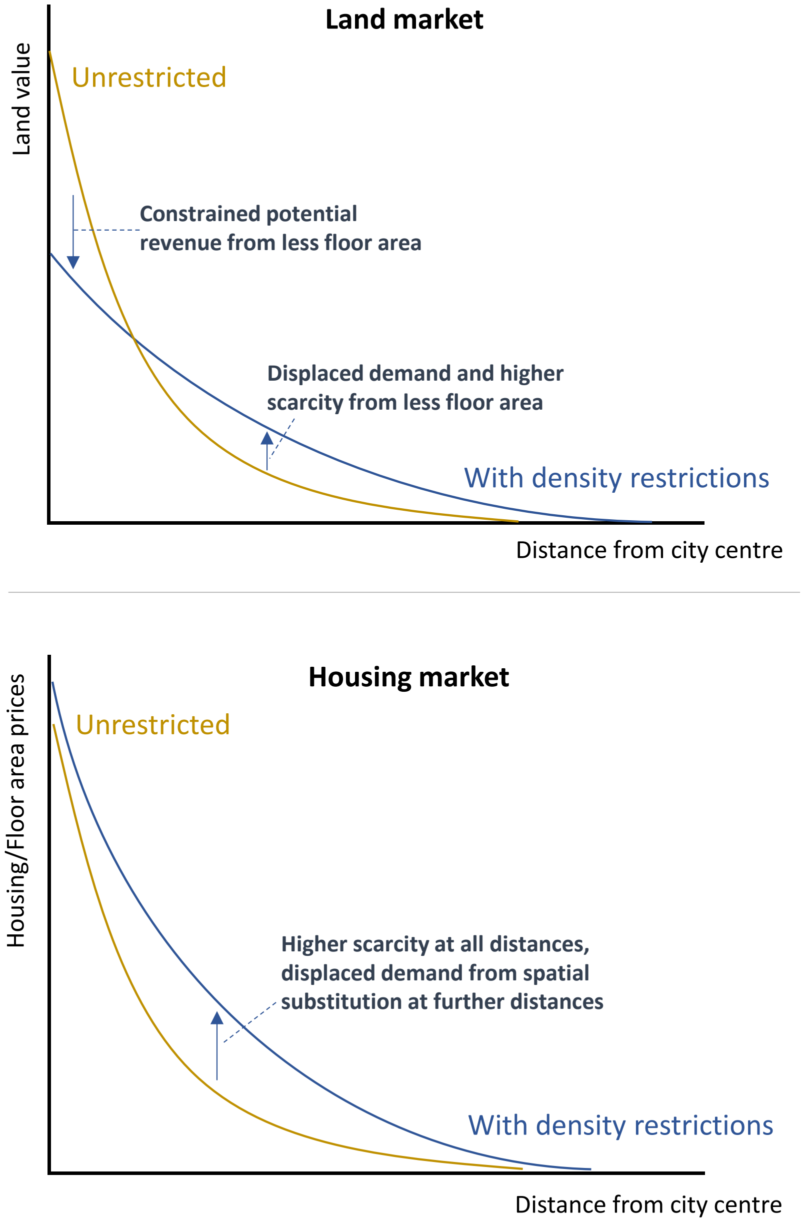
The AMM model is built on two key assumptions:

1. Cities exist to maximise access to opportunity and amenity
2. Access can be attained by either direct proximity, or by transport.

Since commuting and transport is costly in terms of money and time, households prefer to live closer to the centre of the city, all else equal. Land is less scarce further away from the city centre, but the cost of transport to the city centre is higher. Thus, households trade off the cost of housing with the cost of travel. In spatial equilibrium, the sum of all housing and commuting costs can be held constant or near-constant as distance changes, assuming households have similar preferences.

When zoning restrictions prevent development from reaching the density levels that would occur in an unrestricted market, land values react differently at different levels of existing demand, but housing prices rise throughout the city. This concept is illustrated in Figure 2 below.

Figure 2: The Alonso-Muth-Mills model – effects of density restrictions in the urban core



Source: The AMM model is developed in Alonso (1964), Muth (1969), and Mills (1967). This figure is adapted by the authors.

Up-zoning relaxes restrictions on density. Accordingly, we expect the MDRS to allow the urban landscape to move closer to the unconstrained spatial equilibrium that the AMM model would predict, reversing the arrow directions in both diagrams in Figure 2. The top diagram of the figure shows that land values react differently to zoning restrictions depending on the strength of demand at each location and at constrained locations nearby. The bottom diagram of Figure 2 shows that house-price effects of zoning restrictions move in the same direction at all distances from the centre regardless of what happens to land values at each distance. Our model design is informed by this theoretical framework, as we describe further below.

2.2.2 Model Approach

To estimate the effects of MDRS on housing supply, we use a parcel-level[7] spatial econometric model to simulate how a change in zoning rules would affect the number of dwellings added over time based on observations of what happened in Auckland following the enactment of the AUP.

We use the historical data from the AUP as a natural experiment, to fit our model for forecasting the effect of an up-zoning on the number of dwellings added.

There are three steps to the model:

Step 1: Simulate the land-value shock that accompanies a relaxation of zoning constraints

Since the AUP and MDRS policies relax zoning restrictions, this increases the potential revenue of a parcel of land (if demand is sufficient) because more floor area can be added. This in turn increases the land value, which captures the present value of greater potential future cash flows.

We simulate this change in land value for each parcel caused by the change in zone. This phenomenon is described in the literature as the "up-zoning premium" (see Greenaway-McGrevy 2020 for a recent estimate of this premium based on post-AUP property sales).

We can quantify the actual land-value shocks following the AUP using a difference-in-difference estimate for Auckland (see Appendix C.2 for a description of this method). This is a robust method for estimating the effects of a treatment, such as up-zoning, on a subset of a population, such as residential parcels. The method requires data measured from both a control and a treatment group at different times, which we have for Auckland before and after the AUP.

For other cities, we have no natural experiment in the recent past, so we estimate the land-value shock using a regression discontinuity approach. This method uses the observed differences in land value across zones for otherwise similar properties to estimate the effect of zoning on land value.

We use these simulated land-value shocks as inputs into steps 2 and 3 of our model, informing both the probability of development for an observed parcel and the amount of added floor area for parcels that do develop.

Step 2: Find the probability that a parcel added at least one dwelling, based on each parcel's post-shock land value, zone status, and existing level of development

The purpose of step two is to simulate a set of locations where added dwellings might be built under each forecast scenario, whether with or without the MDRS. This allows us to examine how differences in model assumptions influence the spatial distribution of development.

In any medium-term period, only a small fraction of homeowners will consider further developments on their property at all, regardless of the development viability their property may have. Many factors contributing to a homeowner's decision to redevelop will not be affected by zoning rules, but others will. The major factors affected by zoning rules are:

- The permissible dimensions of development, which affect the potential revenue or benefits of redevelopment, as described in Step 1.

[7] By 'parcel-level', we mean that individual rateable units of property are aggregated to the level of LINZ primary parcels. For cases where multiple parcels are associated with the same set of rateable units, we cluster the parcels and treat the resulting cluster as a single large observation. Single-parcel observations make up most of the sample for all urban areas in the study.

- The costs in money, time, and effort to obtain legal clearance to develop. Both the AUP and the MDRS involve an element of intended reduction in this cost factor.

Other factors contributing to the homeowner's decision but not influenced by zoning rules include:

- The opportunity costs of any demolition of existing buildings required for redevelopment.
- The level of market demand for dwellings at or near a parcel's location.

There are many other potential factors, but our data is limited, so our model only accounts for those listed above.

We use our observations of how land values, opportunity costs, zoning, and distance from the city centre were statistically associated with whether a parcel added at least one dwelling (thus excluding floor area expansions that added to an existing house) during the 2016 to 2021 period to arrive at an implied probability of development for each of the 218,000-plus parcels in our study area, based on updated data for those characteristics. This updated data includes the most recent available (as opposed to pre-AUP) data points for each parcel as well as any adjustments, such as for land-value shocks. We use these estimated probabilities in two ways:

- We sum them to arrive at our estimate for the total number of development events across the study area.
- We choose our hypothetical development locations using a random weighted probability, where the weights are the estimated probabilities. These hypothetical development locations are chosen without replacement[8].

Step 3: Find the increase in the floor-area ratio if at least one dwelling was added

The amount of floor-area ratio (FAR) increase is determined by the cost-benefit considerations of the developer or homeowner. A homeowner/developer will consider the opportunity costs, the construction and consultation costs, and intangible costs such as the nuisance of construction or the stress of managing the process, as well as the potential revenue increase from adding more floor area. The higher the potential revenue, the more floor area will be added, all else equal. The higher the opportunity costs of development, the less floor area will be added, all else equal.

For each development event simulated in Step 1, we can quantify the statistical relationship between the actual FAR increase observed since the AUP and the pre-AUP levels of demand, zoning restrictions, simulated land-value changes, and opportunity cost of development for each parcel.

We can then use these quantified, or 'fitted' relationships to forecast the likely increase in FAR for each parcel, after updating what we know about changes in demand, opportunity cost, and zone since the pre-AUP date used for fitting. We calculate the number of dwellings added based on this estimate of FAR increase, the land area of each parcel, and the updated regulatory limits of each zone.

To find the number of dwellings added that can be attributed to the MDRS, we forecast and compare the number of dwellings added in both a with-policy (applying less restrictive zone assumptions and simulating a land-value shock), and a without-policy counterfactual case (keeping zones as they are and using actual current land values).

[8] When a parcel is selected, we do not replace it back into the set of all parcels before selecting another parcel. This ensures that we do not select a parcel twice.

2.2.3 Application to other Tier 1 Urban Areas

The next part of the analysis applies this model to other Tier 1 urban areas: Hamilton, Tauranga, Wellington, and Christchurch. Both demand and constraint conditions differ in each city, and Auckland is an outlier particularly in terms of demand. To apply our fitted model to non-Auckland cities, we need to adjust each of the three model steps:

- For Step 1, the land value shock from up-zoning, we use regression estimates on data from each city to measure the difference by zone in the relationship between land value and distance from the city centre. This is a proxy for the level of constraint in land values from zone restrictions. Using the theoretical framework of the AMM model, these regression results also inform our assumptions below about how the level of constraint influences the estimated increase in FAR from relaxing zone restrictions.
- For Step 2, the estimate of likelihood to add at least one dwelling, we use the AUP-based relationships between development demand, opportunity cost, and zone constraints to predict likelihood to develop based on property-level equivalence across cities[9].
- For Step 3, the estimate of added dwellings given that a property adds at least one, we adjust the expected change from up-zoning (for example, from Wellington's Outer Residential zone to the new MDRS) to the difference in predicted FAR increase between two relevant zones from the Auckland case (the 'zone gap'). We choose the zone gap in Auckland (taken from available combinations of the four measured AUP zones) that showed the most similar degree of relaxation in constraints to what we expect in that city. These expectations are informed by consideration of the differences in allowable development between existing zones and the MDRS in each city, which AUP zones they align most closely to in terms of defined building constraints, and the observed land value discontinuities between zones in each city as described above. Full zone alignment tables are provided in Appendix B.

2.2.4 Data

The available data for our model necessitates the use of proxies for the following driving factors:

- As a combined proxy for the level of demand adjusted for opportunity cost of development at the individual parcel level, we use the Quality of Capacity metric ("quality score") developed for HUD as part of the Wider Costs and Benefits of Urban Growth Methodology (PwC 2020). The quality score is described further in the following subsection.
- The development limits under the MDRS have no exact equivalent in the residential zones of any Tier 1 urban area's operative district plans, and zones in non-Auckland cities do not perfectly correspond to AUP zones. To complete our forecast, we must associate our observed zone effects with the modelled zone changes by matching each zone and simulated zone change with its closest available proxy in the data. Details of these associations are provided in Appendix B.

The quality score

The quality score is a useful metric to efficiently proxy demand-side development potential at the parcel level. It is a combination of two proxies—one for demand relative to other areas of each city, the other for opportunity cost of development. The first component uses land value per square metre (m^2) to proxy the level of demand for built floor area in that location.

The second component captures the opportunity costs of development. When landowners or developers consider whether to build more floor area on a specific property, one of the key factors is

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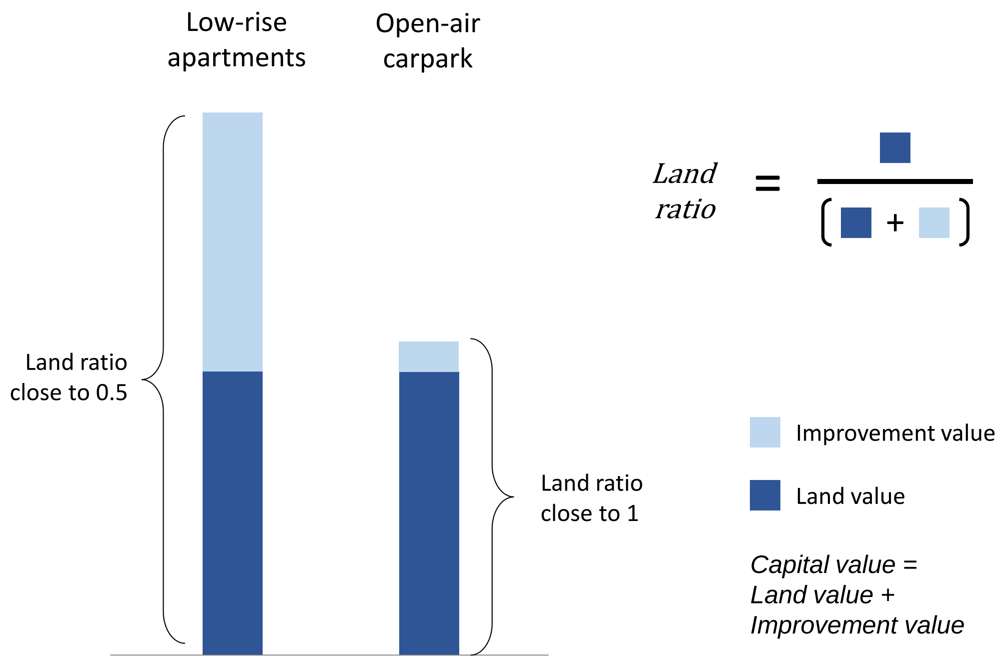
[9] We also adjust the assumed base level of likelihood in each city to align the number of forecast development events in the without-policy case to each city's observed level of development over the same historical period covered by the AUP data.

the opportunity cost of giving up the value of whatever is already built on the required land. Two properties with the same land value in the same neighbourhood will still have different levels of development appeal if the existing improvements are different.

Figure 3 compares two such hypothetical properties. We expect that adding dwellings is more likely for the open-air carpark than for the low-rise apartments due to the high opportunity cost of tearing down an apartment building and foregoing the revenue it could earn without adding dwellings.

Our data separates land value from improvement value at the parcel level. This allows us to incorporate the opportunity cost of redevelopment into our regression analysis using the land ratio (the land value of a property divided by the total capital value of the property). This is written as LV/CV and illustrated in Figure 3. Typically, the higher the land ratio, the greater the potential for development.

Figure 3: The role of the land ratio



Source: Authors' illustration.

A high land ratio represents a lower cost of development as the improvement value is relatively low compared to the land value. Thus, the higher the land ratio, the higher the quality score. The same applies for the land value per m^2 component.

The two components of the quality score are combined as a geometric average, by raising both to a power between 0 and 1 before multiplying them together. This has the effect of favouring balanced combinations of the two components over extreme values in one or the other. Both component values are numbers between 0 and 1, as is the final score. The full equation is as follows:

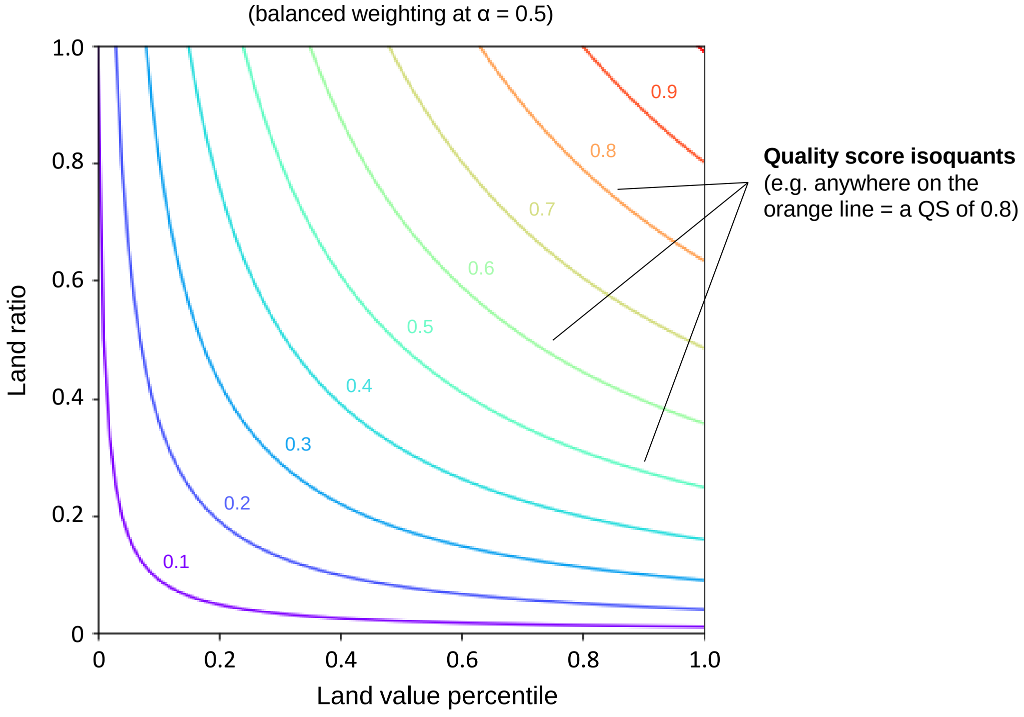
$$Quality\ Score = (LV/CV)^{\alpha} LVrank^{\beta}$$

Where:

- CV is the capital value or likely price a parcel or property would sell for at the time of valuation

- *LV* is the likely price a parcel's land would sell for at the time of valuation without any buildings or improvements
- *LVrank* is the percentile rank of a parcel's land value per m² among all parcels in the urban area
- α and β are weightings between 0 and 1 (that sum to 1) for the geometric weighted average. These are used to emphasise the effects of one component or the other according to the analytical question at hand. In this analysis, both are set to 0.5, so equal weight is given to each component.

Figure 4: Quality score by component inputs



Source: PwC 2021.

Advantages of the quality score include:

- It accounts for both site-specific opportunity cost and location potential relative to other sites.
- It does these two things in a way that is easily calculated, applicable in any city, and uses a dataset that is readily available historically and at a granular level to councils and ministries.
- It does not rely on actual sales, but on ratings valuation estimates, so it is available for all rateable units in a city.
- Its components, such as land value, can be modified to reflect expected shocks arising from policy changes based on a well-developed body of empirical analysis. In other words, we can observe today's actual quality scores, but also simulate what they would be if land values changed.

- The land value component is an effective general proxy for a broad range of factors contributing to desirability from a development perspective, including access to opportunity and proximity to amenities.

Disadvantages of the quality score include:

- It does not capture much about the willingness of a landowner to participate in the market for development.
- It relies on a dataset that is difficult for the public to access in bulk (data for individual properties is publicly available), making replication difficult for non-government researchers.

Zones

There are four primary residential zones under the AUP that will also be subject to the MDRS. These are:

- Single House Zone (SHZ): Allows for a single primary dwelling or conversion of existing (2013 or older) dwellings into a maximum of two dwellings. Maximum building site coverage is 35%, maximum height is 8 metres.
- Mixed Housing Suburban Zone (MHS): Allows for up to three dwellings and two storeys. Maximum building coverage is 40%, maximum height is 8 metres.
- Mixed Housing Urban Zone (MHU): Allows for up to three dwellings and three storeys. Maximum building coverage is 45%, maximum height is 11 metres.
- Terrace Housing and Apartment Zone (THAB): Enables apartment buildings of up to 5-7 storeys depending on proximity to centres. No explicit limit on dwellings. Maximum building coverage is 50%, maximum height is 16 metres.

A map of these zones is shown in Figure 1 above.

The SHZ provides a control group for our observations of the effect of up-zoning under the AUP, since these areas did not experience a significant change of zoning rules under that policy. The other three zones provide different levels of 'treatment' with which we can align our future zone change to say, "if the MDRS in City X has a similar effect to Zone Y under the AUP, the impact is likely to be Z given a similar time-frame…". That we have three different levels of constraint release (ie the three up-zoned zones in the AUP) allows us to adjust for differing levels of baseline constraint in different cities.

The zone with rules most like the MDRS in terms of allowable floor area is the MHU. Both the MHU and MDRS allow 3 dwellings and 3 storeys, but the MDRS allows slightly more site coverage, more permissive height in relation to boundary (HIRB), and easier consenting.

As such, while we use the MHU as our proxy for the MDRS in our Auckland forecast, we believe these differences in zoning rules will bias results toward a conservative estimate. Full descriptions of alignment of zones for the other Tier 1 urban areas and their constituent TAs are provided in Appendix B.

Box B: Key model features, assumptions, and limitations

The unit of analysis for this study is the individual land parcel, allowing the model to take advantage of a rich dataset covering the full set of residential parcels in all five Tier 1 urban areas. The key purpose of the analysis is to understand the effects of zoning rules on development, especially following a change in those rules. Our model incorporates, at the parcel level:

- differences in demand for new dwellings both between cities and within each city, and how these vary by zone
- the opportunity cost of redeveloping existing improvements
- the effect of special character protections
- the maximum permissible building dimensions and floor area for each plot.

Our design prioritises the closest possible simulation of future policy effects rather than a fine-tuned depiction of causal relationships in the post-AUP data.

The interaction between zone and demand characteristics as summarised in a custom metric called the *quality score* is the common thread to a three-step forecast method for additional dwellings. This model incorporates the willingness (in terms of probability) of property owners to enter the market as developers and add a least one dwelling to supply following a relaxation of zoning constraints.

We assume that the average rate of participation in the development market among homeowners, including participation by selling to developers (holding our model variables constant), is similar over time and between cities. In other words, most homeowners will not build more dwellings on their property regardless of the potential revenue, but some will no matter what, and others will only if the economics improve.

The variables that we can model are limited to the data available at the land parcel level, and much of the variation in development is not explained by these variables. This means our modelled scenarios for the distribution of development locations across an urban area will have a wide margin of error.

For our base-case estimates, we assume the MDRS works as intended, unlocking development where demand is highest, and the opportunity cost is lowest. Our model explicitly nullifies the observed statistical effect of special character zones, which historically reduce the likelihood of development. This is because empirical results from the AUP data show that special character areas are much less likely to see development holding quality scores constant and this effect is stronger the higher the quality score. Section 4.8 discusses the treatment of other qualifying matters.

In our forecast, development likelihood is driven instead by the economic quality of the property as a development opportunity given the expected changes to zoning limits. In Auckland's case, most of the properties under special character protections sit within the NPS-UD walkable catchments, so are excluded from the forecasts of MDRS impact.

Areas required to be zoned for a minimum of 6-storeys under the NPS-UD are not included in the analysis, as the primary impact in those areas over the study period is expected to be driven by that policy. While the MDRS does apply to these areas, it is outside the scope of the present analysis to differentiate the effects of the MDRS in these areas from those of the NPS-UD (which have been estimated elsewhere).

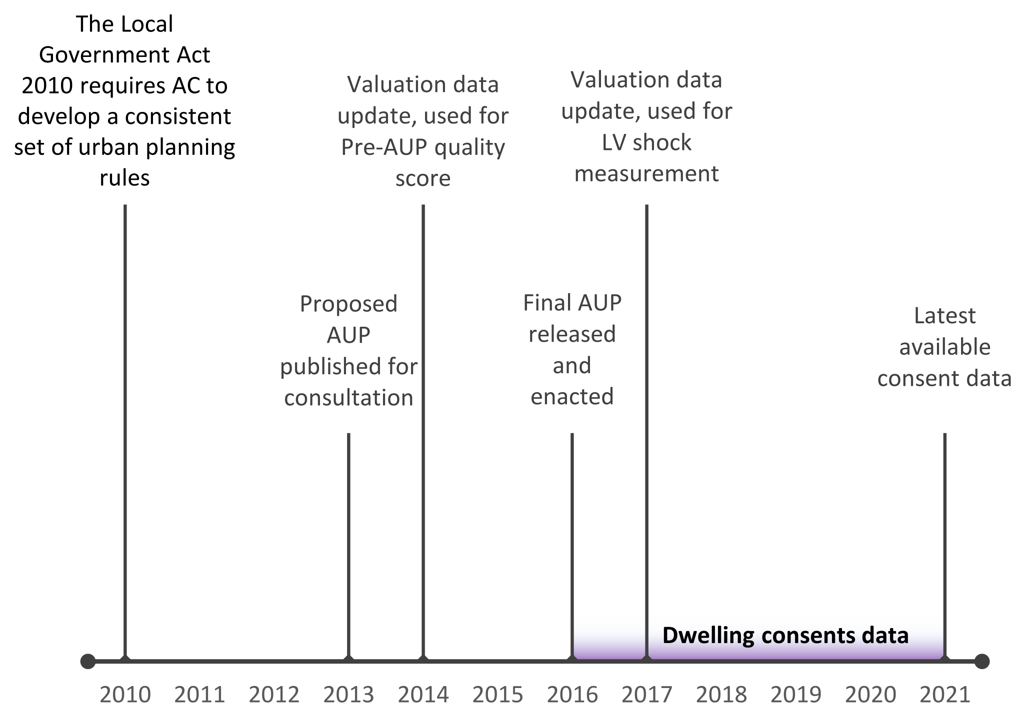
2.2.5 Model specifications

2.2.5.1 Step 1: Estimate the land value shock from a change in zoning constraints

To simulate the land value shock resulting from the MDRS policy, we first measure the actual shock that took place following the AUP, then apply the observed difference between zones according to the planned zone change under the new policy.

In Auckland, our data allows a robust estimate of the effects of up-zoning on land values. We fit Step 1 of our forecast model using a simple regression estimate that tests the relationship between zone interacted with distance from Britomart as predictor variables, and the percentage change in land value observed from 2014 (the most recent valuation update before the release and enactment of the final AUP) and 2017 (the first valuation update following full enactment of the final AUP) as the response variable. The timing of these valuation updates with the AUP policy development and enactment is summarised in Figure 5 below.

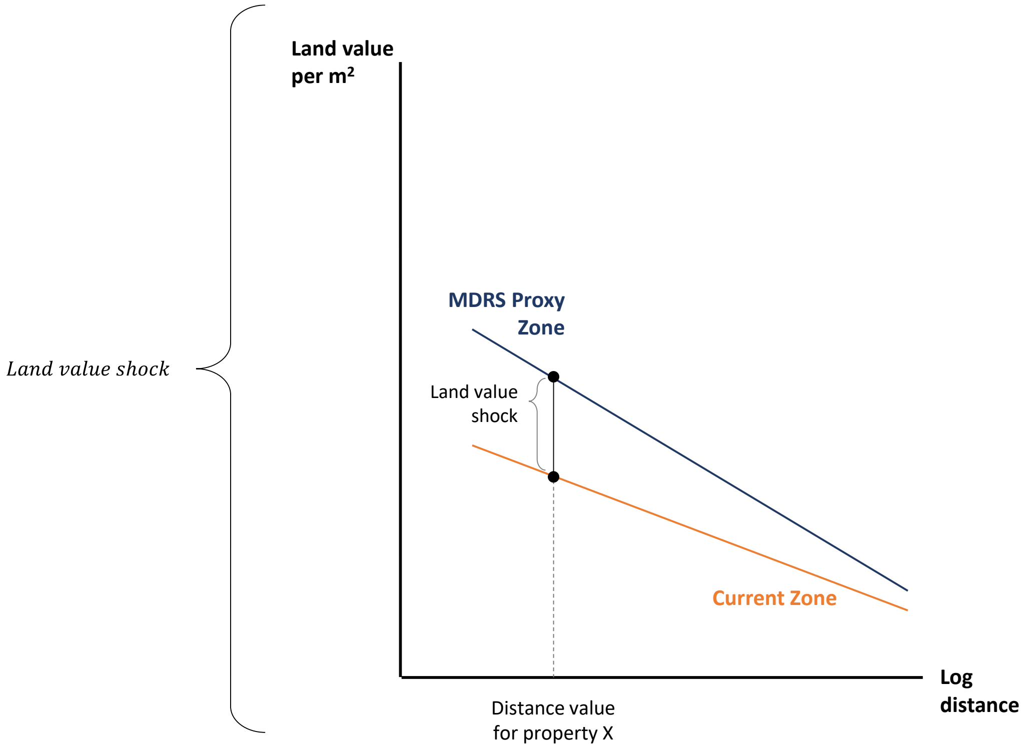
Figure 5: Timeline of the AUP and relevant data sources



Source: Greenaway-McGrevy et al 2020; Auckland Council, HUD data.

In Figure 6 below, the estimated land-value shock for a single property is the difference in the y-axis value (given that particular property's distance from the city centre) between the predicted land value for the property's current zone and the predicted land value for the MDRS proxy zone (eg MHU).

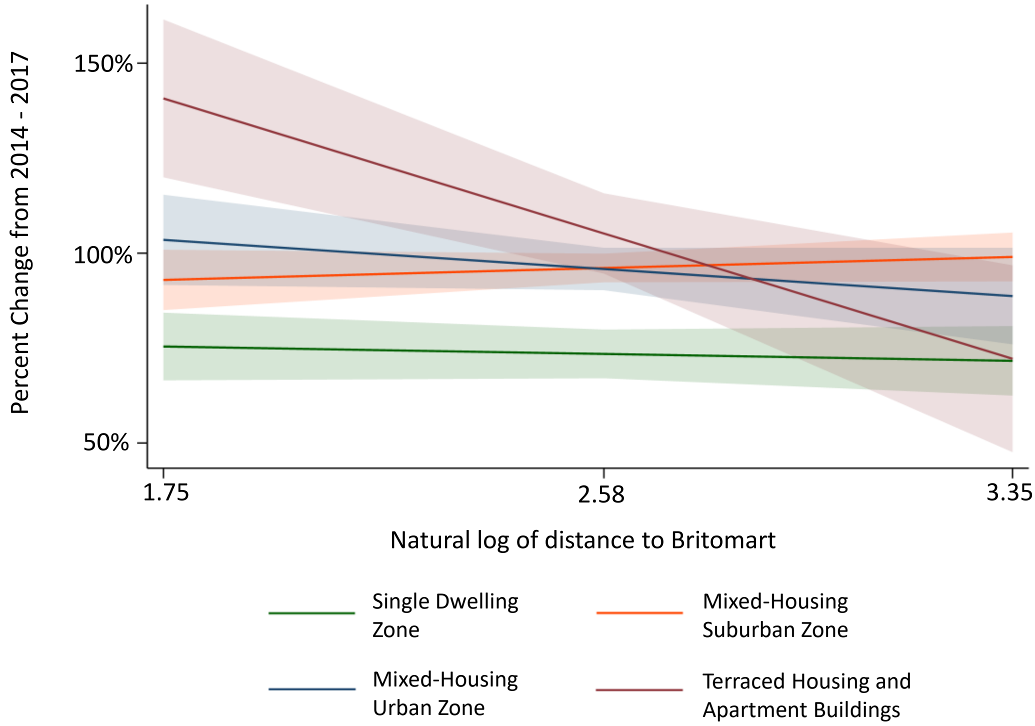
Figure 6: Land value shock simulation for model Step 1



Source: Authors' illustration.

Results for Auckland land-value shocks post-AUP are shown in Figure 7 below. The SHZ shows nearly no variation in relative LV appreciation according to distance from Britomart. In other words, single-house plots across the city increased in nominal value by about 75 percent on average, whether they were in Pukekohe, Herne Bay, or anywhere else.

Figure 7: Change in land value following AUP enactment



Source: HUD data, authors' analysis.
Note: Shaded bands represent 95% confidence intervals. Regression includes control for land ratio. Margins plotted here hold land ratio constant at the mean.

In the MHS, the increase was slightly less the closer a parcel was to Britomart, but not statistically different from a slope of zero (a flat line), like the SHZ. However, the MHS effect independent of interaction with distance (the intercept) was significantly different from both SHZ and zero. This means that parcels in the MHS zone reliably increased in value by more than parcels in the SHZ zone did, but that the difference between the two was not significantly affected by distance from the city centre.

In the MHU, the increase in land value was greater than the SHZ, and the increase was greater the closer a parcel was to Britomart. In the THAB, distance to Britomart had by far the largest effect on the land value increase, moving from about the same as the SHZ on the outskirts to nearly double the increase nearer to the centre.

We use the difference between the way land parcel values reacted to the AUP in different zones at different distances to simulate the way land parcel values will react to the MDRS in the future. To do this for Auckland, we use the marginal change from each parcel's current zone to the level of change expected at the new zone at that parcel's distance from the city centre. Forecast results are presented in Section 4.

2.2.5.2 Step 2: Estimate the likelihood of adding at least one dwelling

Using data up to 2021, we estimate the probability of properties in our control and treatment zones to have at least added one dwelling since the AUP enactment. We use the quality score (interacted with zone status) of each property as our primary predictor, and control for the pre-NPS-UD special character status and distance to Britomart of each property.

We then use these estimates (coefficients) to project the probability of adding at least one dwelling in the medium term. The fitted model is applied to an updated dataset, using quality scores updated to include land value shocks from step 1, zone coefficients using the MHU as a proxy for the MDRS (so up-zoned parcels apply the MHU coefficient), and neutralising the effect of special character status. Model equations are shown below.

Estimation using historical data (post AUP): logit with continuous-categorical interaction

$$AddedDwelling_i = \beta_0 + \beta_1 QS_{pre_i} + \beta_2 Zone_i + \beta_3 QS_{pre_i} * Zone_i + \beta_4 \ln(Distance_i)$$

$$+\beta_5 SpecialCharacter_i + \varepsilon_i$$

Forecast for post-MDRS

Without MDRS

$$P(AddDwelling) = \hat{\beta}_0 + \hat{\beta}_1 QS_{post_i} + \hat{\beta}_2 Zone_i + \hat{\beta}_3 QS_{post_i} * Zone_i + \hat{\beta}_4 \ln(AdjustedDistance_i)$$

$$+ \hat{\beta}_5 NewSpecialCharacter_i$$

With MDRS

$$P(AddDwelling) = \hat{\beta}_0 + \hat{\beta}_1 QS_{shocked_i} + \hat{\beta}_2 NewZone_i + \hat{\beta}_3 QS_{shocked_i} * NewZone_i + \hat{\beta}_4 \ln(AdjustedDistance_i) + \hat{\beta}_5 NewSpecialCharacter_i$$

Where:

$AddedDwelling_i$	is a dummy indicating whether a property added at least one dwelling from 2016 to 2021.
$P(AddDwelling)$	is the predicted probability[10] that a property adds at least one dwelling in the medium term.
β_{0-5}	are the coefficients to be estimated using historical post-AUP data.
$\hat{\beta}_{0-5}$	are the fitted coefficients from the estimation using historical data.
QS_{pre_i}	is the pre-AUP quality score calculated using 2014 land values and land ratios for each parcel.
QS_{post_i}	is the latest available quality score for each parcel (ranges from 2017 to 2021, depending on valuation updates).
$QS_{shocked_i}$	is QS_{post_i} adjusted for land value shocks from Step 1.
$Zone_i$	is the AUP zone for each parcel.
$NewZone_i$	is the zone category for the 'treatment' zone, ie the zone chosen as a proxy for the MDRS. The fitted coefficient for the proxy zone replaces the original zone coefficient in this equation.

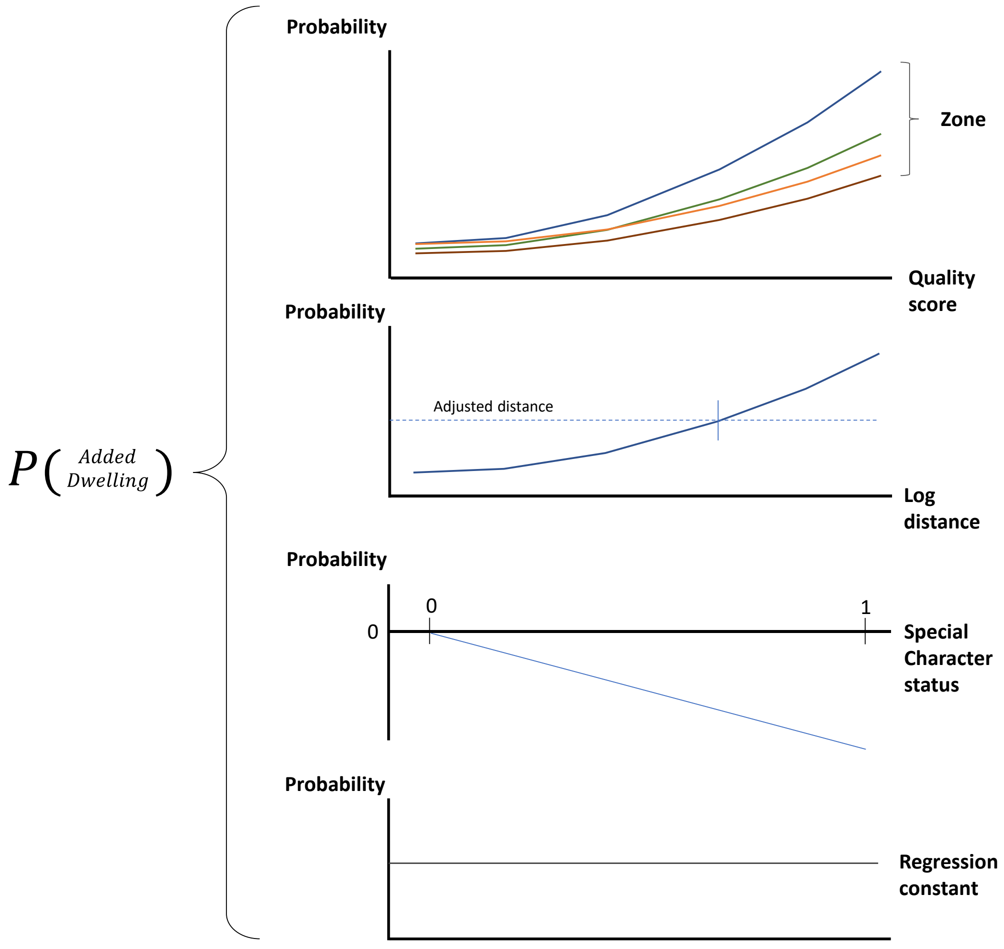
[10] Our forecast equations here use notation for probability for ease of interpretation. Estimated logit coefficients predict odds ratios, not probability, and must be converted to probabilities, resulting in the non-linear relationship between dependent and independent variables observed in Figures 12 and 13.

$\ln(Distance_i)$	is the natural log of distance in kilometres from a selected point in the city centre.
$\ln(AdjustedDistance_i)$	is a scalar replacing the distance covariant for all observations. This collapses the distance effect to a constant.
$SpecialCharacter_i$	is a dummy for whether a property is located in a special character overlay area.
$NewSpecialCharacter_i$	is set to zero for base case estimates both with and without the policy, as the special character effect is assumed to have been nullified by the NPS-UD. We test variations to this in our sensitivity analysis.
ε_i	is the error term.

Step 2 visual summary

Figure 8 illustrates how the parts of the forecast equations above are combined to arrive at a final probability estimate for each parcel. The coefficients determine the slope and direction of each line, and the final probability of adding at least one dwelling is the sum of the y-axis value from each set of axes in the figure.

Figure 8: Probability of adding at least one dwelling, by model component

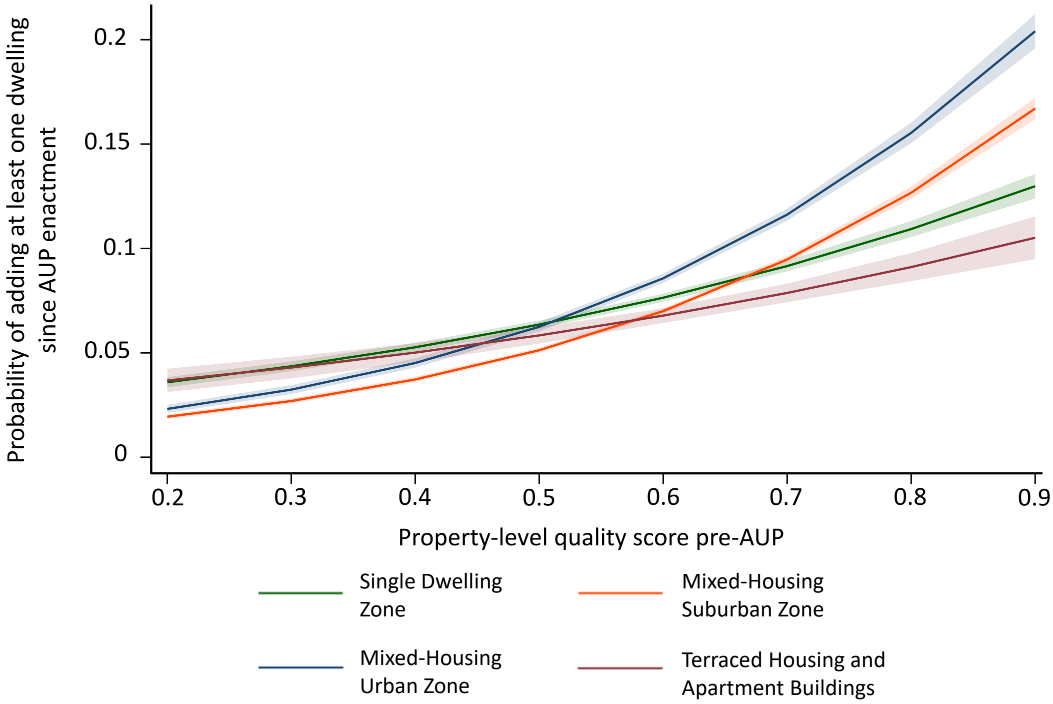


Source: Authors' illustration.

Fitted model results

Figure 9 summarises the coefficient results from the first regression as a logit margin plot. It shows the probability of adding at least one dwelling post-AUP at different pre-AUP quality scores for each zone, with special character status at zero and distance from Britomart at the median. Full regression outputs are provided in Appendix C.

Figure 9: Probability of development as predicted by quality score and zone



Source: Auckland Council and HUD data, authors' analysis.

These results show that as quality score increases, there is an increase in the probability of adding at least one dwelling for every zone as would be expected. For zones that are less constraining for the intensity of development, the relationship between quality score and probability of development is more pronounced at higher quality scores (eg >0.6).

The results for MHS and MHU compared to SHZ are evidence that zoning restrictions continue to constrain Auckland's housing supply and exacerbate affordability issues. This is also evidence that wider up-zoning across Auckland is likely to lead to more residential development than would otherwise take place.

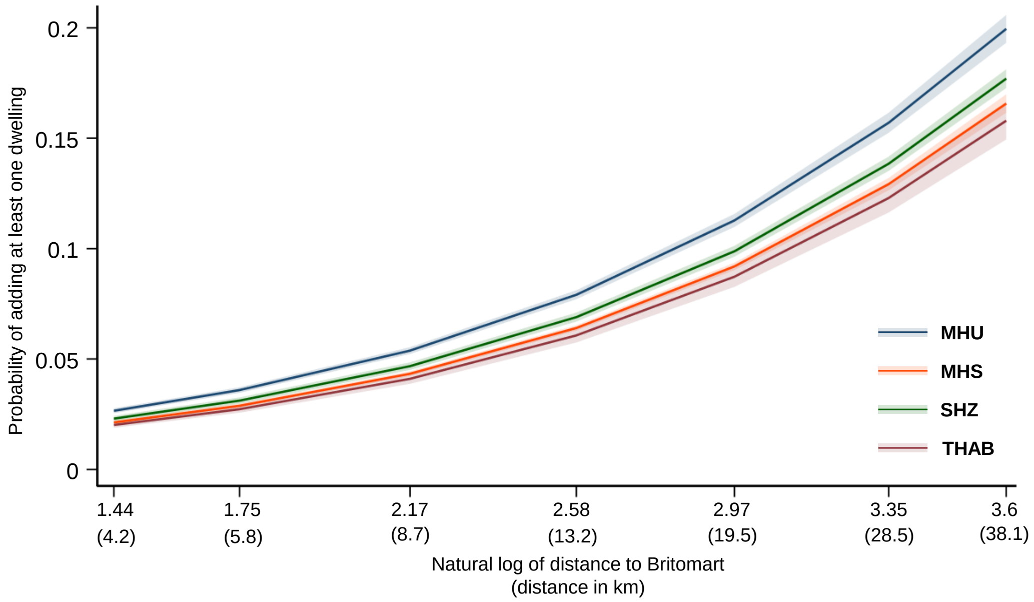
The exception is for the THAB, which shows a weaker likelihood response to higher quality scores than even the SHZ. This may be due to the higher risk and more complex preparation required for mid-rise and larger developments resulting in slower uptake. One THAB development also represents more dwellings on average than developments in the other zones, as our Step 3 analysis shows, so on the level of individual dwellings the development probability for THAB zones will be understated compared to the others.

The conclusion of Step 2 is to take the sum of calculated probabilities across all residential parcels in the policy-affected area. We do this for each tested scenario. This total becomes the estimate for that scenario of the total count of parcels that will add at least one dwelling in the medium term. We then rank all parcels from highest to lowest estimated probability and select the top n most likely parcels, where n is the sum of probabilities for the scenario.

Breaking the pattern of the AUP – adjustments to the distance effect

Our analysis reveals a counterintuitive insight about the pattern of development that took place following the AUP. Adding dwellings was statistically *more likely* the *further away* a parcel is from the city centre, after controlling for quality score, zone, and special character status. This does not align with the demand patterns predicted by the AMM model. Further analysis reveals that while the zones themselves are distributed widely across distances, areas where the zones increased the permissible development capacity beyond the existing improvements by enough to add at least one dwelling were much less common as we approach the centre. In other words, the zoning changes released constraints by much more on the outskirts of the city than in the high-demand areas. Figure 10 shows the fitted relationship between distance and probability of adding at least one dwelling for each zone at the median quality score.

Figure 10: Development likelihood by distance and zone at the median quality score



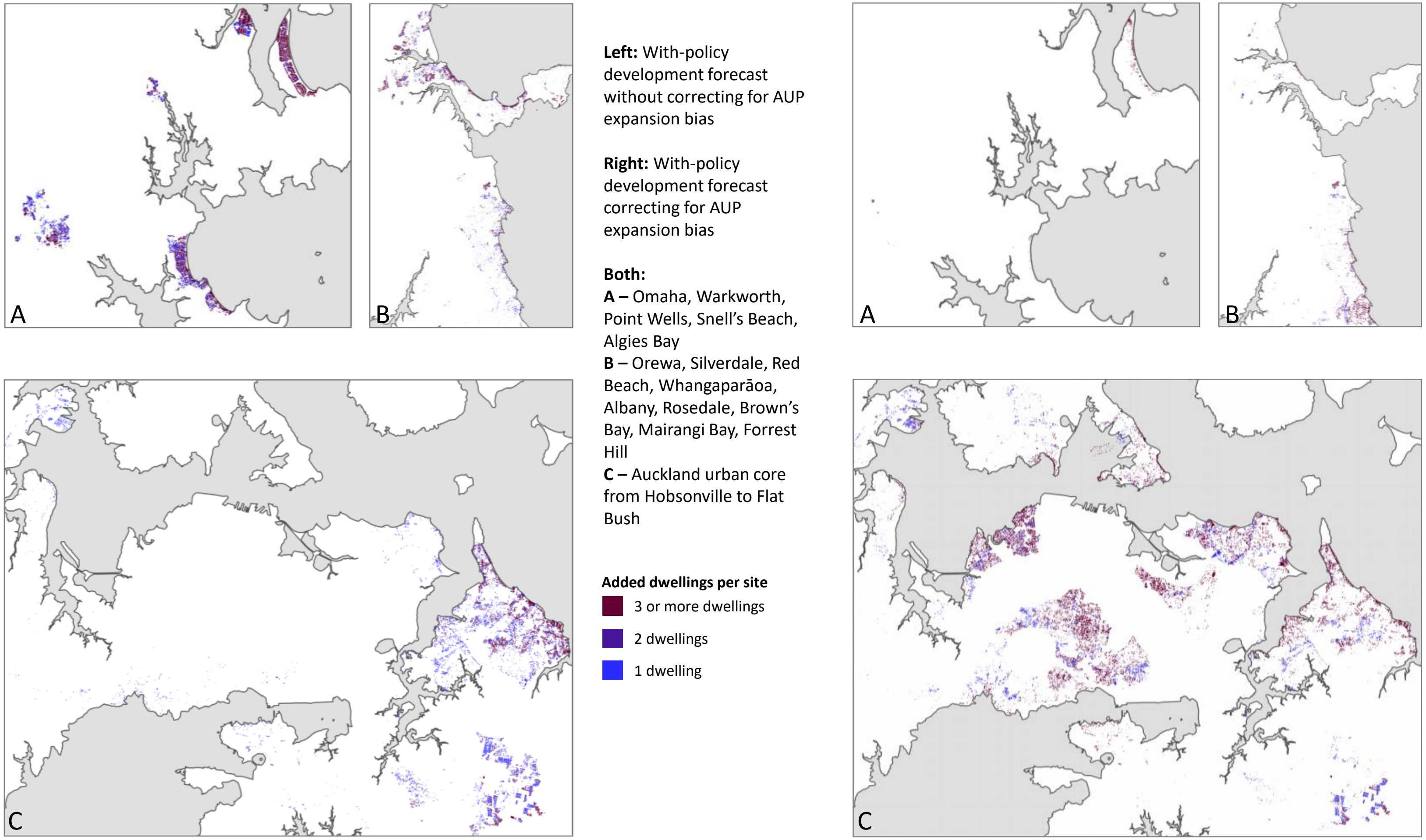
Source: Authors' analysis.

The presence of a recent natural experiment such as the AUP makes our approach one of the most analytically robust methods available for quantifying the actual results of relaxing zoning restrictions. However, the NPS-UD and the MDRS are intended to alter fundamental patterns about where and how much housing development takes place. Fitting any model to historical data will tend to replicate some of those historical patterns in our forecasts in ways that may not hold if the policy succeeds as intended.

The distance parameter in our model provides a way for us to neutralise this effect in our forecasts, to simulate how development might take place if the MDRS and NPS-UD are successful in unlocking development where demand is strongest.

The maps in Figure 11 on the following page show the difference in spatial development patterns generated by our model both with and without a correction for the bias toward city-fringe development observed in the AUP data. Note that the total policy impact in both cases is approximately equal, and that the NPS-UD walkable catchments are not included in the forecast.

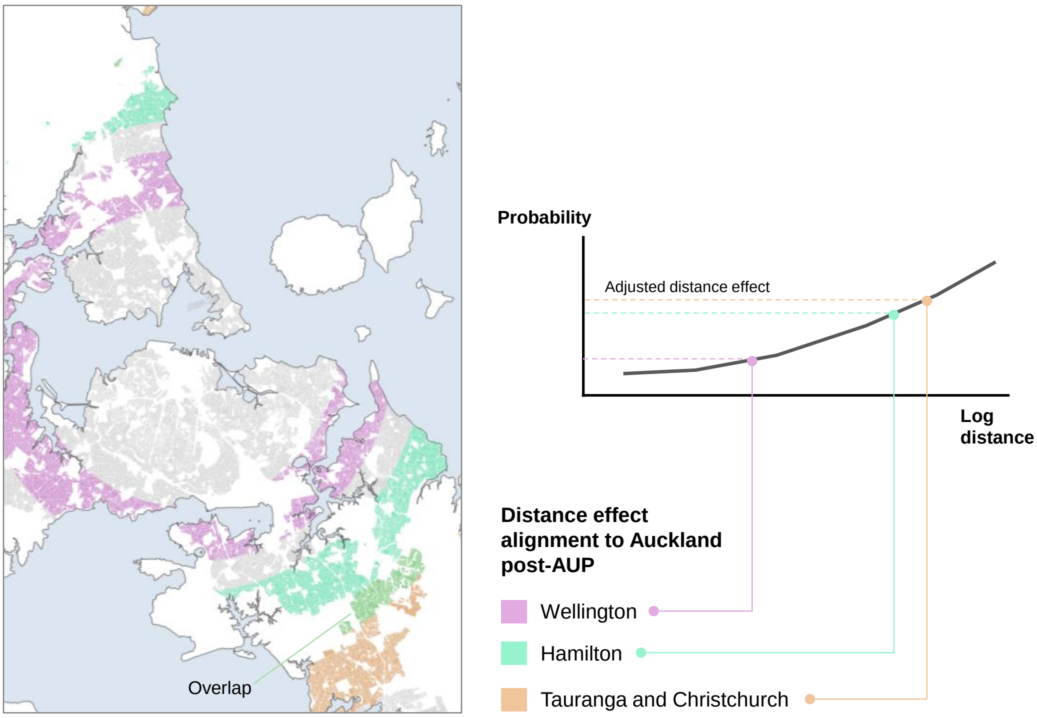
Figure 11: Modelled spatial distribution of highest likelihood development with and without correcting for the AUP urban fringe expansion bias



Source: Authors' analysis

This adjustment to the distance parameter for modelled parcels is also useful when we come to applying the fitted model to non-Auckland urban areas, where the coefficient for distance from Britomart in Auckland has little relevance. We use the distance parameter instead to adjust the base-level modelled constant to align the without-policy forecast with historical consent trends in each city (Figure 12).

Figure 12: Aligning without-policy forecasts to historical consents for non-Auckland cities



Source: Authors' analysis.

Figure 12 above shows the results of this alignment as well as the range of distance tested in our sensitivity tests for each city. As we discuss further in the sensitivity analysis, Wellington's unusually low levels of consents cause it to align at a much lower distance parameter than the other cities.

2.2.5.3 Step 3: Estimate the expected increase in FAR conditional on adding at least one dwelling on historical data

For each parcel that passes the probability threshold for adding at least one dwelling, we estimate the expected FAR increase in the five-to-eight years following enactment of the MDRS. We then derive dwelling counts from this expected FAR increase based on the average 2019 dwelling size in each zone and TA, subject to the regulatory limits on building dimensions and total dwellings for each parcel's simulated zone. Model equations for FAR estimates are shown below.

2.2.5.4 Estimation using historical data (post-AUP)

$$(FAR\ increase|AddedDwelling) = \beta_0 + \beta_1 QS_{pre_i} + \beta_2 Zone_i + \beta_3 QS_{pre_i} * Zone_i + \beta_4 LandArea_i + \varepsilon_i$$

Forecast for post-MDRS
Without MDRS

$$(\text{Est.}\ FAR\ increase|AddDwelling) = \hat{\beta}_0 + \hat{\beta}_1 QS_{post_i} + \hat{\beta}_2 Zone_i + \hat{\beta}_3 QS_{post_i} * Zone_i + \hat{\beta}_4 LandArea_i$$

With MDRS

$$(Est.FAR\ increase|AddedDwelling) = \hat{\beta}_0 + \hat{\beta}_1 QS_{post_i} + \hat{\beta}_2 NewZone_i + \hat{\beta}_3 QS_{post_i} * NewZone_i + \hat{\beta}_4 LandArea_i$$

Where:

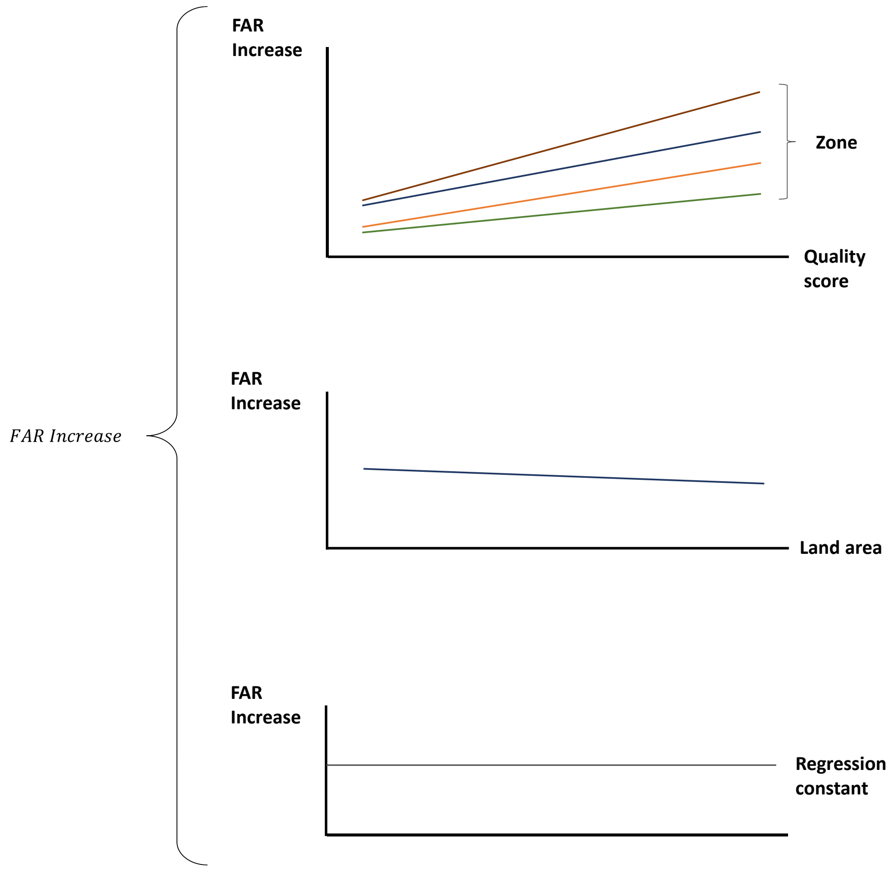
$(FAR\ increase\|AddedDwelling)$	is the observed floor area ratio added in the post-AUP data for each parcel, conditional on that parcel having added at least one dwelling.
$(Est.FAR\ increase\|AddedDwelling)$	is the expected floor area ratio added for each parcel, conditional on that parcel adding at least one dwelling.
$LandArea_i$	is the land area in metres squared for each parcel.

**All other variables are as defined in Step 2 above.*

Step 3 visual summary

Figure 13 illustrates how the parts of the forecast equations above are combined to arrive at a final FAR increase estimate for each parcel. The coefficients determine the slope and direction of each line, and the final estimated increase in FAR is the sum of the y-axis value from each set of axes in the figure.

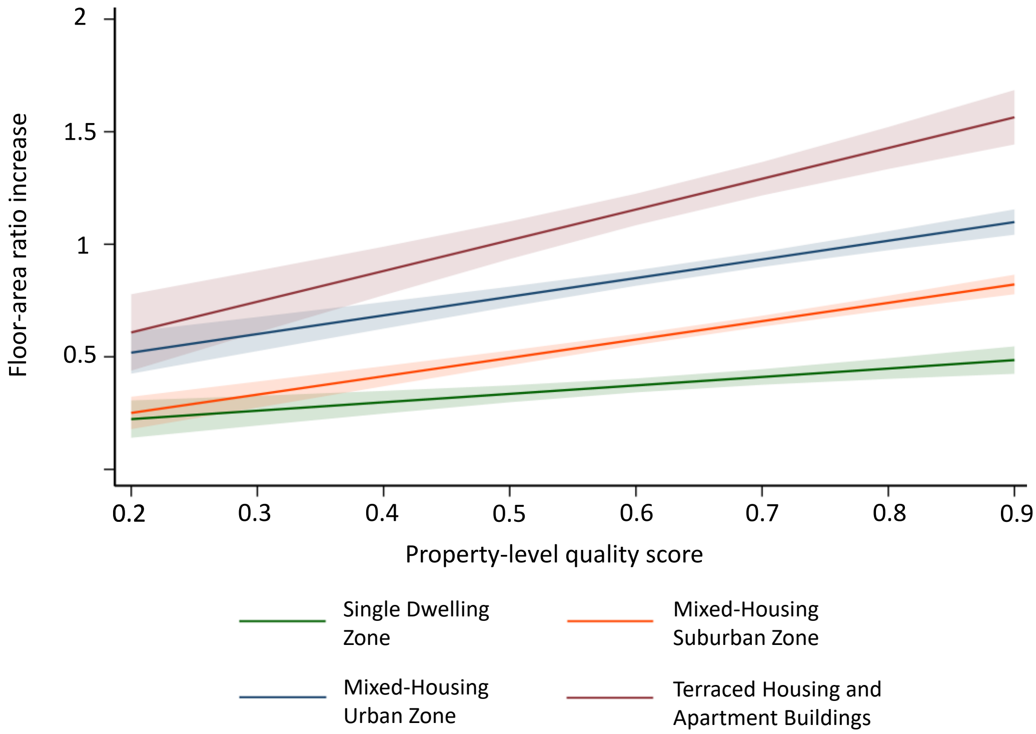
Figure 13: Estimate FAR increase



Source: Authors' illustration.

Figure 14 below summarises results from the first (historical estimation) regression. It shows that the increase in FAR becomes greater as quality score increases, regardless of zone, and that this relationship becomes stronger the more permissive the new zone is. The subset of data used here is those that added at least one dwelling, but we do not have data on whether any floor area was demolished in the process. For our model forecasts, we make the conservative assumption that one average-sized dwelling's worth of floor area is removed for each up-zoned parcel that adds at least one dwelling.

Figure 14: FAR increase per development event



Source: Auckland Council and HUD data. Authors' analysis.

In the figure, a FAR increase of 0.5 on the y-axis for a property with a building coverage of 50% implies an increase of one storey. We use this relationship along with a control for land parcel area to predict the increase in FAR for each parcel that adds at least one dwelling in each simulated scenario.

2.2.5.5 Applying the model in non-Auckland cities

Different cities have different levels of demand and different constraints. As described above, we make adjustments in each of the three model steps to adjust our forecasts to the local conditions of each city.

For the land-value shock from up-zoning, we can get an estimate of the impact of zoning on a parcel's land value by comparing parcels that are similar in most relevant respects (such as general demand in the area), but different in their zone status. As we only have a natural experiment for up-zoning in Auckland, we use this alternative approach with local data from each non-Auckland city.

The results are not as robust as a difference-in-difference design using a natural experiment because we do not know what other factors contributing to land value may differ by zone in a non-random way. However, the estimates we observe are consistent with our expectations informed by the AMM model in all cities, and the resulting shocks to quality scores are small compared to the distribution of quality scores in each city.

3 A spatial forecast of the development impact of the MDRS

3.1 Overview

In the original CBA, we estimated probabilities in two ways:

- We sum them to arrive at our estimate for the total number of development events across the study area. The simple sum is equal to the total count of expected development sites.
- We rank properties by probability, then choose our hypothetical development locations from the most likely properties.

This process aggregates probabilities across all parcels and so our estimates are also aggregated for city-wide estimates. However, this approach does not tell us about the distribution of development sites in the city. For example, we can select a large number of equally probable outcomes that each allocate development differently between the sub-geographies of a city.

In other words, our original approach does not tell us anything about where these development sites might be located. We generalise the initial CBA by allowing for variation in which parcels will redevelop. We achieve this by randomly selecting parcels to redevelop based on their existing parcel-level probabilities. This allows us to see the distribution of redevelopment in the sub-geographies of a city. To account for variance in our estimates, we simulate thousands of specific probable outcomes.

We then provide an average expected development for each sub-geography. We do this at both the SA2 and TA levels.

3.2 Methodology

We estimate the total number of developments in the city by summing the existing parcel-level probability estimates. This gives us the total count of expected development sites. We shall denote the total number of development sites as n.

Then we randomly choose a parcel to redevelop. We choose which parcel to redevelop using a random weighted probability, where the weights are the existing parcel-level probabilities. This process is repeated n times without replacement[11]. The result is a set of n parcels that are assumed to redevelop.

For each of the selected parcels, we estimate the number of dwellings added using the initial CBA methodology described in Section 2.2.2. The result of this simulation is the number of dwellings added for each parcel, where the parcels were selected randomly based on the existing parcel-level probabilities.

[11] When a parcel is selected, we do not replace it back into the set of all parcels before selecting another parcel. This ensures that we do not select a parcel twice.

We repeat this simulation 1,000 times for each urban area. Finally, we report the mean, and median number of dwellings added, as well as the 25^{th} and 75^{th} percentiles at the SA2 and TA levels.

4 Results and discussion

4.1 Results relative to the original CBA

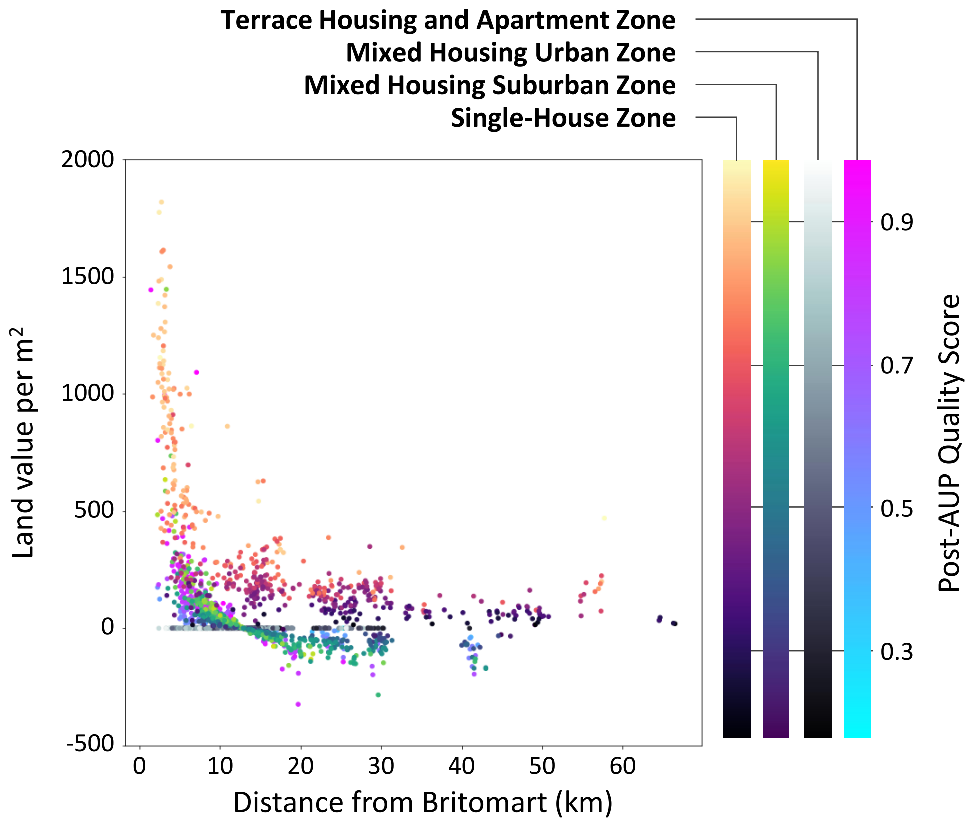
The forecasted total number of dwellings added for each TA or urban area, when summed from the SA2 level, may not be exactly the same as the aggregate forecasts in the original CBA. The TA-level totals represent the summed mean, median, and inter-quartile ranges of each constituent SA2. In an actual outcome, we would expect a variety of results – some SA2s will have more development than their probabilities imply, others will have less. Summing the mean or median estimate for each SA2 gives a different result than assessing the aggregate probability across the urban area as we did in the original CBA (although they fall within the same range of uncertainty). The results presented in this section are not intended to replace or as a revision to the original CBA estimates, which were determined using a different methodology designed for aggregate regional estimates. Rather, they represent our best estimate for the range of likely outcomes for each individual SA2.

4.2 Auckland

4.2.1 Step 1: Estimate the change in land value post-MDRS

Based on the land value shocks by zone following the AUP, and their relationship to distance from Britomart, we forecast a similar shock following the MDRS. The simulated changes in land value per m^2 post-MDRS in Auckland are shown in Figure 15 below.

Figure 15: Simulated post-MDRS land value shock in Auckland by zone and quality score



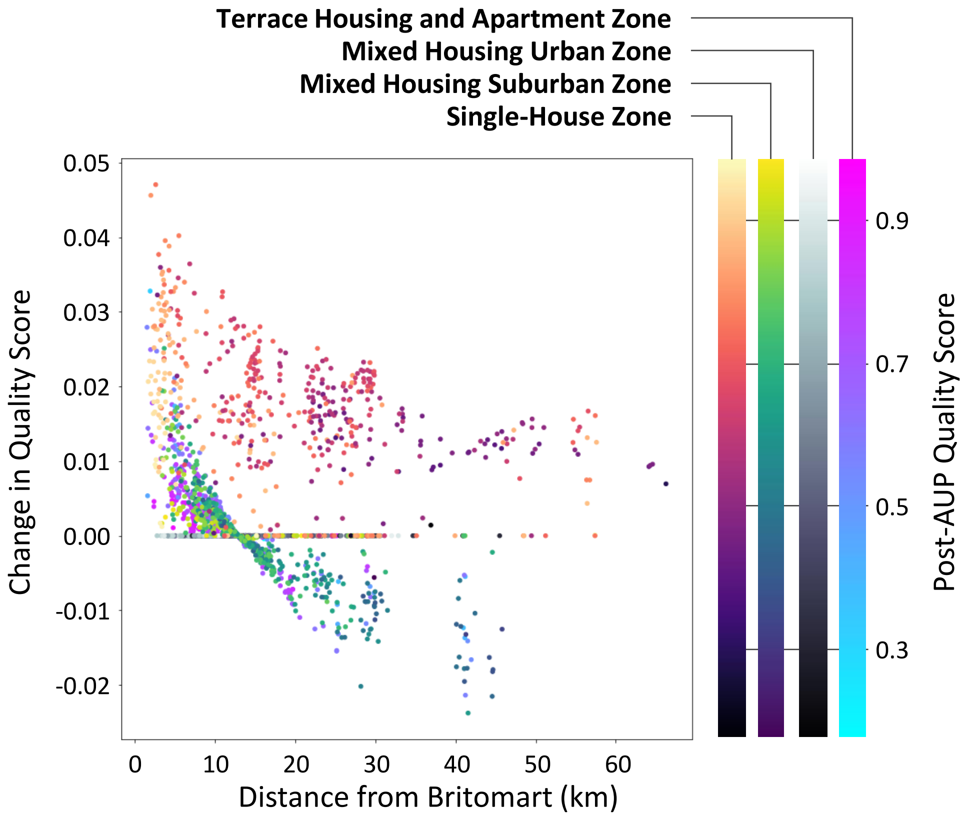
Source: Authors' analysis.

Note: The chart shows a random sample of 500 plots from each zone.

The four colour ramps in the figure represent the post-AUP quality scores for the four AUP zones in our data. In the scatter plot, notice that the grey colour ramp shows no land-value shock at any distance from Britomart. This is because the MHU is our proxy zone for the MDRS, so no simulated up-zoning takes place for those parcels. For the other zones, the change in land value is driven by the same regression results shown in Figure 7. In that figure, wherever the blue line for the MHU shows a higher or lower land-value than a parcel's current zone, our simulated shock is the difference in land-value change between the two lines. This means that at some distances from the city centre, we forecast a decrease in land values as a result of the up-zoning. This is consistent with the AMM model framework described in Section 2.2.1.

The simulated land value changes are applied to the post-AUP quality score calculations to reflect the impact of the zone change on demand for each property. The resulting changes in quality score for Auckland are shown in Figure 16.

Figure 16: Simulated post-MDRS quality score shocks in Auckland by zone and pre-shock quality score



Source: Authors' analysis.
Note: The chart shows a random sample of 500 plots from each zone.

The simulated quality score shocks in Auckland and in the other Tier 1 urban areas are consistently small compared to each observation's pre-shock scores. This implies that the land-value shock from the policy (Step 1) will have only a minor influence on a property's likelihood of development compared to that property's existing development demand conditions (Steps 2 and 3).

4.2.2 Step 2: Probability of adding at least one dwelling

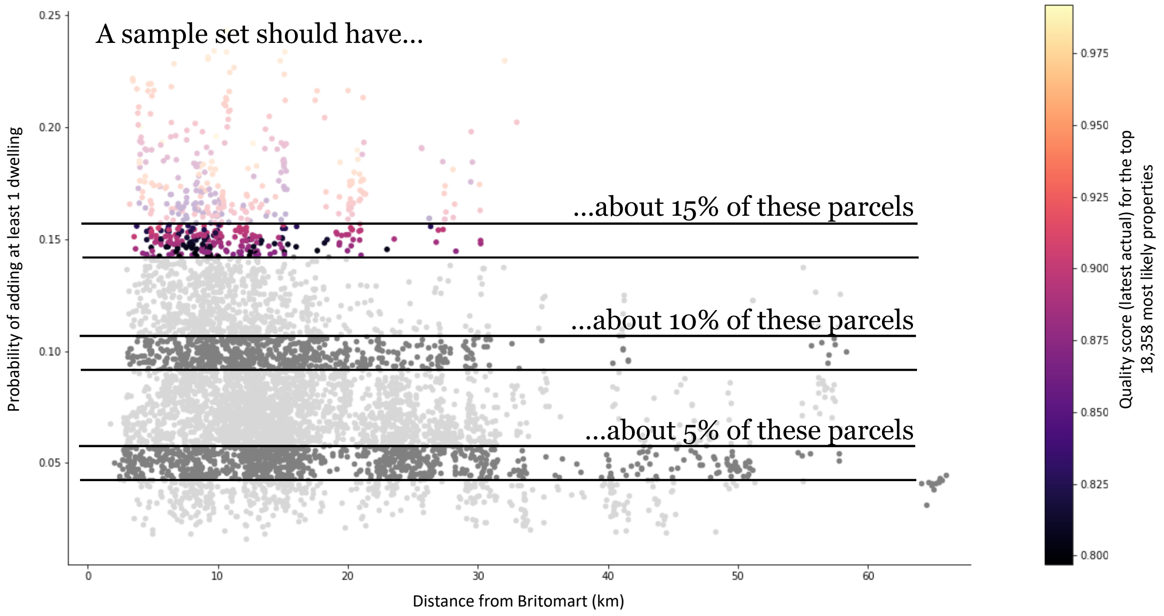
As the property-level quality score increases, the probability of adding at least one dwelling also increases. This is true for all zones. However, this is most prominent for the MHU and MHS zones. Our model uses the fitted coefficients for each zone, pre-AUP quality score, special character status, and distance from Britomart, and applies them using updated zone and special character status and updated quality scores, including the simulated shock from Step 1.

Each property is assigned a probability of adding at least one dwelling based on the fitted coefficients and updated model variables. This is done once without the policy effects (quality score shock, special character effects, and zone change) and once with the policy effects.

To simulate the selection of parcels that add at least one dwelling following the new policy, we first sum the predicted probabilities for all policy-eligible residential parcels (the four zones, less any parcels within the NPS-UD 6-storey catchment areas). We use this sum of probabilities as our estimate for the total count of development events for the forecast scenario.

To select properties for further estimations of dwelling counts, building dimensions, costs, and benefits, we simulate possible scenarios using a random weighted probability, where the weights are the existing parcel-level probabilities. We repeat this process *n* times without replacement,[12] where *n* is the total count of development events described above. Figure 17 shows how a single possible scenario might distribute development events across the population of parcels.

Figure 17: Plot selection based on probability predictions – Auckland



Source: Authors' analysis.

To account for variance in our estimates, we simulate 1,000 specific probable outcomes like the one shown above.

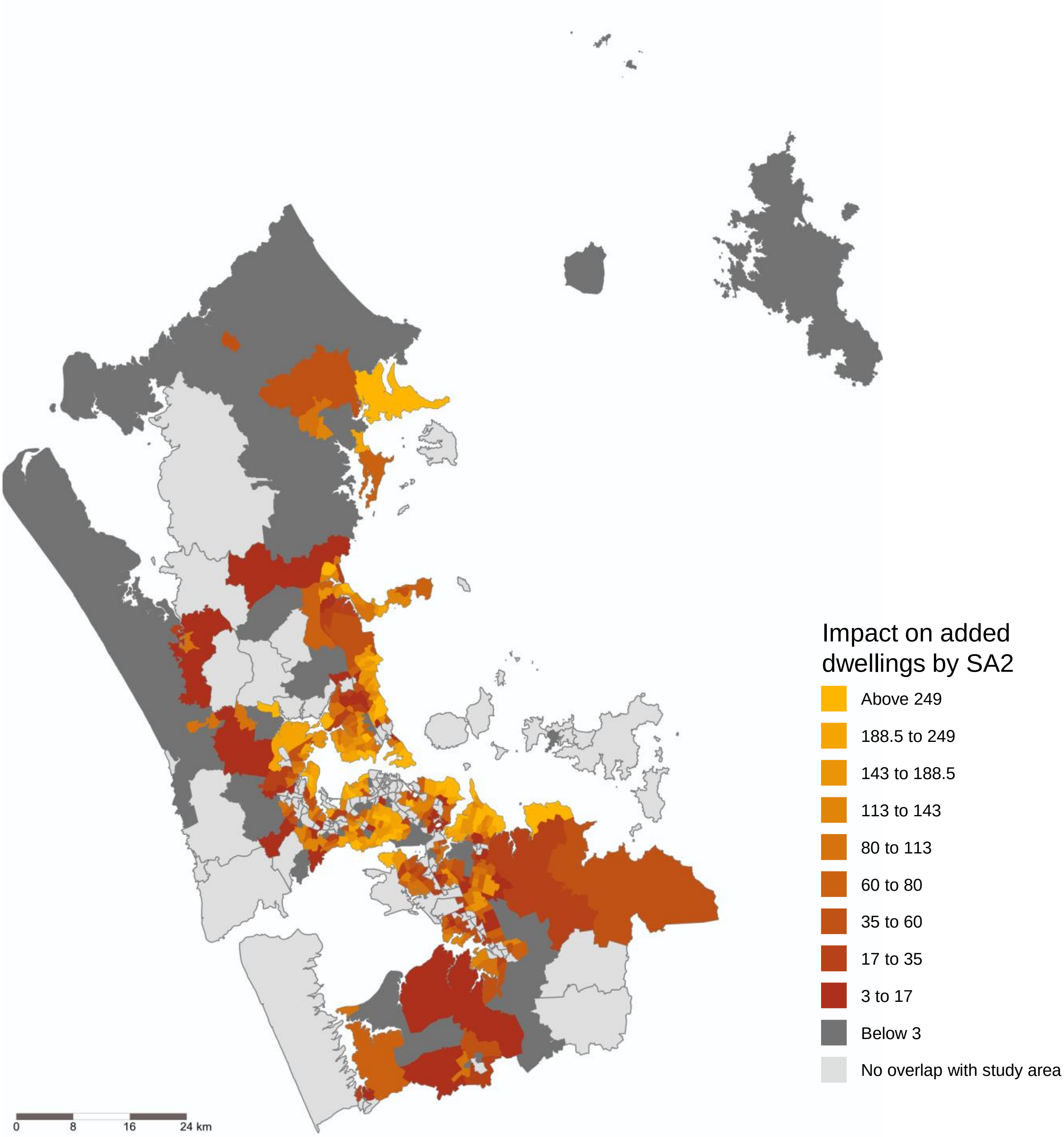
4.2.3 Step 3: Floor area ratio increase conditional on adding at least one dwelling

For each property selected in the previous step using ranked probabilities, we estimate the increase in FAR expected based on the property's quality score, zone, and land area. To do this, we apply the fitted coefficients from the AUP data, which generate a prediction like the one shown in Figure 14 above but adjusted for the simulated shocks to quality score and zone, as in Step 2.

In our original CBA, our results were not intended as a spatial prediction for where Auckland's future development will take place, but rather as a set of illustrative hypothetical scenarios for how the predicted quantities of dwellings would be arranged under each scenario's assumptions. By randomly selecting parcels to redevelop based on their existing parcel-level probabilities, our new results allow us to see the probable distribution of redevelopment in the sub-geographies of a city. Figure 18 below shows the median impact on added dwellings in Auckland as a result of the MDRS at the SA2 level. Appendix A provides a detailed breakdown of developments at the SA2 level.

[12] When a parcel is selected, we do not replace it back into the set of all parcels before selecting another parcel. This ensures that we do not select a parcel twice.

Figure 18: Median impact on added dwellings in Auckland



Source: Author's analysis

4.2.4 Dwelling impact results for Auckland

- Without the MDRS, we forecast a 35,522 increase in the number of dwellings in policy-affected areas.
- With the MDRS, we forecast an 81,361 increase in the number of dwellings in policy-affected areas.
- Policy impact is an additional 45,839 dwellings in policy-affected areas.

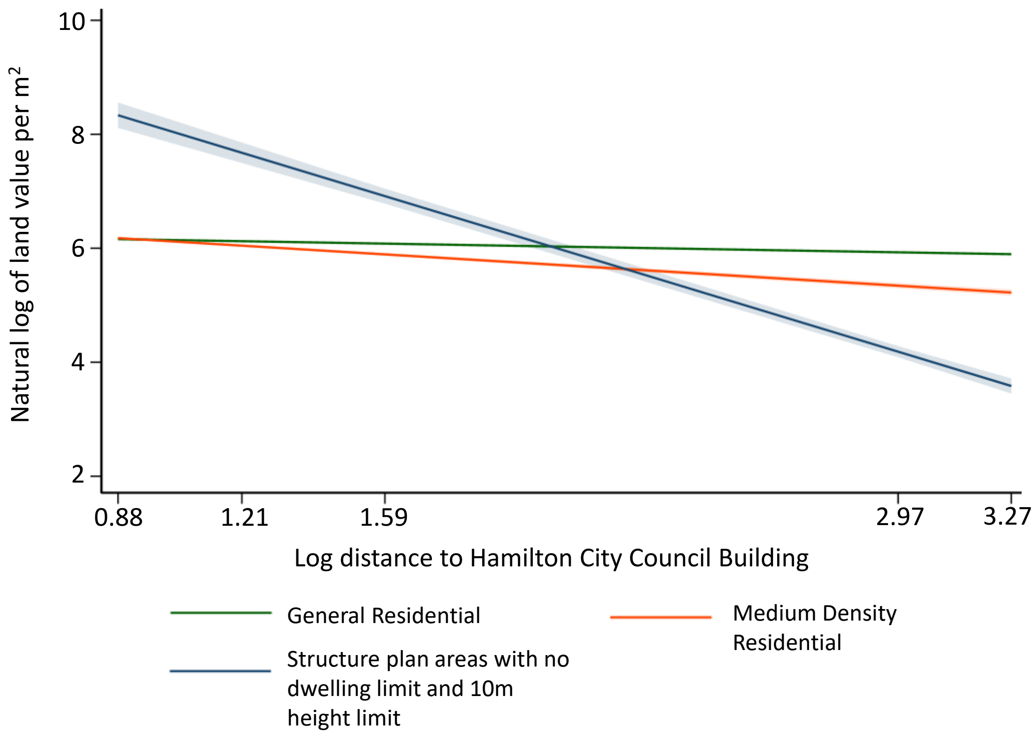
4.3 Other Tier 1 urban areas

Since we do not have a natural experiment in other Tier 1 urban areas, we adjust the model to align with local demand and constraints as described in the approach section above. The following subsections present model outputs for the four non-Auckland Tier 1 urban areas.

4.4 Hamilton

In Hamilton, land values show less variation by distance to the centre than in other urban areas. Most of the residential areas are in the General Residential and Medium Density Residential zones. To simulate the land-value shock from the MDRS, we use a subset of zones with characteristics closer to the new policy than to Auckland's SHZ. This subset comprises the structure plan areas on the edges of Hamilton and in outlying towns that have no listed dwelling limit and a height limit of 10 metres. Figure 19 shows the discontinuity in land values by zone grouping.

Figure 19: Land value by zone and distance to city centre - Hamilton

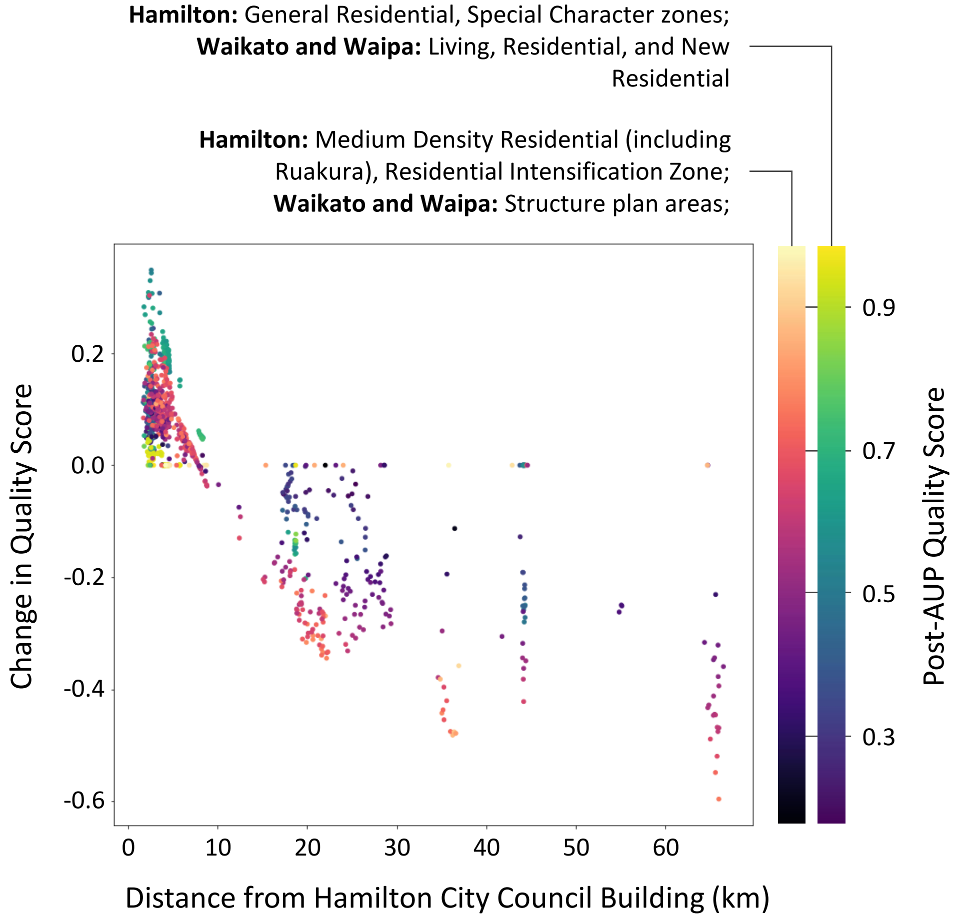


Source: Authors' analysis.

In our land value regressions, the special character zones to the East of Hamilton's city centre are grouped with the General Residential zone, along with the Living, Residential, and New Residential zones from Waikato and Waipā. The Medium Density Residential group includes Hamilton's Medium Density Residential zone including Ruakura and the Residential Intensification Zone, as well as some structure plan areas in Waikato and Waipā.

The observed discontinuity pattern means that most of the properties forecast to see a positive land value shock from up-zoning are in Hamilton City rather than the neighbouring districts. This is consistent with the AMM model to the extent that nearby towns are a substitute for living in Hamilton City—relaxing constraints in the centre leads to a decrease in land value for substitute locations farther away. This is clear in Figure 20, where positive quality score shocks are exclusively in the distance range below 10 km from Hamilton City Council.

Figure 20: Simulated quality score shock from MDRS – Hamilton

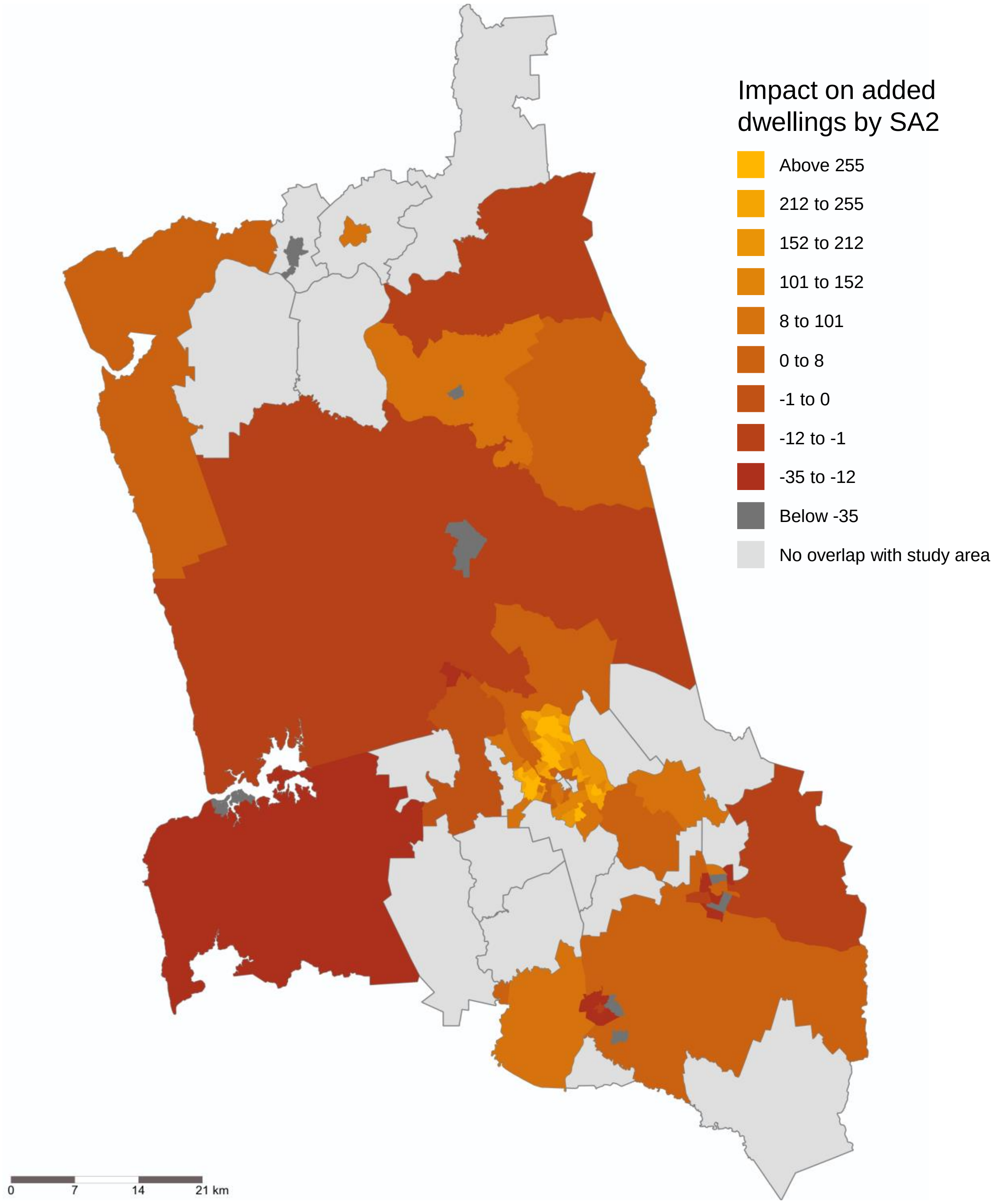


Source: Authors' analysis.

We use these adjusted quality scores as inputs to steps 2 and 3 of our model, which forecast the location and quantity of likely development of new dwellings in Hamilton over the five-to-eight years following the enactment of the MDRS.

Figure 21 below shows the median impact on added dwellings in Hamilton as a result of the MDRS at the SA2 level. Appendix A provides a detailed breakdown of developments at the SA2 level.

Figure 21: Median impact on added dwellings in Hamilton



Source: Author's analysis

4.4.1 Dwelling impact results for Hamilton

Table 3: Mean dwelling impact results for Hamilton

	Without policy	With policy	Policy impact
Waikato District	1,556	1,131	-425
Hamilton City	5,615	15,781	10,166
Waipā District	1,524	1,079	-445

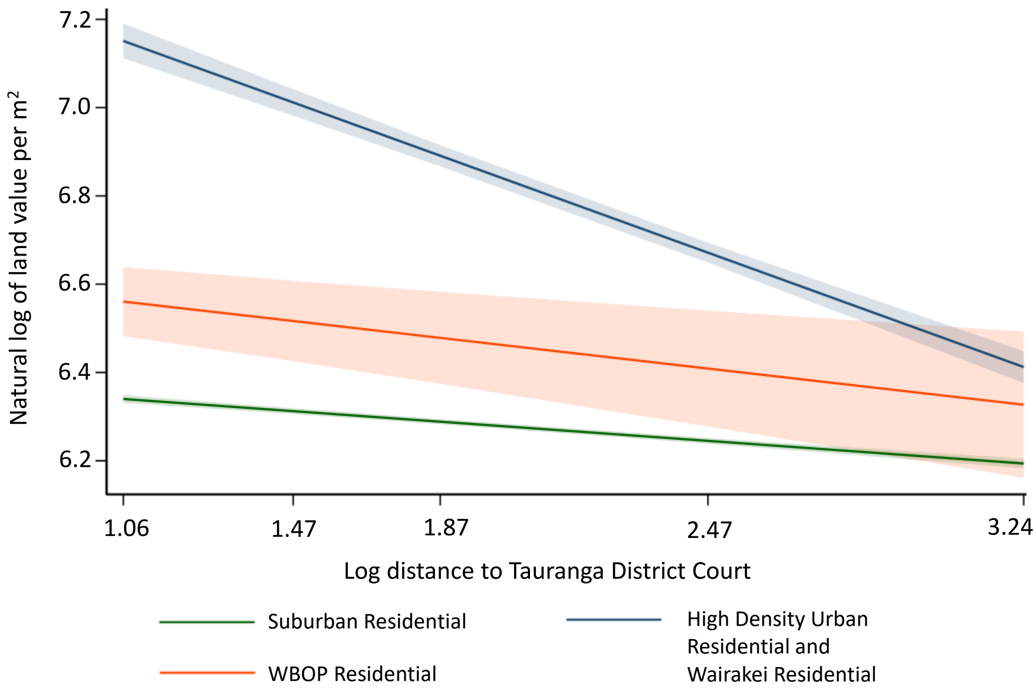
Source: Author's analysis

We forecast that the MDRS will decrease the number of added dwellings in Waikato District and Waipā District, while more development is attracted to Hamilton City.

4.5 Tauranga

Land values in Tauranga show a clear and significant statistical difference by zone at all distances to the city centre. This suggests that much of the city may face constraints to development. Figure 22 shows the discontinuities in land values in Tauranga post-MDRS by zone. The wide shaded band around the linear estimate for Western Bay of Plenty residential areas indicates a smaller sample size and lower statistical confidence for the estimated relationship for that group.

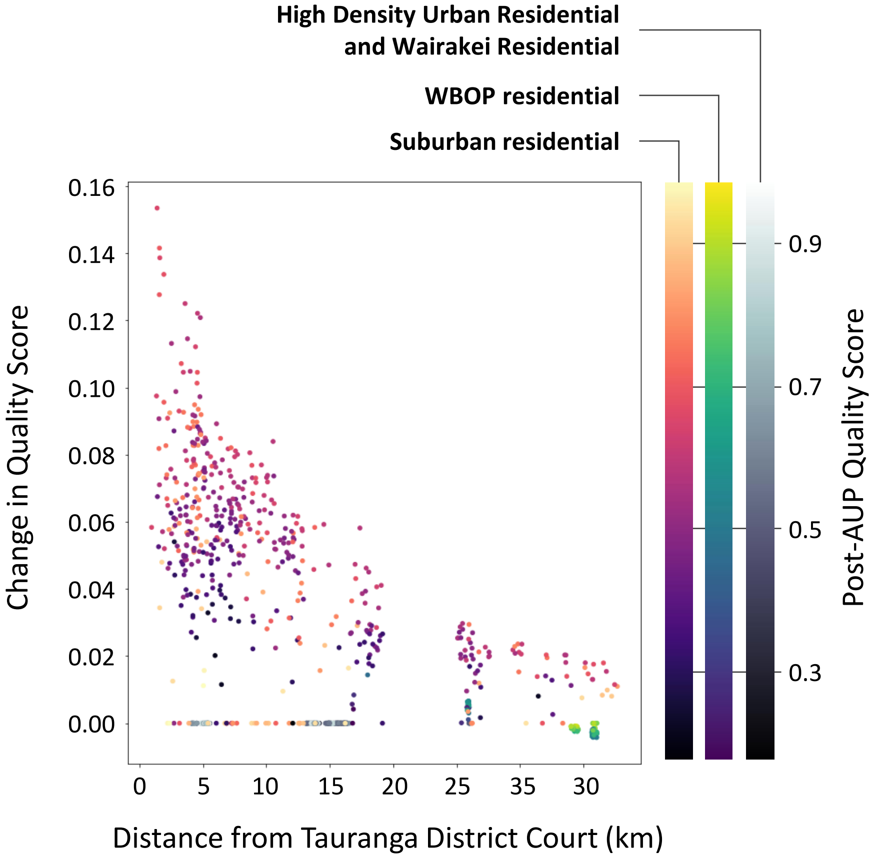
Figure 22: Land value by zone and distance to city centre - Tauranga



Source: Authors' analysis.

Unlike in Hamilton, Tauranga's simulated land value and quality score shocks are positive at nearly all distances from the centre. These are shown for a sample of parcels in Figure 23 below.

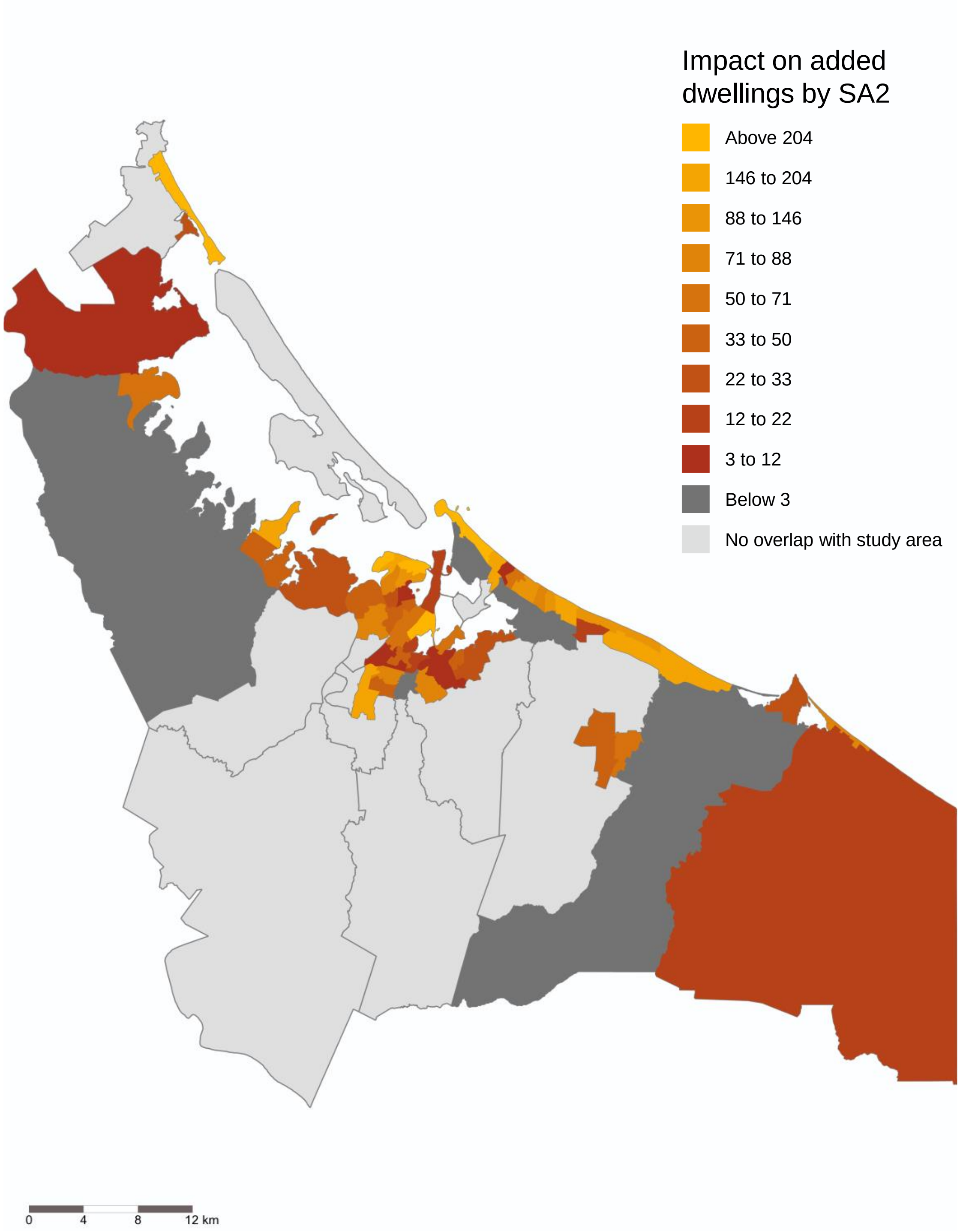
Figure 23: Simulated quality score shock from MDRS – Tauranga



Source: Authors' analysis.

As in the other urban areas, we use the shocked quality scores to estimate likelihood, location and quantity of development with and without the policy. Figure 24 below shows the median impact on added dwellings in Tauranga as a result of the MDRS at the SA2 level. Appendix A provides a detailed breakdown of developments at the SA2 level.

Figure 24: Median impact on added dwellings in Tauranga



Source: Author's analysis

4.5.1 Dwelling impact results for Tauranga

Table 4: Mean dwelling impact results for Tauranga

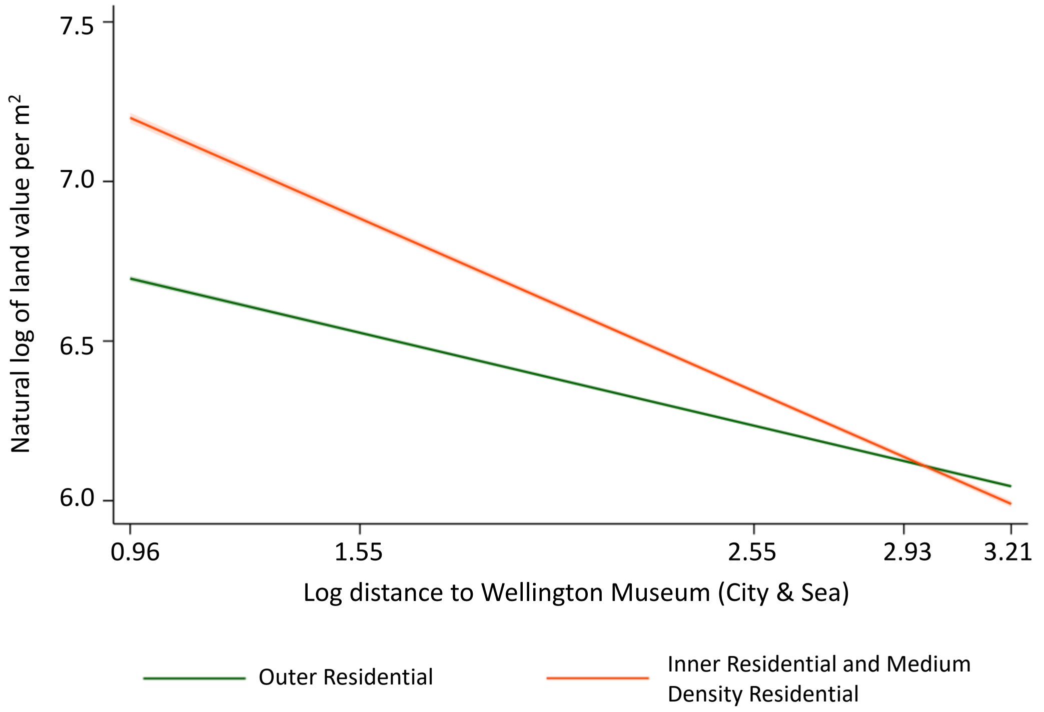
	Without policy	With policy	Policy impact
Western Bay of Plenty District	922	1,808	886
Tauranga City	3,010	6,941	3,931

Source: Author's analysis

4.6 Wellington

In Wellington, the Inner Residential zone and Medium Density Residential zone show very similar land value patterns. While their names imply that the latter might be more permissive, both permit one dwelling and up to 50% building coverage. The Inner Residential zone also has special character protections in many neighbourhoods. These two zones have been grouped together, along with the Medium Density Residential Activity Area in Lower Hutt and the Suburban Zone in Porirua, each of which are more permissive than the Wellington City zones. Figure 25 shows the discontinuity in land values in Wellington post-MDRS by zone.

Figure 25: Land value by zone and distance to city centre – Wellington

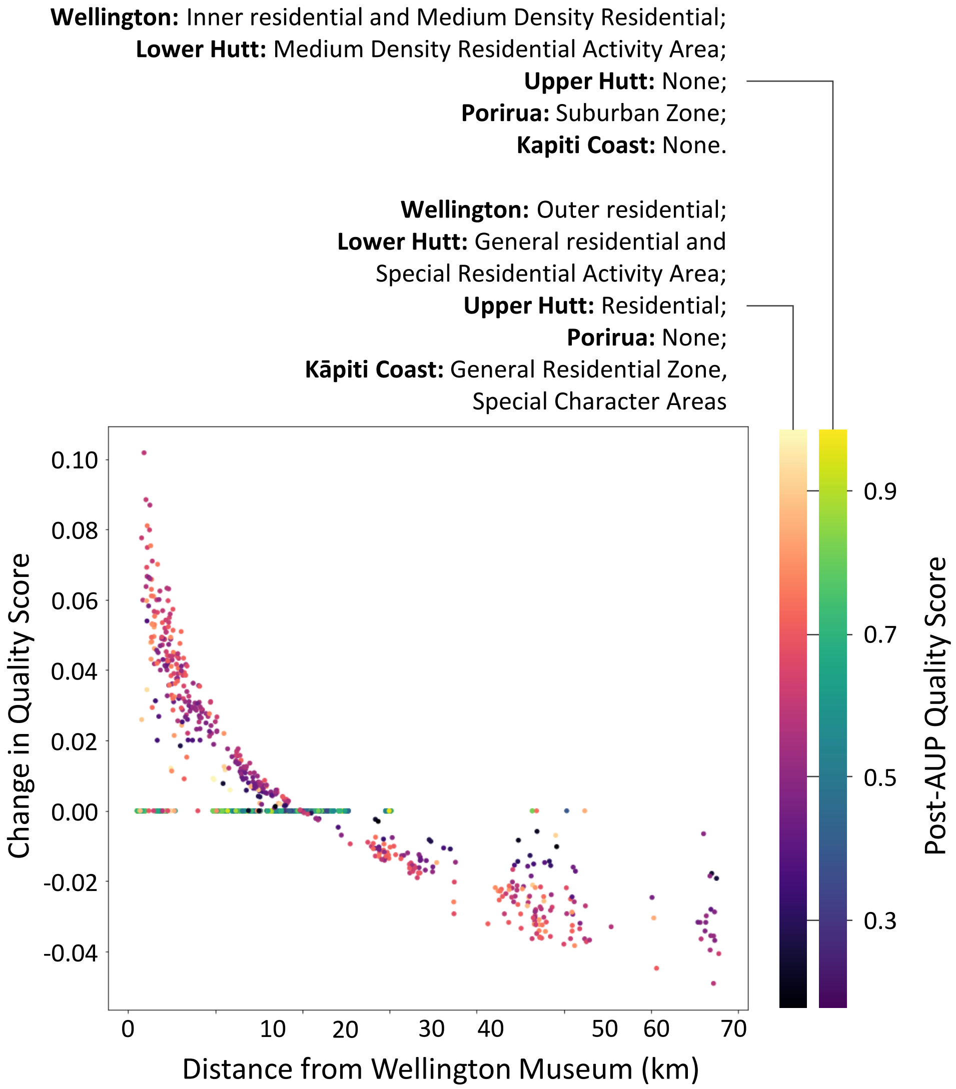


Source: Authors' analysis.

The Outer Residential zone in Wellington has been grouped with the General Residential and Special Residential Activity Area zones in Lower Hutt, the Residential zone in Upper Hutt, and the General Residential zone and Special Character Areas in Kāpiti Coast. The land value discontinuity patterns imply that a broad release of development capacity may lead to rising land values in Wellington City but falling land values in the more distant residential zones.

This pattern is simulated in our modelled quality score shocks, a sample of which are shown in Figure 26 below.

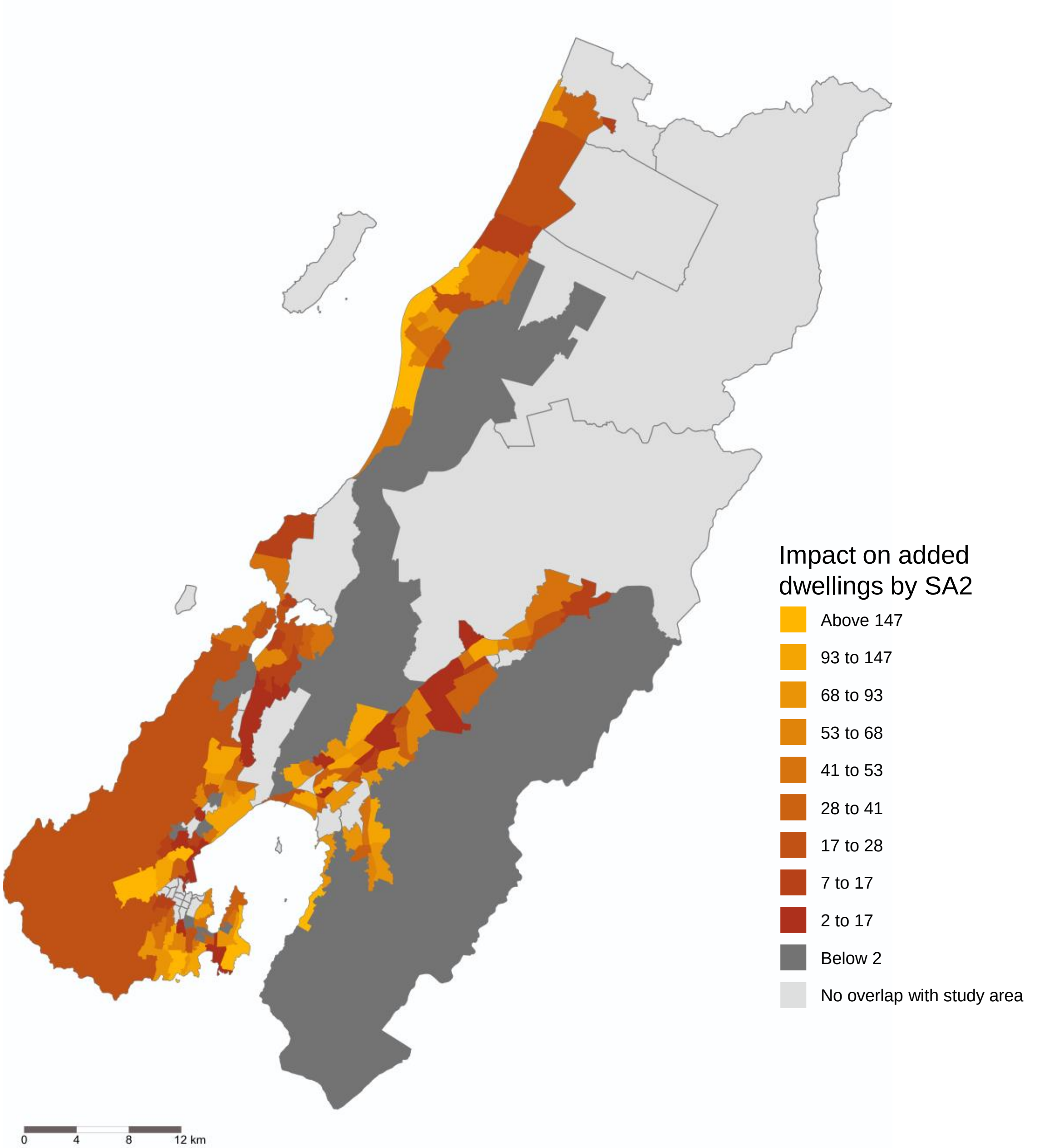
Figure 26: Simulated quality score shock from MDRS - Wellington



Source: Authors' analysis.

The forecast pattern of development is more dispersed in Wellington than in the other cities, reflecting that the NPS-UD catchment areas in Wellington cover much more of the urban core. Figure 27 below shows the median impact on added dwellings in Wellington as a result of the MDRS at the SA2 level. Appendix A provides a detailed breakdown of developments at the SA2 level.

Figure 27: Median impact on added dwellings in Wellington



Source: Author's analysis

4.6.1 Dwelling impact results for Wellington

Table 5: Mean dwelling impact results for Wellington

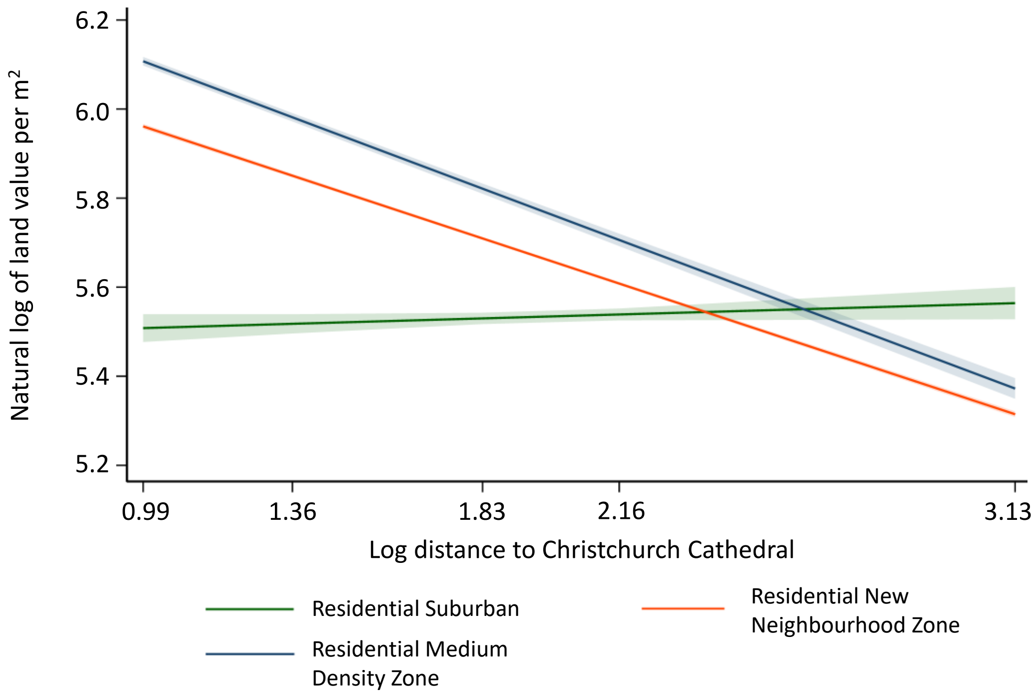
	Without policy	With policy	Policy impact
Kapiti Coast District	1,048	2,680	1,632
Porirua District	1,215	1,689	474
Upper Hutt City	479	1,068	589
Lower Hutt City	1,358	3,445	2,087
Wellington City	2,103	6,147	4,134

Source: Author's analysis

4.7 Christchurch

Christchurch shows a significant difference between zones in the relationship between distance from the city centre and land value. Our regression results for land value discontinuity between zones are shown in Figure 28 below.

Figure 28: Land value by zone and distance to city centre – Christchurch



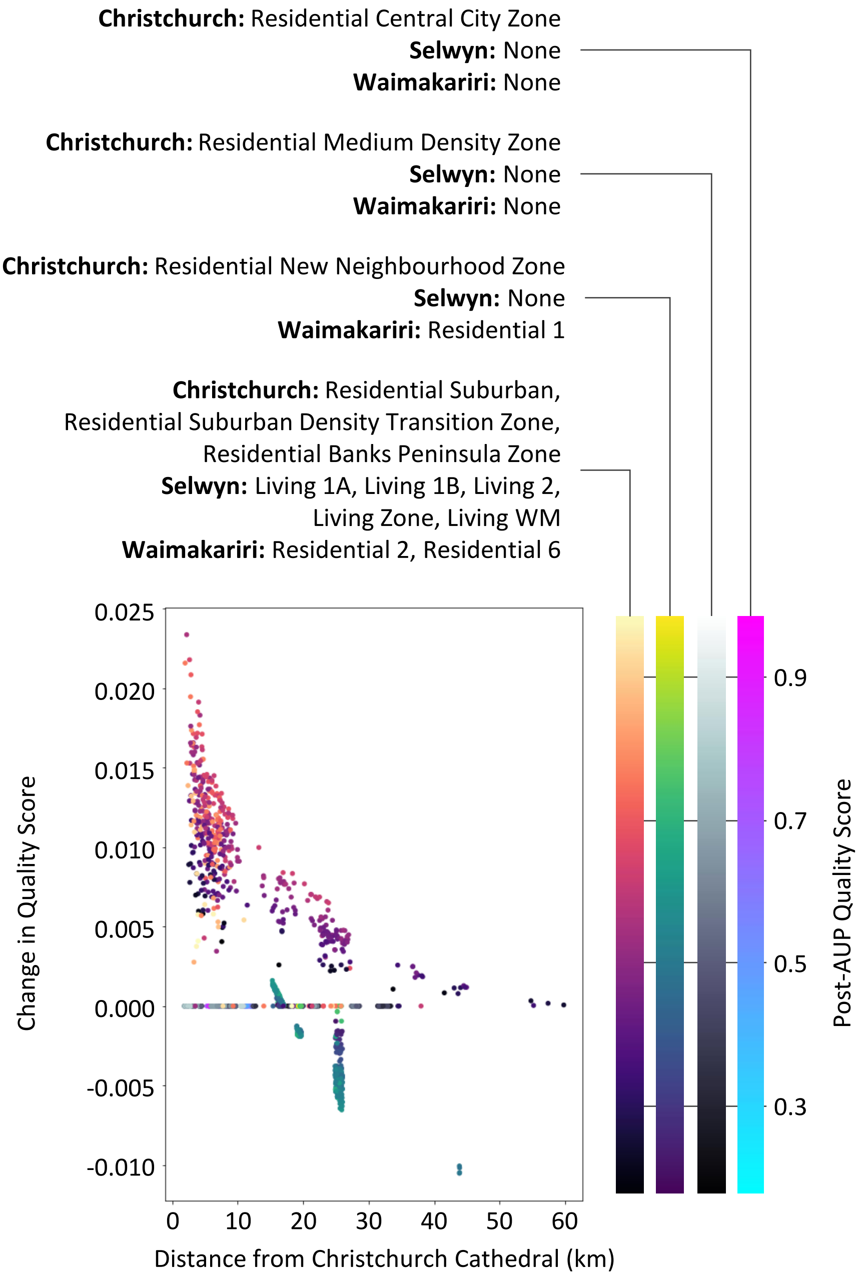
Source: Authors' analysis.

The zones shown in the figure represent groupings according to zone characteristics. The 'Residential Suburban' zone includes the Residential Suburban, Residential Suburban Density Transition, and Residential Banks Peninsula zones in Christchurch; the Living 1A, Living 1B, Living

2, Living Zone, and Living WM zones in Selwyn; and the Residential 2 and Residential 6 zones in Waimakariri.

Based on these observed discontinuities, our land value and quality score shocks are much more significant for parcels currently zoned as Residential Suburban or similar than for other zones. The quality score shocks are shown for a sample of parcels in Figure 29 below.

Figure 29: Simulated quality score shock from MDRS – Christchurch



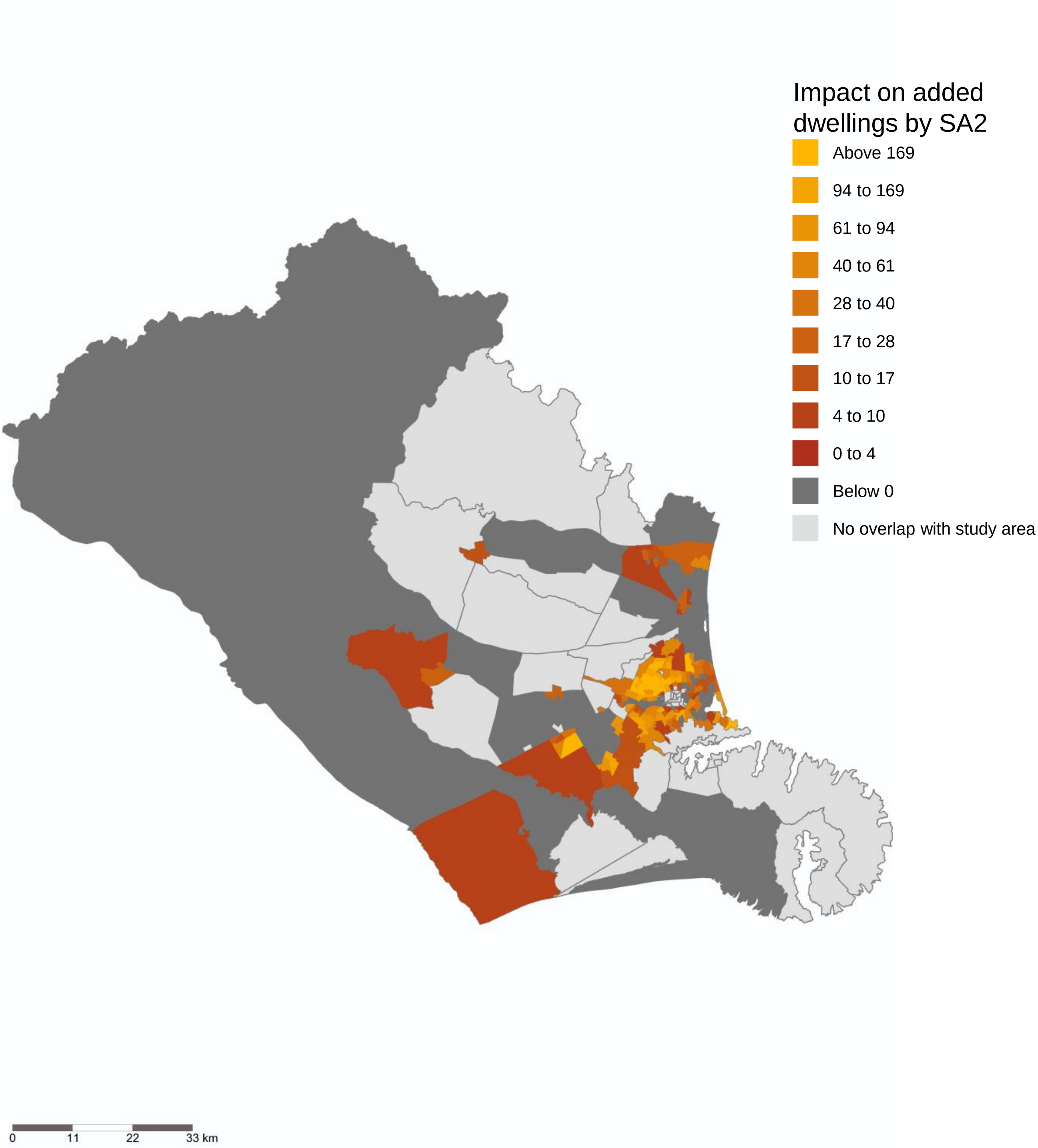
Source: Authors' analysis.

Note: Zone alignments for land-value shocks are chosen based on local land-value discontinuities and may differ slightly from the alignments used for floor area changes in Step 3.

We use these adjusted quality scores as inputs to steps 2 and 3 of our model, which forecast the location and quantity of likely development of new dwellings in Christchurch over the five-to-eight years following the enactment of the MDRS.

Figure 30 below shows the median impact on added dwellings in Christchurch as a result of the MDRS at the SA2 level. Appendix A provides a detailed breakdown of developments at the SA2 level.

Figure 30: Median impact on added dwellings in Christchurch



Source: Author's analysis

4.7.1 Dwelling impact results for Christchurch

Table 6: Mean dwelling impact results for Christchurch

	Without policy	With policy	Policy impact
Waimakariri District	1,172	1,441	269
Christchurch City	9,465	18,884	9,419
Selwyn District	1,440	2,109	669

Source: Author's analysis

In terms of our model, the impact in Christchurch is strong because historical consents have been strong and quality scores are high. Conceptually, Christchurch is unique among the Tier 1 urban areas in that its prices have been more stable over the last decades. No other Tier 1 urban area had a median house price as a multiple of median income that was no higher in April 2020 than it was in April 2014.[13] This may be due to the unusual demand conditions created by the devastating 2011 Christchurch Earthquake, after which building consents spiked during reconstruction, but population growth slowed for several years and housing preferences appear to have shifted toward less densely developed areas.[14]

Since mid-2020 however, the price-income multiple has begun to climb. Population growth has also recovered to pre-earthquake levels after a period of decline from 2011 to 2013. Land values in the city centre have recovered well relative to improvement values, implying lower average opportunity cost of redevelopment compared to the other city centres. Together, these factors provide insight into the difference in data inputs that have led to a stronger modelled policy response in Christchurch.

In other words, the policy can be more effective than average in Christchurch because where other urban areas have a housing crisis to address, Christchurch is in the enviable position of having a housing crisis to prevent.

4.8 Note on treatment of qualifying matters

Both the NPS-UD and the MDRS include provisions that allow councils to exempt specific properties from minimum up-zoning requirements according to a list of "qualifying matters," including consideration of the provisions of other National Policy Statements, potential interference with nationally significant infrastructure, and several others.[15]

To apply an exemption under one of the qualifying matters, councils must demonstrate their case based on site-specific analysis, including what characteristics of the site make the level of directed development inappropriate, why those characteristics justify limiting development in light of the national significance of the policy's urban development objectives.

This is a stark departure from the status-quo for exemptions to allowable development before the NPS-UD, where typically the case had to be made *for* development rather than *against* it. Because the burden of demonstration for qualifying matters applies to specific sites and falls on councils in their planning process, our original CBA assumption is that only a few sites with clear cases for exemption will be put forward under qualifying matters. We model our base case forecasts under this assumption. One advantage of this approach for the purpose of the current work is that these

[13] REINZ and Stats NZ data.
[14] PwC 2020, Stats NZ.
[15] See NPS-UD 2020, Section 3.32 and 3.33.

estimates can serve as a baseline development expectation against which to estimate the costs of providing exceptions to the MDRS in specific areas.

4.9 Robustness checks

As robustness checks for our spatial econometric model, we tested three alternate model specifications to examine their effects on the primary relationships that drive our forecast results. These are described in the subsections below.

4.9.1 Spatial autocorrelation

In plain language, we tested and found that the estimated relationships between quality score and both likelihood of development and quantity of development are not random in the way the errors (differences between fitted model expected values and actual observations) are spatially distributed. We conducted an alternate method of estimating these errors that is robust to this kind of spatial dependence to understand whether the spatial clustering or anti-clustering (dispersion) in the data harms the accuracy of our estimates of the key model relationships and concluded that it does not.

In more technical language, we conducted a Moran's I test for spatial autocorrelation in regression residuals for both the logit and Ordinary Least Squares (OLS) steps. We found that residuals are spatially correlated, with index values of 0.022 for the logit and 0.016 for the OLS. Moran's Index values near zero imply that we observe both non-random spatial clustering and non-random dispersion in the residuals.

To test whether the presence of spatial autocorrelation affects the statistical significance of our coefficient estimates, we use the Conley standard errors method (Conley 1999) to correct for spatial autocorrelation, finding no relevant effect on the significance of our coefficient estimates. Further technical details of these test results are provided in Appendix C.3.

4.9.2 Neighbourhood-level fixed effects

We tested both the logit and OLS models with neighbourhood-level fixed effects for Auckland and found that the general relationship between quality score and both the likelihood to develop and quantity of development were unchanged, including in terms of differences in slope between zones. That is, higher quality scores were still associated with higher likelihood and quantity of development, and this relationship was more pronounced for the MHS and MHU zones than for SHZ.

While the specific estimates of slopes and intercepts were altered by the presence of neighbourhood-level fixed effects, we decided to omit these from the final model to avoid overfitting our forecasts to observed neighbourhood-level patterns in the past, which the policy intends to alter.

4.9.3 Single-step approach to the dwellings-added estimate

We also tested a single-step model, directly estimating the average FAR increase across the city in each zone as predicted by the quality score. This provided similar results in terms of zone-quality score relationships and city-wide average FAR increases.

However, this method disperses modelled increases in floor area across all observations as predicted by their quality score, zone, land area, and distance from the city centre. Consequently, it does not provide insight into potential scenarios for how development might be spatially arranged throughout a city, as the two-step model does.

5 Restrictions

This report has been prepared for the Ministry for the Environment and the Ministry of Housing and Urban Development ('the Ministries') to set out our spatial estimates of the likely development impact of the Medium Density Residential Standards policy at the Statistical Area 2 level. This report has been prepared solely for this purpose and should not be relied upon for any other purpose. We accept no liability to any party should it be used for any purpose other than that for which it was prepared.

This report and accompanying data tables have been prepared solely for use by the Ministries and appointed peer reviewers, as well as for initial circulation among the local district and city councils whose territories are included in our modelled estimates. They may not be copied or distributed to third parties without our prior written consent.

To the fullest extent permitted by law, PwC accepts no duty of care to any third party in connection with the provision of this report and/or any related information or explanation (together, the "Information"). Accordingly, regardless of the form of action, whether in contract, tort (including without limitation, negligence) or otherwise, and to the extent permitted by applicable law, PwC accepts no liability of any kind to any third party and disclaims all responsibility for the consequences of any third party acting or refraining to act in reliance on the Information.

We have not independently verified the accuracy of information provided to us and have not conducted any form of audit in respect of the Ministry for the Environment or the Ministry of Housing and Urban Development. Accordingly, we express no opinion on the reliability, accuracy, or completeness of the information provided to us and upon which we have relied.

The statements and opinions expressed herein are based on information available as at the date of the report, have been made in good faith, and have been made on the basis that all information relied upon is true and accurate in all material respects and not misleading by reason of omission or otherwise. We reserve the right, but will be under no obligation, to review or amend our report, if any additional information, which was in existence on the date of this report, was not brought to our attention, or subsequently comes to light.

It is not possible to assess with certainty the implications of COVID-19 on the economy, both generally in terms of how long the current crisis may last and more specifically in terms of its impact on housing supply and demand. We note our advice is subject to significant caveats and caution at this time due to uncertainty that exists for residents and developers including (among other matters) the demand for products or services, access to capital, supply chain disruption, and the extent and duration of the measures implemented by various governments and authorities to contain or prevent spread of COVID-19.

This report is issued pursuant to the terms and conditions set out in our Consultancy Services Order dated 2 June 2022.

Appendix A. SA2 level development impacts

A.1 Auckland

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
110200	2	0	-1	4
110400	1	0	0	0
110500	48	47	34	61
110700	1	0	-1	3
110900	37	36	26	48
111100	83	82	66	98
111200	0	0	0	0
111300	142	141	123	161
111400	1	0	0	0
111500	514	513	480	548
111700	217	213	190	239
111800	0	0	0	0
111900	77	77	63	91
112100	14	13	5	21
112200	21	20	11	30
112300	16	13	8	19
112400	96	94	79	110
112500	0	0	0	0
112700	253	249	223	281
112800	81	81	66	95
112900	142	141	124	159
113000	21	21	7	34
113100	79	79	65	92
113200	1	0	0	2
113300	164	163	142	185
113400	74	72	57	88
113600	117	117	99	135
113800	4	4	-5	14
113900	176	176	153	198
114000	254	251	224	279
114100	34	33	24	43
114200	96	95	75	114
114400	117	117	100	134
114600	113	113	96	130
114700	5	4	0	8
114800	40	40	29	50
114900	107	105	84	131

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
115000	82	80	67	96
115100	114	112	97	131
115200	148	148	128	167
115300	0	0	0	0
115400	126	125	109	143
115500	0	0	0	0
115600	0	0	0	0
115700	60	58	45	72
115800	233	232	206	257
115900	284	283	255	312
116000	78	77	63	92
116100	1	0	0	0
116200	139	138	114	161
116400	9	6	0	17
116500	167	167	141	193
116700	17	16	7	25
116800	213	212	184	243
116900	70	70	56	83
117000	194	193	165	221
117200	302	300	269	335
117400	49	44	30	60
117500	162	162	136	187
117600	8	8	1	14
117700	165	166	138	193
117900	243	243	213	274
118000	0	0	0	0
118100	21	21	12	30
118200	165	165	141	190
118300	145	145	120	168
118400	82	81	66	95
118500	53	54	41	66
118600	5	5	1	10
118700	131	131	105	153
118900	356	353	323	387
119000	197	195	168	225
119100	105	103	84	124
119200	40	39	22	57
119400	26	25	16	34
119500	179	178	154	205
119700	22	22	13	30
119800	47	47	34	59
119900	97	97	77	116
120000	188	188	162	212

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
120100	22	21	13	31
120200	164	162	128	198
120300	215	214	185	242
120400	26	26	15	35
120500	141	142	114	167
120600	25	25	4	47
120700	134	133	109	160
120800	161	162	136	183
120900	20	20	5	35
121000	70	70	51	90
121100	0	0	0	0
121200	9	8	3	13
121300	37	37	22	51
121400	61	62	46	74
121500	34	33	23	42
121600	79	80	62	97
121700	34	33	17	49
121800	149	149	123	174
121900	134	134	104	164
122000	12	12	7	17
122100	83	81	64	102
122200	285	283	253	315
122300	128	127	101	152
122400	93	93	72	112
122500	46	46	25	67
122600	171	170	142	201
122700	151	151	120	181
122800	115	113	90	136
122900	99	99	76	123
123000	6	6	1	11
123100	72	70	52	93
123200	185	184	157	212
123300	108	107	88	127
123400	193	192	163	222
123500	1	0	0	0
123600	254	254	220	288
123700	477	478	437	518
123900	194	193	170	217
124000	162	160	132	193
124200	1	0	0	2
124300	7	6	-1	15
124400	127	127	106	148
124500	210	207	175	238

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
124600	73	68	45	91
124700	1	0	0	0
124800	330	325	293	362
125200	158	157	132	180
125300	206	205	182	234
125400	149	149	122	177
125500	4	4	0	8
125600	74	73	56	91
125800	188	188	160	216
125900	77	77	58	96
126000	82	82	69	95
126200	271	272	240	301
126300	211	211	188	234
126400	27	26	12	41
126500	103	103	81	126
126900	80	78	64	92
127000	205	202	171	240
127100	140	138	118	161
127300	117	118	92	143
127400	279	278	254	305
127600	3	3	0	6
127700	42	40	28	55
127800	29	28	19	38
128100	103	102	82	122
128200	289	289	258	320
128300	38	38	28	47
128500	49	48	34	62
128600	11	10	4	16
128800	107	108	85	130
128900	129	129	105	152
129000	2	1	0	4
129200	239	240	203	276
129300	199	202	166	233
129400	235	233	197	272
129500	69	68	52	86
129600	125	124	108	142
129700	309	308	274	341
129800	146	143	117	173
129900	279	278	241	315
130100	134	132	112	155
130300	198	198	169	225
130400	143	142	121	166
130500	99	98	80	117

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
130600	212	213	182	243
130700	352	353	316	386
130900	61	60	43	78
131000	3	3	-4	9
131100	116	115	88	141
131200	1	0	0	2
131400	265	266	242	286
131500	10	9	4	15
131600	190	190	170	210
131700	20	20	6	33
132000	26	25	16	35
132100	59	59	38	80
132500	136	135	114	157
133000	377	378	350	404
134000	254	252	233	273
134200	1	1	-3	5
134600	0	0	0	0
134700	136	135	113	159
134900	2	0	0	4
135400	119	118	96	144
135500	72	72	57	86
135800	3	2	0	6
136300	2	2	-1	5
136500	35	32	15	50
136600	128	129	104	151
136700	4	4	0	8
136800	55	54	39	70
137000	70	70	50	91
137100	59	59	44	75
137200	2	2	-4	8
137300	73	72	50	93
137500	1	0	0	0
137600	78	77	55	103
137800	9	8	3	15
137900	167	168	140	192
138000	109	108	88	129
138100	131	131	114	149
138200	154	153	130	176
138300	194	193	164	222
138400	177	176	153	200
138600	126	125	102	149
138700	3	2	0	5
138900	247	246	213	279

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
139000	196	197	165	228
139300	229	227	206	252
139500	147	146	119	174
139600	169	167	139	201
139700	137	137	113	161
139800	57	56	42	72
139900	263	263	228	297
140000	86	86	68	104
140100	69	68	50	86
140200	191	192	163	220
140400	8	8	-2	19
140500	23	22	14	31
140600	206	203	179	233
140700	1	1	-3	5
140800	375	374	337	410
140900	321	320	286	354
141100	235	232	195	275
141200	107	103	85	126
141300	167	168	142	190
141500	225	226	197	253
141600	269	267	237	298
141700	193	191	163	223
141800	189	189	146	230
142000	181	180	149	216
142100	227	227	196	259
142300	217	216	188	245
142400	128	127	107	151
142500	155	149	119	184
142600	154	154	120	187
142700	277	277	239	315
142800	200	200	170	231
142900	160	159	133	184
143000	282	278	233	325
143100	133	132	106	161
143200	91	90	70	111
143400	219	217	189	249
143500	242	240	205	278
143600	261	260	231	291
143700	131	129	104	157
143800	25	25	15	34
143900	133	132	106	158
144000	424	421	381	467
144100	269	266	233	301

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
144300	299	297	266	331
144400	88	88	67	107
144700	3	3	-5	11
144900	36	35	25	47
145000	226	224	195	256
145100	256	253	216	299
145200	81	82	59	102
145300	64	55	35	82
145500	3	1	0	6
145600	133	134	101	163
145700	4	3	-1	8
145800	197	197	161	231
145900	0	0	0	0
146000	12	12	3	20
146100	341	339	306	374
146200	72	71	56	87
146300	79	77	57	98
146400	280	280	245	313
146500	5	5	0	10
146800	186	184	154	215
147000	63	62	47	78
147100	17	14	7	22
147200	4	4	0	6
147500	173	170	145	198
147600	0	0	0	0
147800	192	193	159	221
148000	178	177	151	204
148100	333	332	295	367
148200	61	59	44	76
148300	116	115	94	138
148400	291	290	256	325
148500	25	24	9	40
148600	68	67	52	82
148800	158	157	133	182
148900	31	31	10	52
149000	220	219	188	254
149100	81	80	65	96
149200	176	175	145	208
149300	178	179	151	204
149400	36	36	19	53
149500	59	58	46	74
149700	276	275	243	307
149800	206	204	172	238

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
150000	31	30	10	53
150100	1	0	0	3
150200	125	125	106	145
150300	58	58	40	77
150400	344	344	310	376
150500	185	185	156	212
150600	514	511	470	559
150700	183	182	155	210
150800	60	59	45	76
150900	88	87	67	107
151000	79	78	64	93
151200	51	48	27	72
151300	275	276	241	309
151500	199	198	171	229
151600	80	79	59	101
151800	26	25	13	39
151900	82	80	63	100
152000	114	115	80	146
152200	152	153	130	176
152300	0	0	0	0
152400	186	182	157	214
152500	62	61	47	76
152600	22	22	6	36
152800	83	82	65	100
152900	121	121	98	143
153000	42	41	30	53
153100	13	12	5	21
153200	35	34	24	46
153400	570	568	532	606
153500	78	77	60	97
153600	41	39	28	52
153700	111	111	91	131
153800	229	230	199	256
153900	7	7	2	12
154000	3	3	-1	7
154100	155	148	122	177
154200	41	40	27	52
154300	328	327	301	355
154400	46	45	30	61
154700	51	51	38	65
154900	24	24	12	36
155000	299	299	271	331
155100	56	55	38	74

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
155200	27	27	18	36
155600	140	138	114	161
155700	33	31	13	49
155800	43	44	17	65
155900	17	17	9	25
156000	1	0	0	0
156100	16	16	8	24
156200	90	88	70	109
156300	3	3	0	5
156400	360	359	332	388
156600	32	32	15	50
156800	41	41	29	54
156900	68	66	52	84
157100	21	17	6	31
157200	15	15	1	28
157300	81	80	67	94
157400	282	281	252	310
157500	36	35	14	58
157700	12	13	-6	29
157800	79	77	64	93
157900	8	8	3	13
158000	120	118	99	140
158100	77	76	56	97
158200	65	64	51	79
158300	101	101	80	121
158400	19	19	8	30
158500	88	86	71	104
158600	182	180	152	208
158700	72	72	55	89
158800	20	20	11	29
158900	8	6	0	14
159000	99	99	80	116
159100	6	6	-1	12
159300	178	178	152	201
159400	97	95	80	112
159500	66	66	50	82
159600	114	113	98	131
159700	21	20	3	37
159800	1	0	0	2
159900	17	16	-3	37
160000	39	39	25	52
160200	86	87	70	103
160400	68	67	50	83

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
160500	76	76	59	95
160600	19	18	5	30
160700	130	130	109	153
161000	69	68	51	82
161100	119	119	99	138
161200	26	26	15	37
161300	6	5	1	10
161400	18	15	8	25
161500	92	92	74	111
161600	3	3	0	6
161800	51	50	37	64
162100	68	68	55	81
162200	24	24	14	33
162300	0	0	0	0
162400	67	67	54	78
162500	127	125	106	146
162600	37	37	24	48
162700	41	41	31	52
162900	33	32	21	43
163300	123	123	103	143
163400	89	88	71	106
163500	57	57	43	71
163700	90	88	72	107
163800	0	0	0	0
163900	67	66	52	80
164000	20	19	12	28
164200	83	79	62	98
164300	40	36	19	56
164400	18	17	9	26
164500	13	13	6	20
164600	4	1	-2	5
165000	13	13	8	18
165100	13	12	-3	28
165300	42	41	29	52
165400	47	46	33	60
165500	96	89	72	108
165600	35	35	24	45
165700	1	0	0	0
165800	2	1	0	3
165900	92	91	75	110
166100	22	22	14	30
166200	28	25	14	37
166300	0	0	0	0

A.2 Waikato District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
169700	0	0	0	0
170000	-84	-84	-94	-75
170300	-56	-55	-63	-48
170400	0	0	-1	0
170500	52	52	34	71
170700	-8	-8	-11	-4
170800	38	37	23	53
170900	-3	-3	-8	2
171100	-37	-37	-45	-28
171200	-6	-7	-12	-1
171300	0	0	0	0
171400	-38	-37	-45	-30
171500	-89	-88	-102	-76
171600	-143	-144	-165	-121
171700	-2	-2	-4	0
171800	-15	-16	-23	-8
171900	-6	-6	-14	3
172000	-12	-12	-22	-2
172100	-12	-12	-26	2
172200	-19	-19	-27	-10
172300	1	1	-2	5
172400	0	-1	-5	4
172600	2	1	-4	8
172700	0	0	0	0
172800	-1	-1	-5	2
173200	4	4	0	7
173300	8	8	2	14
173400	0	0	0	0

A.3 Hamilton City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
175200	0	0	0	0
175300	243	243	221	262
175400	36	36	27	46
175500	188	187	169	206
175600	153	152	134	171
175700	78	78	65	91
175800	323	322	295	349
175900	361	360	337	384
176000	149	149	131	166
176100	247	246	226	267
176200	383	383	357	409
176300	1	0	0	0
176400	226	226	203	250
176500	299	299	274	324
176600	250	250	227	272
176700	197	196	179	214
176800	111	111	93	129
176900	308	307	288	331
177000	229	226	211	247
177100	262	260	238	284
177200	213	212	189	237
177300	242	243	220	264
177400	202	202	183	222
177500	200	201	181	220
177600	291	291	267	314
177700	304	303	280	328
177800	181	182	162	200
177900	292	291	268	318
178000	242	242	222	264
178100	291	291	267	316
178200	183	182	162	203
178300	5	5	1	9
178400	103	103	88	119
178500	204	203	185	224
178600	12	12	5	19
178700	92	92	76	108
178800	159	158	139	180
178900	3	2	0	6
179100	101	101	85	117
179200	168	168	149	187
179300	5	5	2	8

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
179500	34	34	26	41
179600	219	220	199	240
179800	2	2	0	5
179900	132	132	114	151
180000	36	36	29	44
180100	125	125	108	142
180200	149	148	134	164
180300	149	148	130	168
180400	143	142	126	161
180500	134	134	115	151
180600	227	226	206	250
180700	256	255	232	279
180800	127	127	111	144
180900	175	176	154	195
181000	197	197	178	215
181100	282	282	260	305
181200	231	231	209	252
181300	9	8	0	17

A.4 Waipā District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
181900	0	0	0	0
182100	14	13	8	20
182200	0	0	-1	0
182400	7	5	0	11
182500	-5	-5	-8	-1
182600	42	41	28	56
182700	-29	-29	-44	-15
182800	-55	-56	-68	-40
182900	-10	-10	-18	-3
183000	-24	-23	-31	-16
183100	0	0	0	0
183200	2	1	-6	9
183300	-15	-15	-21	-9
183400	-24	-25	-30	-18
183500	-25	-25	-34	-15
183600	-34	-35	-42	-27
183700	-25	-25	-34	-17
183800	-51	-52	-63	-39
183900	-40	-40	-52	-28
184000	-34	-35	-42	-27
184100	-6	-6	-10	-2
184200	-37	-37	-47	-28
184300	-29	-29	-36	-22
184400	-28	-28	-35	-20
184500	0	0	0	0
184600	3	3	0	6
184800	-40	-40	-52	-28
184900	0	0	0	0

A.5 Western Bay of Plenty District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
190200	332	331	304	358
190300	8	7	2	13
190400	26	26	17	35
190500	0	0	0	0
190600	56	55	41	70
190900	0	0	0	0
191000	189	189	164	210
191100	39	39	28	50
191200	22	22	14	29
191900	46	45	33	59
192000	0	0	-1	0
192100	51	50	38	64
192300	28	28	18	38
192400	73	73	58	88
192500	15	15	6	23

A.6 Tauranga City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
192600	214	213	195	234
192800	204	204	182	225
192900	146	146	128	163
193000	38	37	27	47
193100	78	78	65	91
193200	248	246	227	270
193300	133	134	117	150
193400	24	23	16	31
193500	86	86	72	99
193600	3	3	0	6
193700	231	226	204	253
193800	13	12	7	17
193900	0	0	0	0
194000	46	46	35	56
194100	34	34	24	44
194300	214	212	191	236
194400	63	63	51	75
194600	68	68	55	80
194700	10	9	4	15
194800	237	234	209	261
194900	180	179	160	199
195100	181	179	162	201
195200	34	33	25	42
195300	11	12	6	17
195400	85	86	72	99
195500	3	3	0	6
195600	33	33	24	41
195700	20	20	13	27
195800	60	59	48	70
195900	58	58	47	71
196000	12	11	5	18
196100	0	0	-2	2
196200	119	119	103	134
196300	6	5	1	10
196400	72	71	58	86
196500	0	0	0	0
196600	38	37	27	48
196700	25	25	16	33
196800	83	83	69	96
196900	22	22	12	31
197000	88	88	76	101

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
197100	169	168	152	184
197200	95	95	81	109
197300	21	21	12	29
197400	102	102	88	117
197500	145	145	128	163
197600	180	179	159	198

A.7 Kapiti Coast District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
236300	70	69	59	82
236500	31	31	20	41
236600	26	25	18	33
236700	13	12	6	19
236800	304	304	281	328
236900	16	16	9	21
237000	152	151	135	168
237100	155	154	137	172
237200	56	55	43	68
237300	60	60	49	72
237400	18	17	11	24
237500	68	68	55	82
237600	68	67	56	80
237800	52	51	40	64
237900	0	0	0	0
238000	161	160	142	178
238100	50	49	39	60
238300	61	60	48	74
238400	18	17	10	24
238500	201	200	181	220
238600	52	51	43	61

A.8 Porirua City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
238800	16	16	8	24
239000	40	41	26	54
239100	46	45	31	61
239200	47	46	31	63
239300	18	17	8	28
239400	0	0	0	0
239500	21	21	9	33
239600	9	8	2	15
239800	23	23	12	34
239900	1	0	0	3
240000	10	11	3	18
240100	55	55	39	71
240200	27	27	15	39
240300	19	18	7	32
240400	32	32	19	44
240500	7	7	0	14
240600	53	52	36	69
240700	9	9	1	17
240800	14	14	3	23
240900	6	6	0	12
241000	14	13	4	23
241100	5	5	-1	12

A.9 Upper Hutt City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
241300	5	5	-1	12
241400	2	2	0	4
241500	41	41	30	52
241600	101	101	87	115
241700	49	49	40	59
241800	5	5	1	9
241900	135	134	118	150
242000	16	15	9	22
242100	67	66	56	78
242200	28	28	21	35
242300	0	0	0	0
242400	64	64	53	75
242600	24	24	14	33
242700	9	8	2	14
242800	6	6	1	10
242900	37	36	27	45

A.10 Lower Hutt City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
243100	0	0	0	0
243200	111	109	95	127
243300	1	0	0	3
243400	102	101	86	116
243500	49	48	38	60
243600	69	68	56	80
243700	18	18	13	23
243800	3	2	0	5
243900	1	0	-1	2
244100	6	6	2	9
244200	124	124	105	142
244300	40	39	26	52
244400	79	78	66	92
244500	24	23	15	33
244600	2	2	0	3
244700	95	93	79	108
244800	98	98	78	116
244900	58	58	45	71
245000	66	66	48	84
245100	35	34	25	43
245200	4	3	0	7
245300	4	3	1	6
245400	15	14	9	21
245600	28	27	20	35
245800	39	38	28	48
245900	39	39	29	50
246000	81	80	68	94
246100	93	92	78	107
246200	81	80	66	95
246300	56	56	44	66
246400	81	80	67	93
246600	50	50	38	61
246800	0	0	0	0
246900	75	75	61	88
247000	100	100	86	114
247100	34	33	23	43
247200	201	201	180	222
247300	73	71	58	86
247400	54	53	42	65

A.11 Wellington City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
247500	23	23	17	29
247600	20	19	12	27
247800	23	22	15	31
248000	6	6	1	10
248100	137	137	120	152
248300	72	71	55	89
248400	56	56	42	68
248500	31	31	21	40
248600	26	25	17	33
248700	59	59	46	71
248800	1	0	0	2
248900	2	0	0	3
249000	5	4	1	9
249100	8	8	4	12
249400	177	176	156	197
249500	79	79	64	93
249600	6	5	2	9
249700	106	105	88	123
249800	30	28	18	40
249900	203	202	183	222
250000	2	1	0	3
250100	96	96	81	111
250200	7	7	4	11
250300	218	217	197	237
250400	216	215	193	237
250500	44	43	34	52
250600	192	191	172	213
250700	2	2	0	3
250800	103	101	85	117
250900	37	35	21	49
251200	15	14	10	20
251500	23	22	16	30
251900	35	34	26	43
252200	41	41	29	52
252600	64	62	50	74
252700	76	75	61	88
252800	127	124	107	144
252900	0	0	0	0
253000	5	4	0	9
253100	97	95	81	111

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
253200	46	45	35	55
253300	58	55	37	76
253400	54	52	43	63
253500	39	34	24	48
253600	25	24	14	36
253700	0	0	0	0
253800	173	170	153	192
253900	50	49	41	59
254000	168	166	148	188
254100	47	46	35	57
254200	33	32	25	40
254300	117	114	95	136
254400	0	0	0	0
254500	69	69	56	81
254600	148	147	129	165
254700	98	97	84	110
254800	86	86	72	99
254900	69	69	57	80
255000	4	4	2	7
255100	162	162	143	180
255200	213	212	192	233

A.12 Waimakariri District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
313200	15	14	3	27
313300	-1	-2	-9	6
313700	-5	-5	-12	2
313800	7	7	3	12
313900	18	18	9	28
314000	16	16	5	26
314100	11	11	3	19
314200	13	12	4	21
314300	0	0	-6	5
314400	0	0	0	0
314500	8	8	0	17
314600	19	18	6	31
314700	16	17	-1	33
314800	0	0	-3	3
314900	14	14	4	24
315000	4	4	-2	9
315200	0	0	-4	3
315300	24	23	13	35
315400	50	51	36	64
315500	0	0	0	0
315600	-9	-9	-18	0
315700	19	17	7	30
315800	0	0	0	0
315900	5	4	-5	15
316000	10	10	3	18
316100	22	21	11	31
316200	8	6	-1	15
316300	4	0	-1	2

A.13 Christchurch City

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
316600	33	32	23	42
316800	9	9	2	14
316900	44	43	32	55
317000	51	50	40	61
317100	0	0	0	0
317200	0	0	0	0
317300	52	52	37	65
317400	52	51	41	63
317500	43	42	32	52
317600	105	105	91	119
317700	182	182	158	204
317800	210	209	184	237
317900	239	239	213	266
318000	109	108	86	131
318100	30	29	19	41
318200	13	12	4	21
318300	182	181	160	204
318400	12	9	4	16
318500	105	106	87	123
318600	93	93	76	109
318700	71	71	56	85
318800	71	71	56	87
318900	137	137	118	154
319000	109	107	86	131
319200	209	206	182	235
319300	36	36	23	49
319400	58	57	42	72
319500	198	199	177	221
319600	99	99	81	117
319700	240	239	211	267
319800	68	68	54	82
319900	182	181	157	205
320100	113	115	94	132
320200	293	293	263	323
320300	24	23	14	33
320400	2	1	-1	4
320500	51	51	38	63
320600	255	256	228	281
320700	216	216	193	241
320800	194	194	171	217
320900	50	48	37	61

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
321000	155	155	132	178
321100	71	72	54	88
321200	62	61	48	75
321300	168	169	149	187
321400	293	294	265	321
321500	231	231	205	257
321600	44	44	33	56
321700	71	71	55	86
321800	101	100	82	121
321900	32	32	21	42
322000	33	32	21	43
322100	147	147	125	167
322200	204	204	176	230
322300	4	3	-1	9
322400	189	187	164	211
322500	11	11	5	17
322600	282	280	254	309
322700	62	62	46	78
322800	14	14	6	21
322900	86	86	74	99
323000	147	146	117	178
323100	96	97	78	115
323200	10	9	0	19
323300	61	60	46	74
323400	50	50	38	63
323500	1	0	0	2
323600	18	18	11	25
323700	29	28	17	41
323800	33	33	23	43
323900	8	8	-1	16
324000	38	38	26	51
324100	13	13	7	19
324300	104	103	88	122
324400	1	0	-2	4
324500	13	13	-1	27
324600	33	33	23	43
324700	17	17	10	23
325000	53	52	37	66
325100	25	24	13	36
325200	1	0	-3	4
325300	10	10	4	16
325400	74	74	59	89
325500	1	0	0	0

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
325600	35	35	21	49
325900	3	3	-1	7
326000	27	28	18	36
326100	3	2	-1	6
326200	1	0	-2	3
326300	97	96	77	115
326500	18	18	9	27
326700	44	44	32	57
326900	102	100	81	121
327200	24	24	10	37
327300	76	75	62	88
327500	12	12	3	21
327600	7	6	2	11
327700	64	64	45	81
327800	25	24	14	35
327900	1	0	-1	2
328000	120	120	102	137
328200	21	21	12	30
328300	15	15	5	25
328400	31	30	18	43
328500	15	14	8	21
328600	14	13	3	26
328700	0	-2	-10	9
328900	3	2	0	6
329000	60	59	49	69
329100	68	68	51	83
329200	78	77	61	94
329300	7	7	0	13
329400	8	7	-5	20
329500	64	64	49	79
329700	29	28	8	50
329800	15	14	4	25
329900	8	7	1	15
330000	9	9	5	14
330100	39	40	26	54
330200	26	26	14	38
330300	41	39	26	52
330400	30	30	20	40
330500	45	44	31	58
330600	132	131	112	152
330700	0	0	0	1
330800	95	94	76	113
330900	43	43	31	54

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
331000	15	14	6	23
331100	30	29	17	43
331200	2	1	-1	4
331300	24	23	13	33
331400	51	50	36	63
331500	4	3	-1	7
331700	77	76	58	94
331800	1	1	-3	5
331900	32	31	21	42
332000	4	4	0	8
332100	78	77	63	93
332400	29	28	19	38
332700	181	180	156	205
333100	0	0	0	0

A.14 Selwyn District

SA2 ID	Mean impact	Median impact	25th percentile	75th percentile
333600	2	1	-3	6
333700	2	2	-4	8
333800	0	0	-4	3
333900	5	4	-4	13
334000	17	17	6	28
334100	2	2	-4	8
334200	0	-1	-4	3
334500	0	0	0	0
334600	21	21	10	31
334900	19	19	7	30
335000	5	5	-6	16
335100	17	16	6	26
335200	31	32	17	46
335300	43	43	29	58
335400	5	4	-4	12
335500	219	220	193	245
335600	0	0	0	0
335700	81	81	66	96
335800	0	0	-3	4
335900	13	13	8	18
336000	71	70	55	86
336100	106	105	88	124
336200	9	8	-2	18
336400	0	0	0	0

Appendix B. Zone alignment tables

Table 7: Zone alignment for housing supply impact – Hamilton, Waipā, and Waikato

Provisions	Medium Density Residential Standards	Hamilton							Waipā	Waikato	
		General Residential	Medium Density Residential	Ruakura Medium Density Residential	Residential Intensification Zone	Special character zones, near inner city	Outlying Residential Development Zones (other structure plans)	Peacockes Structure Plan Area	Residential Zone	**Franklin Section** Residential Zones	**Waikato Section** Living Zone
Dwellings permitted	**3**	1	None	1	None	1	None	None	1	1	1
Building height	**11m**	10m	10m	10m	12.5m	7m	8m to 10m	10m to 12m	9m	8m	7.5m
Height in relation to boundary	**6m + 60°**	3m + 28° to 45°	3m + 28° to 45°	3m + 28° to 45°	3m + 28° to 45° (Where adjoining general residential or special character)	3m + 28° to 45°	3m + 28° to 45°	3m + 28° to 45°	2.7m + 28° to 45°	3m + shortest distance between building and site boundary	2.5m + 37°
Building coverage	**50%**	40%	50%	50%	50%	35%	Up to 40%	8% to 50%	40%	Up to 40%	40%
Treatment		Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ, Special Character Status	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ

Source: District Operative Plans, MfE, authors.

Table 8: Zone alignment for housing supply impact – Tauranga and Western Bay of Plenty

Provisions	Medium Density Residential Standards	Tauranga City				Western Bay of Plenty	
		Suburban Residential Zone	City Living Zone	High Density Residential Zone	Wairakei Residential Zone	Residential	Medium Density Residential
Dwellings permitted	**3**	1	2	1	1	1	1
Building height	**11m**	9m	9m	9m	9.5m	8m	9m 12m (Waihi)
Height in relation to boundary	**6m + 60°**	2.7m + 45° to 55°	2.7m + 45° to 55°	2.7m + 45° to 55°	2.7m + 45° to 55°	2m + 45°	2m + 45°
Building coverage	**50%**	45% - sites over 500m2 55 % - sites less than 500m2	45% - sites over 500m2 55 % - sites less than 500m2	No limit	No limit	40%	40%
Treatment		Align to AUP SHZ	Align to AUP SHZ	Align to AUP MHS	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ

Source: District Operative Plans, MfE, authors.

Table 9: Zone alignment for housing supply impact – Wellington and Lower Hutt

Provisions	Medium Density Residential Standards	Wellington			Lower Hutt		
		Outer Residential Area	Inner Residential Area	Medium Density Residential Area	General Residential Activity Area	Special Residential Activity Area	Medium Density Residential Activity Area
Dwellings permitted	**3**	2	1	1	2	1	No limit
Building height	**11m**	8m	10m	8m - Johnsonville 10m - Kilbirnie	8m	8m	10m
Height in relation to boundary	**6m + 60°**	2.5m + 45°	2.5m + 45° to 71°	2.5m + 56° to 63°	2.5m + 45°	2.5m + 45°	3.5m + 45°
Building coverage	**50%**	35%	50%	50%	40%	30%	60%
Treatment		Align to AUP SHZ	Align to AUP SHZ, special character status	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ, special character status	Align to AUP MHU

Source: District Operative Plans, MfE, authors.

Table 10: Zone alignment for housing supply impact – Upper Hutt, Porirua, and Kāpiti Coast

Provisions	Medium Density Residential Standards	Upper Hutt		Porirua	Kāpiti Coast	
		Residential	Residential (Centres Overlay)	Suburban Zone	General Residential Zone	General Residential Zone with Ōtaki Beach, Raumati, and Paekākāriki beach residential precincts
Dwellings permitted	**3**	1	1	3 (2 share a party wall and one detached)	1	1
Building height	**11m**	8m	8m	8m	8m	8m
Height in relation to boundary	**6m + 60°**	2.7m + 35° to 45°	2.7m + 35° to 45°	3m + 45°	2.1m + 45°	2.1m + 45°
Building coverage	**50%**	35%	45%	35%	40%	35%
Treatment		Align to AUP SHZ	Align to AUP SHZ	Align to AUP MHS	Align to AUP SHZ	Align to AUP SHZ with special character status

Source: District Operative Plans, MfE, authors.

Table 11: Zone alignment for housing supply impact – Christchurch

Provisions	Medium Density Residential Standards	Christchurch					
		Residential Suburban Zone	Residential Suburban Density Transition Zone	Residential Medium Density Zone	Residential Banks Peninsula Zone	Residential New Neighbourhood Zone	Residential Central City Zone
Dwellings permitted	**3**	1	1	No limit	1	No limit	No limit
Building height	**11m**	8m	8m	11m	7m	8m	8m to 30m
Height in relation to boundary	**6m + 60°**	2.3m + 55°	2.3m + 55°	2.3m + 55°	2m + 45°	2.3m + 55°	2.3m + 55°
Building coverage	**50%**	35%	35%	50%	35%	40% to 45%	No limit
Treatment		Align to AUP SHZ	Align to AUP SHZ	Align to AUP MHU	Align to AUP SHZ	Align to AUP MHS	Align to AUP THAB

Source: District Operative Plans, MfE, authors.

Table 12: Zone alignment for housing supply impact – Selwyn and Waimakariri

Provisions	Medium Density Residential Standards	Selwyn	Waimakariri			
		Living Zones	Residential 1 Zone	Residential 2, 3 and 6 Zones	Residential 6A Zone	Residential 7 Zone
Dwellings permitted	**3**	1	1	1	1	1
Building height	**11m**	8m	8m	8m	10m	8m 9m (Area A)
Height in relation to boundary	**6m + 60°**	2.5m + 30° to 55°	2.5m + 35° to 55°	2.5m + 35° to 55°	2.5m + 35° to 55°	2.5m + 35° to 55°
Building coverage	**50%**	40% approx average in most zones	50%	35%	24% to 38%	40% to 60%
Treatment		Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ	Align to AUP SHZ

Source: District Operative Plans, MfE, authors.

Appendix C. Supplementary technical material for housing supply estimates

C.1 Regression results

The following subsections show regression outputs for our three model steps for each Tier 1 urban area.

C.1.1 Auckland

To avoid multicollinearity among our categorical variables, we have dropped the Single Housing Zone (SHZ) dummy from the regression, making it our base category. The regression outputs for the percentage change in land value are given in Table 13 below.

Table 13: Regression output – percentage change in land value – Auckland

Source	SS	df	MS	Number of observations	217,523
Model	4537.36625	8	567.170782	F-statistic	14.01
Residual	8808296.03	217,514	40.4953062	Probability > F-statistic	0.0000
Total	8812833.4	217,522	40.5146762	R-squared	0.0005
				Adjusted r-squared	0.0005
				Root mean squared error	6.3636

Percentage change in land value	Coefficient	Standard error	t-statistic	p-value	95% confidence interval low	95% confidence interval high
Zone						
MHS	0.067799	0.150576	0.45	0.653	-0.22733	0.362925
MHU	0.401171	0.208059	1.93	0.054	-0.00662	0.808962
THAB	1.361599	0.340106	4.00	0.000	0.695	2.028199
Zone * Log distance						
Log distance (SHZ)	-0.02361	0.040687	-0.58	0.562	-0.10335	0.056135
MHS	0.061411	0.056219	1.09	0.275	-0.04878	0.171598
MHU	-0.06884	0.080836	-0.85	0.394	-0.22727	0.089599
THAB	-0.40484	0.135408	-2.99	0.003	-0.67023	-0.13944
2014 LV/CV	0.660997	0.097445	6.78	0.000	0.470007	0.851986
Constant	0.378911	0.127359	2.98	0.003	0.129291	0.628532

Source: Authors' analysis.

The coefficients for zone are the difference between the constant for the respective zone and the constant for the SHZ. The coefficients for zone * log distance are the differences between the slope for the respective zone and the slope for the SHZ

The coefficient on log distance is not statistically significant. This means that for the SHZ, when no up-zoning took place, we see a general appreciation in the land value (around a 75% increase in three years at the mean value for 2014 LV/CV), with little variation by distance from the city centre. Whereas, for more permissive zones, especially the Mixed-Housing Urban Zone and Terraced

Housing and Apartment Buildings, distance makes a difference. Thus, the up-zoning effect varied by distance, but the general effect did not.

The regression outputs for Step 2, estimating the probability of adding at least one dwelling, are given in Table 14 below.

Table 14: Regression output – likelihood of adding at least one dwelling

Logistic regression			Number of observations			331,105
			Likelihood ratio chi-squared			9693.36
Log likelihood =	-84767.412		Probability > chi-squared			0.0000
			Pseudo r-squared			0.0541
Log odds of adding at least one dwelling	**Coefficient**	**Standard error**	**z-score**	**p-value**	**95% confidence interval low**	**95% confidence interval high**
Quality score (SHZ)	2.035176	0.081777	24.89	0.000	1.874897	2.195455
Zone						
MHS	-0.91135	0.066824	-13.64	0.000	-1.04232	-0.78037
MHU	-0.75265	0.080239	-9.38	0.000	-0.90991	-0.59538
THAB	0.102557	0.127476	0.8	0.421	-0.14729	0.352405
Zone * quality score						
MHS	1.356778	0.104068	13.04	0.000	1.152808	1.560749
MHU	1.468782	0.122659	11.97	0.000	1.228374	1.709189
THAB	-0.39025	0.197592	-1.98	0.048	-0.77752	-0.00298
Special character	-0.67466	0.060959	-11.07	0.000	-0.79413	-0.55518
Log distance	1.00538	0.013873	72.47	0.000	0.97819	1.032571
Constant	-6.4438	0.072636	-88.71	0.000	-6.58616	-6.30143

Source: Authors' analysis.

The coefficients for zone represent the difference between the intercept for the respective zone and the regression constant, which is the intercept for the SHZ. The coefficients for zone * quality score are the differences between the slope for the respective zone and the slope for the SHZ. For logit regressions, coefficient estimates indicate the fitted linear relationship between the modelled predictors and the log of the odds ratio of outcomes for that predictor. This makes it difficult to directly intuit the meaning of logit results in terms of probabilities. See the margin plot shown in Figure 9 for a graphic presentation of these results in terms of probabilities.

Regression outputs for Step 3, estimating the increase in FAR given that a parcel adds at least one dwelling, are shown in Table 15 below.

Table 15: Regression output – FAR increase conditional on adding at least one dwelling

Source	SS	df	MS	**Number of observations**	**25,398**
Model	1668.1713	8	208.522016	F-statistic	129.62
Residual	4084.3997	25,389	1.60874393	Probability > F-statistic	0.0000
Total	42512.5758	25,397	1.67392116	R-squared	0.0392
				Adjusted r-squared	0.0389
				Root mean squared error	1.2684

Floor area ratio increase	**Coefficient**	**Standard error**	**t-statistic**	**p-value**	**95% confidence interval low**	**95% confidence interval high**
Quality score (SHZ)	0.374482	0.094231	3.97	0.000	0.189783	0.559181
Zone						
MHS	-0.06089	0.078941	-0.77	0.441	-0.21562	0.093838
MHU	0.204171	0.089162	2.29	0.022	0.029408	0.378933
THAB	0.186872	0.135269	1.38	0.167	-0.07826	0.452007
Zone * quality score						
MHS	0.44122	0.121109	3.64	0.000	0.203839	0.678601
MHU	0.454595	0.135119	3.36	0.001	0.189754	0.719435
THAB	0.991064	0.20739	4.78	0.000	0.584567	1.397561
Land Area	-1.99E-06	8.00E-07	-2.49	0.013	-3.56E-06	-4.26E-07
Constant	0.150532	0.060163	2.5	0.012	0.03261	0.268454

Source: Authors' analysis.

The coefficients for zone are the difference between the constant for the respective zone and the constant for the SHZ. The coefficients for zone * quality score are the differences between the slope for the respective zone and the slope for the SHZ.

C.1.2 Christchurch

For Christchurch, we have dropped the dummy indicator for the Residential Suburban Zone (RSZ) from the regression, making it our base category. This means that the coefficient for the quality score is the coefficient for quality score interaction with RSZ and the coefficient for the constant represents the RSZ intercept.

The regression outputs for the percentage change in land value are given in Table 16 below.

Table 16: Christchurch land-value discontinuity regression

Source	SS	df	MS	Number of observations	132,190
Model	12291.7402	7	1755.96288	F-statistic	5357.04
Residual	43327.3832	132,182	.327785805	Probability > F-statistic	0.0000
Total	55619.1234	132,189	.420754551	R-squared	0.2210
				Adjusted r-squared	0.2210
				Root mean squared error	.57253

Land value/m^2	Coefficient	Standard error	t-statistic	p-value	95% confidence interval low	95% confidence interval high
Log distance (RSZ)	-0.26935	0.002528	-106.53	0	-0.2743	-0.26439
Zone						
RNN	-0.1136	0.013457	-8.44	0	-0.13998	-0.08723
RMD	0.153457	0.010163	15.1	0	0.133538	0.173376
Zone * quality score						
RNN	0.056839	0.008691	6.54	0	0.039804	0.073873
RMD	-0.03729	0.00628	-5.94	0	-0.0496	-0.02498
Latest land ratio	0.649791	0.008707	74.63	0	0.632727	0.666856
Constant	5.898737	0.007288	809.42	0	5.884453	5.913021

Source: Authors' analysis.

Note: RNN is the Residential New Neighbourhood Zone group, RMD is the Residential Medium Density Zone group.

C.1.3 Hamilton

For Hamilton, we drop the dummy indicator for the General Residential Zone (GRZ) from the regression, making it our base category. This means that the coefficient for the quality score represents the coefficient for quality score interacted with the GRZ (ie, the GRZ slope), and the coefficient for the constant represents the intercept for the GRZ.

The regression outputs for the percentage change in land value are given in Table 17 below.

Table 17: Hamilton land-value discontinuity regression

Source	SS	df	MS	Number of observations	68,139
Model	3946.56811	6	657.761351	F-statistic	2014.85
Residual	22242.1023	68,132	.326456031	Probability > F-statistic	0.0000
Total	26188.6704	68,138	.384347506	R-squared	0.1507
				Adjusted r-squared	0.1506
				Root mean squared error	.57136

Land value/m^2	Coefficient	Standard error	t-statistic	p-value	95% Confidence interval low	95% Confidence interval high
Log distance (GRZ)	-0.13143	0.00226	-58.15	0	-0.13586	-0.127
Zone						
MDR	0.08104	0.016703	4.85	0	0.048303	0.113777
SP	3.939525	0.181074	21.76	0	3.584621	4.294429
Zone * quality score						
MDR	-0.22684	0.01171	-19.37	0	-0.24979	-0.20389
SP	-1.9066	0.073051	-26.1	0	-2.04978	-1.76342
Latest land ratio	-0.05837	0.015207	-3.84	0	-0.08818	-0.02857
Constant	6.340419	0.01114	569.18	0	6.318585	6.362252

Source: Authors' analysis.
Note: MDR is the Medium Density Residential group, SP is the subset of structure plan areas with no dwelling limit and height limits of 10 metres.

C.1.4 Tauranga

In Tauranga, the Suburban Residential Zone (SRZ) is our base category. This means that the coefficient for the quality score is the coefficient for quality score interaction with the SRZ and the coefficient for the constant represents the intercept for the SRZ.

The regression outputs for the percentage change in land value are given in Table 18 below.

Table 18: Tauranga land-value discontinuity regression

Source	SS	df	MS		
				Number of observations	**54,111**
Model	2589.36102	7	369.908717	F-statistic	844.65
Residual	23694.0034	54,103	.437942507	Probability > F-statistic	0.0000
Total	26283.3645	54,110	.485739502	R-squared	0.0985
				Adjusted r-squared	0.0984
				Root mean squared error	.66177

Land value/m^2	Coefficient	Standard error	t-statistic	p-value	95% Confidence interval low	95% Confidence interval high
Log distance (SRZ)	-0.07626	0.003872	-19.69	0	-0.08385	-0.06867
Zone						
WBOP	0.242432	0.036885	6.57	0	0.170138	0.314726
HDU	1.064785	0.036535	29.14	0	0.993177	1.136394
Zone * quality score						
WBOP	-0.02912	0.027259	-1.07	0.285	-0.08255	0.024312
HDU	-0.26552	0.015691	-16.92	0	-0.29628	-0.23477
Latest land ratio	0.322454	0.016176	19.93	0	0.290749	0.354159
Total valuations post-2016	-0.03098	0.000575	-53.91	0	-0.03211	-0.02985
Constant	6.336463	0.012487	507.44	0	6.311988	6.360938

Source: Authors' analysis.

C.1.5 Wellington

In Wellington, we use the Outer Residential Area (ORA) as our base category. This means that the coefficient for the quality score represents the slope for the quality score interaction with the ORA and the coefficient for the constant represents the intercept for the ORA.

The regression outputs for the percentage change in land value are given in Table 19 below.

Table 19: Wellington land-value discontinuity regression

Source	**SS**	**df**	**MS**	**Number of observations**	**130,063**
Model	19012.0388	4	4753.0097	F-statistic	8970.10
Residual	68914.1649	130,058	.529872556	Probability > F-statistic	0.0000
Total	87926.2037	130,062	.676032997	R-squared	0.2162
				Adjusted r-squared	0.2162
				Root mean squared error	.72792

Land value/m^2	Coefficient	Standard error	t-statistic	p-value	95% Confidence interval low	95% Confidence interval high
Log distance (ORA)	-0.2883	0.002295	-125.63	0	-0.2928	-0.2838
Zone						
MDR	0.740244	0.013393	55.27	0	0.713995	0.766493
Zone * quality score						
MDR	-0.24748	0.005046	-49.04	0	-0.25737	-0.23759
Latest land ratio	0.780849	0.01329	58.76	0	0.754802	0.806896
Constant	6.531676	0.009702	673.25	0	6.512661	6.550691

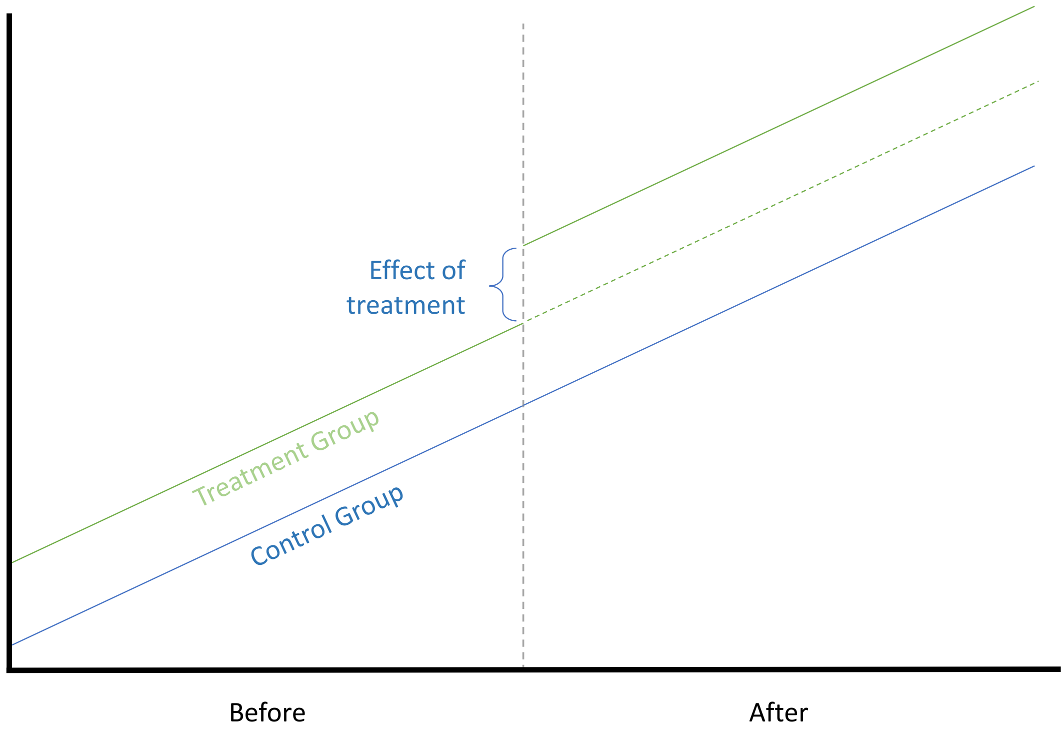
Source: Authors' analysis.
Note: MDR is the Medium Density Residential group.

C.2 Difference in Difference Estimation

Difference in Differences (DiD) is a statistical technique used in econometrics that attempts to measure the impact of a policy intervention or treatment using observational data. DiD analyses often exploit natural or quasi-natural experiments.

Difference in Difference estimation studies the differential effects of a treatment group versus a control group. This is done by comparing the average change of a treatment group, with the average change of a control group. The difference in these average changes gives a causal change due to the treatment.

Figure 31: Difference in Difference Estimation



Source: Authors' illustration.

In Figure 31 above, we have separate trends in a dataset for a treatment group and control group. A DiD estimation examines the difference between the average change in the treatment group and the average change in the control group from before the treatment to after the treatment.

To estimate the change in land value due to the AUP, we can compare the change in land value from parcels that were up-zoned (treatment group) with the parcels that were not up-zoned (control group). The average difference in the land value for parcels that were up-zoned and parcels that were not up-zoned (control group) gives a causal effect of the up-zoning (the treatment).

C.3 Spatial Autocorrelation

C.3.1 Moran's I test for spatial autocorrelation

We test for spatial autocorrelation in the residuals for our modelled estimates in Steps 2 and 3. Results are shown in Table 20 and Table 21 below.

Table 20: Moran's I results – Logit estimation of likelihood to add at least one dwelling

Observed/Moran's I index	0.02223574
Expected index under null hypothesis	-0.000050025
Standard deviation of I under the null hypothesis	0.0002226476
P-value	0.0000

Source: Authors' analysis.

Table 21: Moran's I results – OLS estimation of FAR increase

Computed Moran's I index	0.01640531
Expected index under null hypothesis	-4.29203e-05
Sd	0.0003470399
P value	0.0000

Source: Authors' analysis.

These estimates imply that spatial autocorrelation is present with a high degree of confidence. This is not a surprise, given the model specifications and the geographic distribution of the spatial data employed. Development tends to occur in clusters, especially in areas where land is less scarce, such as the outskirts of Auckland. As a result, the estimates of confidence intervals and significance of coefficients may not be accurately estimated, as the distribution of residuals is non-random or not independent of proximity. We correct the standard errors to account for this spatial dependence in the following section.

C.3.2 Conley standard errors to correct for spatial autocorrelation

In the presence of spatial autocorrelation, the spherical error variance assumption is violated, and so econometric theory would suggest that the estimates of the standard errors are not consistent. Consistency of an estimator means that as the sample sizes gets larger and larger, the value of the estimator gets closer and closer to the true value of the parameter. That is, an estimator is said to be consistent if an estimator converges in probability to the true parameter value. This is often a desirable property as we can assume in large samples that the estimator is approximately its true value.

Conley (1999) presents a method to obtain asymptotically consistent standard errors in the presence of spatial autocorrelation by accounting for spatial dependence. We follow the method described in Conley (1999) for our regression for the probability of adding at least one dwelling and the regression for FAR increase given a property adds at least one dwelling.

The calculation of distance between every possible pair of observations is so computationally intense that it is impractical to run on the full dataset of 331 thousand parcels. Instead, we run the test on a random sample of 40 thousand parcels to understand whether the adjusted standard errors would alter the level of significance for our coefficient estimates of the slopes and intercepts of our estimated relationships between quality score and probability of adding at least one dwelling by zone.

Table 22: Conley standard error estimates for the probability of adding at least one dwelling

Variable	*Coefficient estimate*	*Standard SE*	*Spatial SE*	*Standard Z score*	*Spatial Z-score*	*Standard P-value*	*Spatial P-value*	*Signif. effect*
Intercept (in log odds)								
SHZ	-6.807	0.332	0.523	-20.522	-13.024	0.000	0.000	None
MHS	0.340	0.325	0.292	1.047	1.165	0.295	0.244	None
MHU	-0.266	0.321	0.303	-0.827	-0.878	0.408	0.380	None
THAB	-0.334	0.337	0.300	-0.992	-1.115	0.321	0.265	None
Slope vs. Quality Score								
SHZ	1.837	0.503	0.459	3.650	4.001	0.000	0.000	None
MHS	-0.220	0.539	0.473	-0.408	-0.464	0.683	0.643	None
MHU	0.875	0.526	0.526	1.664	1.663	0.096	0.096	None
THAB	1.395	0.550	0.418	2.536	3.338	0.011	0.001	Higher
Controls								
Log Distance	1.129	0.042	0.111	27.113	10.140	0.000	0.000	None
Special character	-0.742	0.191	0.141	-3.875	-5.258	0.000	0.000	None

Note: Estimates for a random sub-sample of 40,000 observations out of 331,105 parcels and parcel-clusters (where valuations involve multiple parcels) subject to the policy in the four primary residential zones.

As Table 22 shows, the adjustment for spatial autocorrelation has no statistically relevant effect except in cases where it increases the significance of the estimate. Based on this result, we are satisfied to use the original logit model, with the full sample of 331 thousand observations, for our forecast estimates. For the OLS estimate of FAR increase conditional on a property adding at least one dwelling, we run the dependence-adjusted estimate for the full dataset of observations. Results are shown below.

Table 23: Conley standard error estimates for FAR increase given a property adds at least one dwelling

Variable	*Coefficient estimate*	*Standard SE*	*Spatial SE*	*Standard t-score*	*Spatial t-score*	*P-value*	*Spatial P-value*	*Signif. effect*
Intercept								
SHZ	0.088	0.116	0.171	0.764	0.515	0.445	0.607	None
MHS	0.112	0.124	0.172	0.91	0.655	0.363	0.512	None
MHU	0.019	0.123	0.174	0.154	0.108	0.878	0.914	None
THAB	0.162	0.128	0.191	1.264	0.851	0.206	0.395	None
Slope vs. Quality Score								
SHZ	1.848	0.185	0.37	9.988	5	0.000	0.000	None
MHS	-1.495	0.202	0.37	-7.418	-4.04	0.000	0.000	None
MHU	-0.982	0.197	0.375	-4.99	-2.621	0.000	0.009	None
THAB	-0.778	0.205	0.404	-3.791	-1.927	0.000	0.054	Lower
Controls								
Land area	0	0	0	-1.999	-1.577	0.046	0.115	Lower

Note: Estimates use the full sample of 25,398 properties that added at least one dwelling post-AUP.

As with the logit model above, the OLS standard errors show no change in statistical significance when adjusted to account for spatial autocorrelation, except in the case of the slope for the THAB zone and the land area control, which become less significant. As our key coefficient estimates for the slopes and intercepts of the control and treatment zones are unaffected, we conclude that our model results are robust to spatial dependence.