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# Going it Alone: The Impact of Upzoning on Housing Construction in Lower Hutt

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# Going it Alone: The Impact of Upzoning on Housing Construction in Lower Hutt*

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**Abstract**

An implication of Fischel's homevoter hypothesis is that metropolitan regions with fractured governance structures are less-favourably disposed to housing intensification though mechanisms such as zoning reform. This paper presents an exception to this conventional wisdom: Lower Hutt. Part of the wider Wellington metropolitan region of New Zealand, Hutt City Council has implemented a sequence of zoning changes from the late 2010s onwards to enable widespread medium- and high-density housing in residential areas of the city. Using a synthetic control to specify the policy counterfactual, we find that the reforms generated a three- to four-fold increase in consents per capita and tripled the number of housing starts over the six years subsequent to the onset of the reforms. After accounting for potential displacements effects, we estimate that the reforms increased housing starts across the wider metropolitan region by 12 to 17% . These findings support extant evidence that widespread upzoning can have a substantial impact on housing supply, even when limited to a single municipality within a larger metropolitan area.

**Keywords: Zoning Reform, Housing Supply, Policy Spillovers, Parking Minimums**

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# 1 Introduction

Development has concentrated costs and diffuse benefits. Homeowners consequently oppose development when it is local but stand to benefit from distant development elsewhere within a metropolitan region (Fischel, 2001). Metropolitan areas with fractured governance structures are therefore more likely to have suboptimal development and urban sprawl (Fischel, 2004), suggesting that regional amalgamation to internalise the relevant costs and benefits may be a potential antecedent to development housing intensification (Tricaud, 2021; Greenaway-McGrevy and Jones, 2023).

This paper presents a counterexample to this conventional wisdom: Lower Hutt. The city is one of several municipalities that constitute the Wellington metropolitan region of New Zealand. Beginning in the late 2010s, Hutt City Council implemented a sequence of zoning changes with the explicit intention of increasing the city's housing stock through construction of medium- and high- density housing.[1] What is interesting about these changes is that Hutt City implemented them unilaterally. The other councils in the metropolitan area did not independently implement substantive zoning changes over this period.

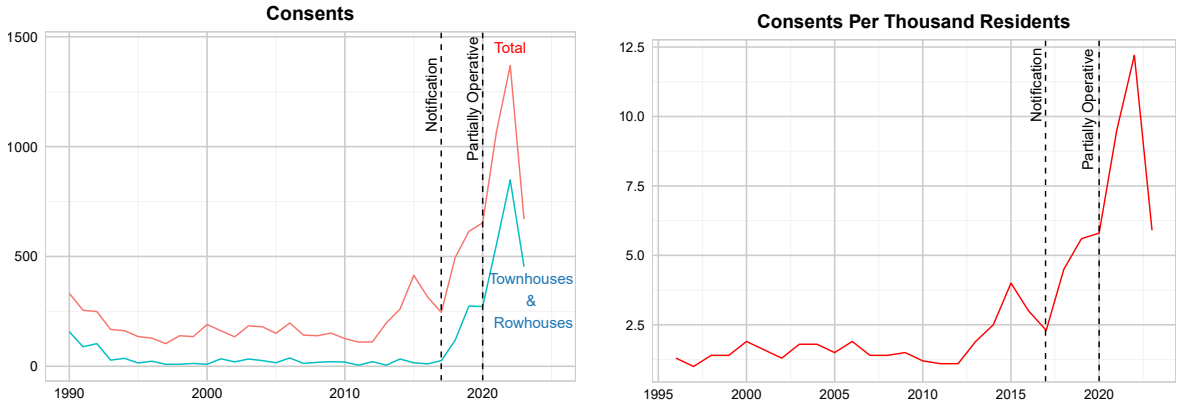
Lower Hutt's zoning reforms appear to have had a substantial impact on housing construction. Figure 1 exhibits consents for new dwellings (or housing starts) from 1990 (when the data begin) until 2023. In recent years, housing construction has reached record highs in both absolute levels and per capita terms. Until 2012, consents per thousand residents remained persistently low, fluctuating between one and two. After notification of the first widespread medium density reform in late 2017, annual consents per thousand residents increased from 2.3 to reach a record high of 12.2 by 2022.[2] This is a more than five-fold increase in the consenting rate. Consents then decreased between 2022 and 2023 as the New Zealand economy contracted.

This paper describes the sequence of policy changes and presents evidence that they have significantly increased housing starts in Lower Hutt. Using a synthetic control to specify the policy counterfactual, we find that the sequence of zoning reforms generated a three- to four-fold increase in the consenting rate, and tripled housing starts over the six years subsequent to the first medium density reform.

[1] Hutt City Council is the name of the local government for Lower Hutt City. It does not include Upper Hutt City, which is governed by Upper Hutt City Council.

[2] There is a local peak in the consenting rate in 2015 driven by a single retirement development that accounted for 184 of the 414 consents issued that year.

Figure 1: New Dwelling Consents in Lower Hutt, 1990 to 2023




Note: Vertical dashed lines refer to notification and partial operationalisation of Plan Change 43, the first widespread upzoning policy adopted in Lower Hutt. See section 2 for further details on these milestones and the timeline of the various zoning reforms in Lower Hutt.

We also present evidence that these reforms increased housing starts across the wider Wellington metropolitan region by between 12 and 17%. The reforms have a comparatively smaller impact on the Wellington region in part because Lower Hutt accounted for a disproportionately small number of housing starts prior to reforms. Lower Hutt accounted for only 13% of all new dwelling consents across the region in the ten years prior to the reform, despite being home to approximately one-in-four residents. Subsequent to the major medium density reform becoming operational, it accounts for 36% of all consents.

We are careful to adopt an empirical design that addresses common pathologies associated with the synthetic control method. First, we exclude the other cities in the Wellington metropolitan region from the donor pool of the synthetic unit, as they could plausibly be affected by the changes in Lower Hutt. Second, we implement a battery of robustness checks, including alternative empirical specifications. Third, we implement the conventional leave-one-out checks commonly used in the synthetic control literature. Fourth, we consider an alternative treatment timing for the policy intervention. Finally, we consider other possible explanations for dwelling consent growth, for instance migratory patterns driven by the COVID-19 pandemic.

We also consider whether reforms in Lower Hutt displaced consents in other jurisdictions within the wider metropolitan region. We do so by estimating a synthetic control for nearby municipalities, using Hutt City's reforms as the intervention, but excluding Lower Hutt from the donor pool. Estimated displacement effects are modest and statistically insignificant. Nonetheless, point estimates of the displacement effects imply a net increase in region-wide consents of between 12 to 17%, depending on the method adopted.

This paper makes several additional contributions to the literature. First, it adds empirical evidence to a debate on the effects of zoning reform that is frequently characterised by entrenched positions, including supply scepticism from many. Widespread zoning reforms in Zurich and Auckland have also been found to have a substantial impact on housing construction (Büchler and Lutz, 2021; Greenaway-McGrevy, 2023), but the limited number of case studies rightly raises concerns about the external validity of these findings. Lower Hutt provides an additional case study on the effectiveness of widespread reform. What is unique about the Lower Hutt example is that it unilaterally upzoned, showing that widespread reform within a fractured metropolitan governance structure can not only be implemented, but successfully stimulate housing supply.

A corollary is that the paper also adds to extant evidence that widespread reforms have vastly different effects than localized (or "spot") upzonings, where supply responses range from non-existent (Freemark, 2020) to a sizeable increase in the probability of development (Dong, 2021). This is consistent with arguments put forward by Phillips (2022), who argues that widespread zoning reform enables greater competition between landowners in supplying developable parcels to housing developers.

Second, it provides empirical evidence on how zoning reform in one jurisdiction impacts other jurisdictions within the same metropolitan area. Our results suggest that zoning reform in one municipality can be an effective policy tool to increase housing supply across the wider area, and need not merely displace construction in nearby municipalities.

Having established that upzoning increased housing starts in Lower Hutt, we conclude the paper by discussing possible reasons for Hutt City's decision to independently implement medium density zoning reforms. While we cannot make a definitive pronouncement, we suggest that several factors are likely to have contributed to the policy decision. These include Hutt City's unique public engagement process, which seeks to be more representative than the conventional public submissions process.

The remainder of the paper is organized as follows. The following section discusses the institutional background of the reforms in Lower Hutt. Section three discusses the data and our methodological approach. Section four discusses the results and section five contains robustness checks. Section six discusses potential factors that led Hutt City Council to pursue widespread zoning reforms. Section seven concludes.

# 2 Institutional Background

## 2.1 New Zealand

Zoning reform has prominently featured in New Zealand's policy landscape over the past decade. The first major reform occurred in Auckland, the nation's largest city. In March 2013, the Auckland City Council announced the first version of the Auckland Unitary Plan (AUP), which would enact planning reform across Auckland, allowing for a greater density in housing development across three quarters of the city's residential area (Greenaway-McGrevy and Jones, 2023). The plan was operationalised in November 2016, and led to a sizeable increase in housing supply (Greenaway-McGrevy, 2023).

The AUP was followed by nationwide reforms. In June 2020, the New Zealand Government released the National Policy Statement on Urban Development (NPS-UD), which required large cities to zone for residential structures of up to six stories within walking distance of rapid transit stations, and prevented councils from requiring developers to provide car parking (Ministry of Housing and Urban Development, 2020). Councils were required to implement these provisions over the following two years, removing parking requirements by February 2022, and operationalising these transit-oriented zoning reforms by August 2022 (Ministry of Housing and Urban Development, 2020). However, implementation was ultimately delayed beyond these deadlines.

In October 2021 the New Zealand Government announced the Medium Density Residential Standard (MDRS) requiring the most populous "tier one" cities (Auckland, Hamilton, Tauranga, Wellington, and Christchurch) to allow up to three dwellings and three storeys on residential parcels (Ministry of the Environment, 2022). This was initially a bipartisan proposal. Representatives of both the centre-left Labour government and opposition centre-right National Party featured in the media announcement (Greenaway-McGrevy, 2022) and both parties voted-in the legislation. However, the National Party subsequently pledged to abolish the MDRS as part of its campaign leading up to the October 2023 election (Brettkelly, 2022; Wilson, 2023), which it subsequently won. Most of the affected Councils have drafted compliant district plans, but none apart from Lower Hutt have operationalised the changes (as of February 2024).

## 2.2 Hutt City

Lower Hutt is the sixth most populous city in New Zealand, with an estimated population of 114,000 as of June 2023 (Stats NZ, 2023b). It is one of four major cities within the Wellington metropolitan region,

along with Wellington City, Porirua and Upper Hutt.[3] Lower Hutt is located around 20 kilometres from the Wellington CBD, meaning that many of its residents commute to jobs in Wellington City.

Like many largely suburban cities across the developed world, Lower Hutt has historically been zoned for low density housing. In 2017, 83% of the city's housing stock was situated in the *General Residential Activity Area*, which generally allowed for detached houses up to two storeys, subject to other requirements (e.g. setbacks, site coverage restrictions, building envelopes and outdoor space) (Hutt City Council, 2017c). Throughout the 2010s, Hutt City Council implemented spot upzonings and rezonings, largely converting recreational land to residential, and allowing for mixed-use development on the Petone foreshore.

Widespread regulatory changes to enable housing intensification in Lower Hutt began with Plan Change 39 ('Transport'), which reduced the parking requirement for new residential dwellings from generally two spaces per unit to one. The public were notified of this change in late 2016, before approval and operationalisation in 2018 (Hutt City Council, 2016).

A major zoning change then followed in November 2017, when Hutt City Council notified the public of District Plan Change 43 ('Residential and Suburban Mixed Use'), which was proposed to "provide for greater housing capacity and a wider range of options for housing styles and sizes at medium densities within the existing urban area of the district" (Stallinger, 2017; Hutt City Council, 2023a). Plan Change 43 spent the following two years in public consultation, before being approved in November 2019. It was partially operative from April 2020 and was fully operative from February 2021.[4]

Plan Change 43 introduced two new zones:

- *Suburban Mixed Use Activity Area*, which introduced a building height restriction of 12 metres (three to four storeys), and allowed for mixed use developments, including for apartments above shops or cafes.
- *Medium Density Residential Area*, with a building height restriction of ten metres, allowing for dwellings such as terraced and clustered houses.

These zones were concentrated in eight areas throughout the city, chosen for "their proximity to shops,

[3] The Wellington commuting zone also extends into a small part of the South Wairarapa Territorial Authority, which is a predominantly rural region.

[4] All parts of Plan Change 43 that were not subject to an appeal from the public were made operative in April 2020. Three appeals were lodged after the Plan Change was approved in November 2019. These were "relatively narrow in focus, with a total of thirteen rules and one policy affected" (Hutt City Council, 2023a). The remainder of Plan Change 43 was operationalised in February 2021 after the three appeals were resolved.

schools, public transport, and access to parks" (Hutt City Council, 2023a). Typically, each area targeted for upzoning consisted of a central Mixed Use Activity Area surrounded by blocks zoned as Medium Density Residential Area. These areas account for around 6 $km^2$, or around 8.3% of residential areas in Lower Hutt.[5]

Plan Change 43 also relaxed land use regulations in existing residential zones to allow greater density. Specifically, the General Residential Activity Area was altered to allow for medium density housing on sites larger than 1400 square metres, thereby permitting terraced and clustered houses on suitably large parcels in this otherwise low density zone. In this sense, the zoning changes were widespread, as they allowed for medium density housing even in the zone traditionally designated for low density, detached housing.

Hutt City Council has also been an early adopter of national policy directives enabling housing intensification. In September 2020, it became the first city in New Zealand to remove minimum car parking spaces as required under the NPS-UD, superseding the impacts of Plan Change 39 (Hutt City Council, 2023c). McCracken (2022) notes that these parking reforms had an immediate impact in Lower Hutt, with parking falling from an average of 1 space per dwelling in 2020 to 0.4 per dwelling in 2022. Hutt City also operationalised the MDRS and NPS-UD in 2023 as part of Plan Change 56 ('Enabling Intensification in Residential and Commercial Areas' (Hutt City Council, 2023b)). A new high density zone, which allows for up to six storeys, covers much of the flat land in the urbanised area of the city. Plan Change 56 was notified in August 2022 before becoming operational in September 2023. As of February 2024, Hutt City Council and Upper Hutt Council are the only tier one councils to have a compliant plan in operation.[6]

Together, these zoning reforms serve as a widespread upzoning 'package' consisting of four sequential policy changes implemented within a relatively short time frame: a *reduction* in parking minimums; a targeted medium density upzoning in central areas with a weaker but more widespread upzoning throughout remaining residential areas; an *abolition* of parking minimums; and a more recent blanket high- and medium- density upzoning that supersedes the previous reforms.

Decomposing the extent to which new housing supply is attributable to each Plan Change is difficult. However, the medium- and high- density reforms are likely to be primary enablers of increased housing supply in Lower Hutt. In low density areas, minimum lot sizes (MLS) and site coverage restrictions are

[5] Source: Authors' calculations based on Statistical Area 1 units that had residential dwelling construction between 2010 and 2022.

[6] Auckland Council operationalised the MDRS and NPS-UD on time in August 2022. The plan was subsequently suspended after a severe flood in January 2023.

the binding constraints on the number of dwellings that can be fit on a given parcel of land. For example, the General Residential Area had a minimum lot size of 400 square metres prior to Plan Change 43. A relaxation of parking minimums would have little effect on dwelling density when these binding constraints remain in place. The relaxation of parking minimums likely amplified the impact of the subsequent medium- and high- density reforms, but they would have had a smaller impact if they had been implemented in isolation. We focus on Plan Change 43 in much of our empirical analysis because it was the first widespread medium density reform.

Further complicating identification of policy effects is that Plan Changes are implemented gradually, not abruptly. Plan Changes begin to be considered in the assessment of dwelling consent applications after public notification. The weight given to the new regulations is initially small but increases as the decision date approaches and as the likelihood of adoption rises. Consequently, Plan Change 43 feasibly influenced applications from November 2017 onwards. Any influence would have initially been small, but gradually increased through to final approval in November 2019. The largest impacts are anticipated after Plan Change 43 became operational, as buildings compliant with the new regulations do not require specific permission from council.

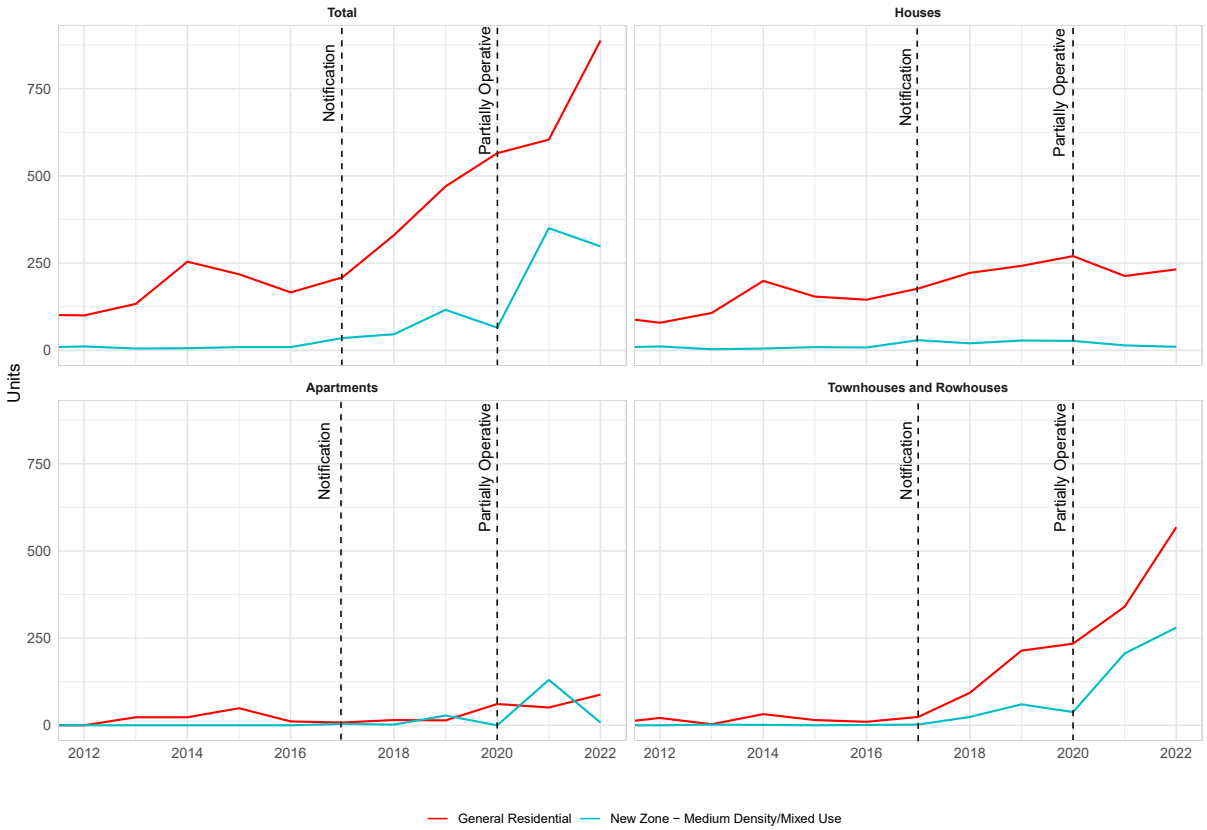
The time series depicted in Figure 1 are consistent with this narrative. Consents are flat from the mid 1990s until 2012, after which there is moderate growth, consistent with increased spot rezonings over the early 2010s. The growth rate in consents then increases significantly after 2017, with attached housing accounting for the majority of the subsequent increase in consents per year. This is consistent with Plan Change 43 having an increasing impact after notification. By 2019 attached housing accounts for the majority of new construction. There is then another increase in the growth rate of consents after Plan Change 43 is partially operative in 2020. However, since parking minimums were abolished in 2020 and Plan Change 56 was notified in 2022, it is difficult to disentangle the effects of Plan Changes 39 and 43 from these later policies. The higher growth rate lasts until 2022, when the national economy enters a technical recession.

To shed light on where the housing construction is occurring, Figure 2 presents consents decomposed into the medium density and general residential zones between 2012 and 2022.[7] We also decompose by housing type: Houses, Townhouses and Rowhouses, and Apartments. Interestingly, the increase in

[7]To assign consents to the different zones, we obtain new consents by Statistical Area 1 (SA1) and then assign each SA1 in Lower Hutt to a zone. According to Statistics New Zealand, a "Statistical Area 1 (SA1) is a statistical geography that is in between the meshblock and the statistical area 2 (SA2) geography. Built by joining meshblocks, SA1s have an ideal size range of 100-200 residents, and a maximum population of about 500" (Stats NZ, 2023a). SA1s in Lower Hutt usually correspond to a single residential block. Because the two new zones were often created at the block level, they closely align with SA1s. Consent data at the SA1 level were not yet available for 2023 at the time of writing, so we only have data at the SA1 level until 2022.

townhouses and rowhouses after notification of Plan Change 43 is located primarily in existing residential areas. After Plan Change 43 becomes partially operative, consents for townhouses and rowhouses increase in the newly-created medium density and mixed use zones, generating the second increase in consent growth between 2020 and 2022.

Figure 2: Dwelling Consents by Zone

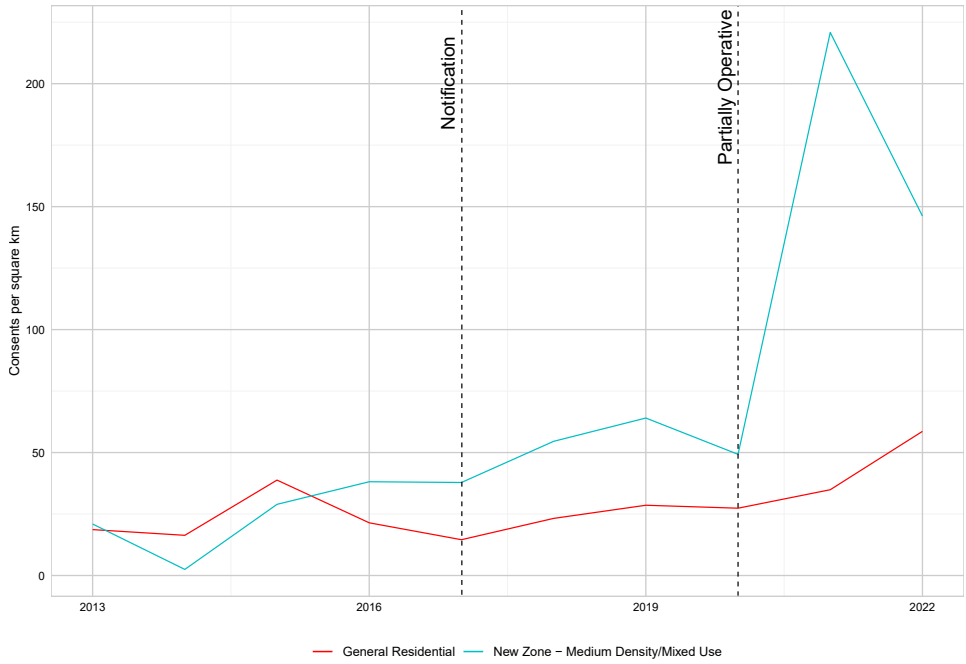



Notes: Vertical dashed lines refer to notification and partial operationalisation of Plan Change 43, the first widespread upzoning policy adopted in Lower Hutt. 'Medium Density/Mixed Use' refers to SA1s that include the newly created Suburban Mixed Use Activity Zone and the Medium Density Residential Area under Plan Change 43. 'General Residential' consists of all other SA1s zoned residential. The General Residential zone allows medium density construction on >1400m parcels under Plan Change 43. Five SA1s that were spot upzoned or rezoned in the 2010s are also not depicted. 'Retirement Village Units' are excluded for visual clarity.

Much of the overall increase since 2017 has occurred in the General Residential Area. This is unsurprising, as (i) this zone covers the most land, and (ii) it was also subject to a relaxations in land use regulations to allow medium density housing on large parcels, and infill housing. To illustrate that re-

forms has generated more intensive use of land, we also plot consents per square kilometre in Figure 3.[8] There is a dramatic increase in dwelling density in the medium density zones after partial operationalisation of Plan Change 43 in 2020.

Figure 3: Dwelling Consents per Square Kilometre by Zone




Notes: Vertical dashed lines refer to notification and partial operationalisation of Plan Change 43, the first widespread upzoning policy adopted in Lower Hutt. 'Medium Density/Mixed Use' refers to SA1s that include the newly created Suburban Mixed Use Activity Zone and the Medium Density Residential Area under Plan Change 43. 'General Residential' consists of all other SA1s zoned residential. SA1s without any residential construction over the period are excluded. The General Residential zone allows medium density construction on >1400m parcels under Plan Change 43. Five SA1s that were spot upzoned or rezoned in the 2010s are also not depicted. Consents include all dwelling categories, including 'Retirement Village Units'.

### 2.2.1 Other Residential Development Policies in Lower Hutt

Lower Hutt also implemented other development policies during the 2010s that plausibly affected housing construction:

- The "Development Stimulus Package", which waived resource consent and building consent fees.

[8] We omit areas without residential construction between 2010 and 2022 when calculating consents per square km.

The policy ran from July 2012 to December 2018. Council figures suggest there were 294 applications using the policy over this period (Tso, 2019).

- Hutt City Council raised infrastructure contribution rates for developers in July 2021 to address the need for more infrastructure growth and upkeep (Tso, 2021).

These policies do not threaten our empirical design, and in most cases will likely result in us underestimating the impact of reforms on housing supply. See section 3.4 for additional discussion.

### 2.3 Wellington Region

The Wellington Region occupies the southernmost part of the North Island of New Zealand and is home to approximately 543,000 people. Its four main cities of Wellington City, Lower Hutt, Upper Hutt, and Porirua account for around 79 percent of the population of the region. The largest of these is Wellington City, the capital of New Zealand, with a population of around 212,000. (Stats NZ, 2023b). The other major population hub in the region is the Kapiti Coast, with a population of just above 50,000, consisting of several towns and coastal settlements. Kapiti Coast is part of the Wellington Region but constitutes its own distinct commuting zone under Statistics New Zealand's delimitation of urban areas.

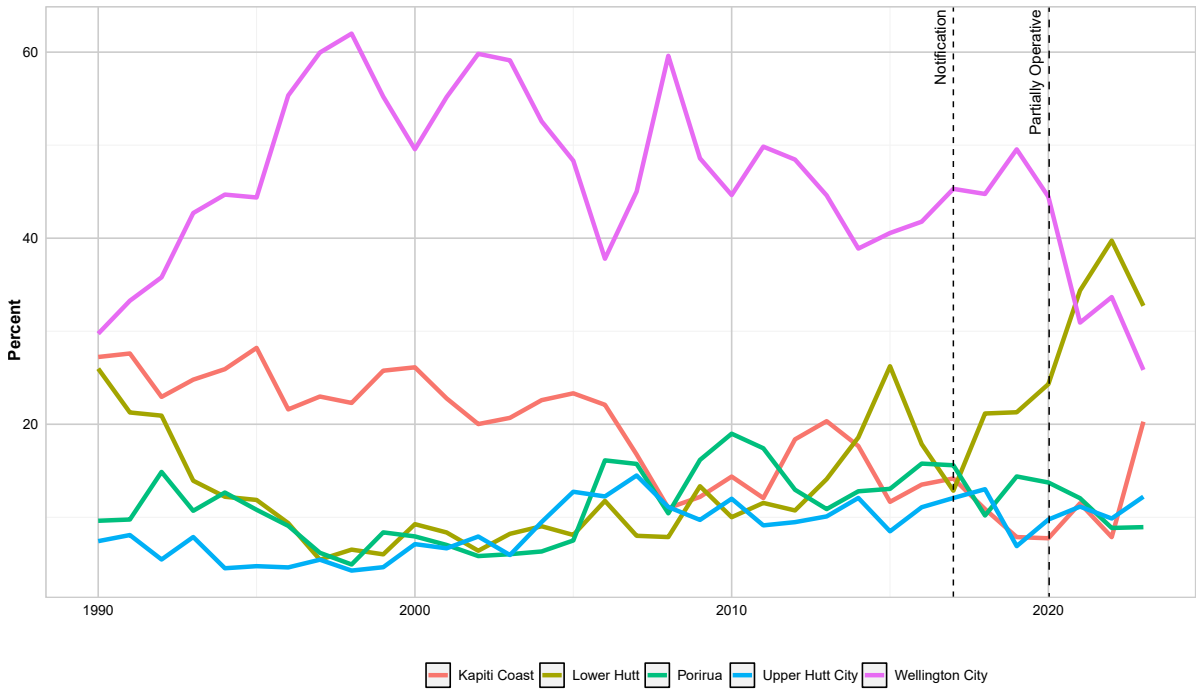
Unlike Hutt City Council, the other constituent councils of the Wellington metropolitan area have not implemented widespread zoning reform. Wellington City released a draft district plan to comply with the MDRS and NPS-UD in late 2021, with the public notified of the proposed district plan in July 2022. The parts of the plan related to intensification under the MDRS and NPS-UD were originally scheduled to meet the required timelines, but are now subject to come into force in late 2023 (Wellington City Council, 2023). Upper Hutt Council and Porirua Council comply with the MDRS through their Intensification Planning Instruments (IPI), but both Councils sought and received permission to delay decisions to adopt the plans until December 2023.[9] Given the National Party's policy to repeal the MDRS, it is unclear whether the councils will retain plans to allow intensification.

Therefore, there is a policy divergence within the Wellington Region. Beginning in late 2017, Hutt City Council unilaterally undertook a sequence of policy changes that made it easier to build medium density housing, while other councils in the metro region have not. Since the Plan Change 43 reform has become operational, Lower Hutt has accounted for a disproportionately large share of all housing starts within the Wellington region. Figure 4 depicts the share of consents by territorial authority for the five territorial authorities. Between 2021 and 2023, 36.1% of housing starts were located in Lower Hutt, despite it

[9] See https://www.upperhuttcity.com/Your-Council/Plans-policies-bylaws-and-reports/District-Plan/Intensification-Planning-Instrument-IPI and https://poriruacity.govt.nz/your-council/city-planning-and-reporting/district-plan/proposed-district-plan/. Upper Hutt's IPI became fully operational in December 2023, while Porirua's IPI has been notified.

being home to approximately one-quarter of residents and accounting for 17.8% of land area across the five territorial authorities. In fact, since 2021, the plurality of consents have been located in Lower Hutt. Meanwhile, over the ten years prior to notification (2007 to 2016), Lower Hutt accounted for only 13.2% of all consents.

Figure 4: Proportion of Consents in Wellington Region by Territorial Authority




Notes: 'Vertical dashed lines refer to notification and partial operationalisation of Plan Change 43, the first widespread upzoning policy adopted in Lower Hutt.

# 3 Data and Methodology

## 3.1 Synthetic Control Method

This section provides an overview of the Synthetic Control (SC) method.[10] Readers familiar with SC may wish to proceed to the next subsection.

We have time series data on an outcome of interest for $N+1$ units indexed by $i = 1, ..., N+1$, where $i = 1$ corresponds to the unit receiving the policy intervention, and $i = 2, ...., N+1$ indexes the "donor pool", a collection of untreated units that is unaffected by the intervention. Observations on the outcome

[10] We borrow heavily from Greenaway-McGrevy (2023), which also applies the synthetic control method to housing starts.

of interest span $t = 1, ..., T$, where the observations prior to intervention span $t = 1, ..., T_0$, $T_0 < T - 1$.

$y_{i,t}$ denotes the observed outcome of interest for unit $i$ in period $t$. Let $y^N_{i,t}$ be the outcome without intervention for each $i$, while $y^I_{1,t}$ is the outcome under the intervention for the affected unit in period $t > T_0$. A synthetic control is defined as a weighted average of the units in the donor pool. Given a set of weights $w = (w_2, ..., w_{N+1})$, the synthetic control estimator of $y^N_{1,t}$ is $\hat{y}^N_{1,t} = \sum_{i=2}^{N+1} w_i y_{i,t}$. The effect of the intervention is then $y^I_{1,t} - \hat{y}^N_{1,t}$.

Abadie and Gardeazabal (2003) and Abadie et al. (2010) choose $\boldsymbol{w}$ so that the resulting synthetic control best resembles a set of pre-intervention "predictors" for the treated unit (below we refer to these as "matching variables"). For each $i$, there is a set of $k$ observed predictors of $y_{i,t}$ contained in the vector $X_i = (x_{1,i}, ..., x_{k,i})$, which can include pre-intervention values of $y_{i,t}$ unaffected by the intervention. The $k \times N$ matrix $\boldsymbol{X}_0 = [X_2 \cdots X_{N+1}]$ collects the values of the predictors for the $N$ untreated units. Abadie and Gardeazabal (2003) and Abadie et al. (2010) select weights $w^* = (w^*_2, ..., w^*_{N+1})$ that minimize

$$\|X_1 - \boldsymbol{X}_0 \boldsymbol{w}\|_{\boldsymbol{v}} = \left( \sum_{h=1}^{k} v_h \left( x_{h,1} - w_2 x_{h,2} - ... - w_{N+1} x_{h,N+1} \right)^2 \right)^{1/2} \tag{1}$$

subject to the restrictions $w_i \in [0, 1]$ and $\sum_{i=2}^{N+1} w_i = 1$, and where $\boldsymbol{v} = (v_1, ..., v_k)$ is a set of non-negative constants. Following Abadie et al. (2010), we choose $\boldsymbol{v}$ to assign weights to linear combinations of the variables in $\boldsymbol{X}_0$ and $X_1$ that minimize the root mean squared prediction error (RMSPE) between the synthetic control and the outcomes of the treated unit over the pre-treatment period. This helps ensure that the synthetic control time series tracks the outcome variable prior to the intervention. Then, the estimated treatment effect for the treated unit at time $t = T_0, \ldots, T$ is $\hat{y}^N_{1,t} = \sum_{i=2}^{N+1} w^*_i y_{i,t}$. Weights $\boldsymbol{w}$ that minimize (1) can found using standard quadratic programming solvers.

### 3.2 Data

We utilise residential building data released by Statistics New Zealand (Stats NZ), the nation's official statistical agency. Our outcome variable of interest are consents for new dwellings per thousand residents. Consents are comparable to a permit or an approval in other countries.[11] Like Greenaway-McGrevy

[11] Consents are not completions. Unfortunately Statistics New Zealand does not track completions under its suite of official statistics. It does produce experimental estimates based on the issuance of a 'code of compliance certificate' (CCC). However, these are aggregated across different Territorial Authorities (TAs) and many TAs are not included. For the TAs included, the proportion of consents that received a CCC over the ten years to December 2018 was 91.2%, on average (Stats NZ, 2022). Using CCC issuance understates completions to a habitable standard since dwellings can be inhabited without a CCC. Using final building inspection as a measure of completion results in a rate of 92.9% over the ten years to December 2018. Until 2017, SNZ surveyed developers to measure completions, resulting in a completion rate above 95% in recent years (Stats NZ, 2017).

(2023) we express dwelling consents in relation to the resident population, such that it measured as 'consents per thousand residents'. This normalisation ensures comparability of construction rates between different regions.[12] We also consider other transformations where the outcome variable is not normalised by resident population. These results are reported in the robustness section and the Appendix.

We subtract the pre-treatment average from the time series of outcomes prior to treatment (Ferman and Pinto, 2021). Abadie (2021) emphasizes that the validity of the synthetic control approach hinges on its ability to replicate the treated unit's outcome prior to intervention. De-meaning the outcome variable can allow the comparison group to reproduce the changes in the outcomes for the treated unit even if the level of the outcome variable cannot be reproduced. The de-meaning normalization results in substantial reductions in pre-treatment Mean Squared Prediction Error (MSPE), suggesting that it is useful in our application. This is also relevant as our method for identifying displacement effects is based on whether the intervention in Lower Hutt has a clear and persistent impact on nearby locations. This requires the synthetic control method to satisfactorily fit pre-treatment outcomes across a variety of units, not just the treated unit.

Our data is at the territorial authority (TA) level. Territorial authorities are the second tier of local government in New Zealand, below regional councils, and are responsible for drafting and implementing spatial plans and land use regulations. There are 67 TAs in New Zealand. We remove Auckland from our donor pool, as it underwent a widespread upzoning under the AUP in 2016, making it subject to the same policy intervention as the treated unit. We also remove Christchurch City, due to the idiosyncratic effects of the 2011 Earthquake on the housing market.[13] Finally, we remove Chatham Islands Territory due to its small size and location far offshore from the mainland. This leaves us with 64 TAs.

Data are reported monthly. We aggregate to annual as monthly consents exhibit substantial volatility and excessive idiosyncratic variance impairs the accuracy of the synthetic control (Abadie, 2021).

### 3.3 Matching Variables

As demonstrated above, the synthetic control method selects comparable controls by matching outcomes prior to the policy intervention. We consider two sets of matching variables.

[12] A drawback of this approach is that sub-national population data are only available from 1996 onwards. This reduces pre-treatment years available for matching.

[13] As noted by Abadie (2021), donor units with large idiosyncratic shocks to the outcome variable during the study period should be omitted. Donor units subject to the same treatment should also be omitted.

**Main Specification**. Under our main specification, the matching variables consist of the outcome of interest for each pre-intervention time period (i.e., 1996 to 2017). Using the maximum range of our pre-intervention time series data reduces the bias in the synthetic control, (Abadie et al., 2010; Abadie, 2021) and ensures that we minimise the pre-intervention MSPE.

**Alternative Specification**. The set of matching variables consist of housing market, economic, and demographic characteristics for each TA:

- Intercensal population growth: The logged difference in population between censuses, observed in 2001, 2006, 2013, and 2018.
- Intercensal personal income growth: The logged difference in average personal income between censuses.
- Dwellings per capita: The number of occupied private dwellings per resident person in census years.
- Projected population growth: The 'medium' forecast annualised rate of population growth published by Stats NZ in 2013 and 2018. This projection is the average rate of population growth expected in the TA until 2040.

We also match on the outcome variable in census years (2001, 2006, 2013) as well as the final pre-treatment intervention year, 2017.[14]

### 3.4 Treatment Timing

Selection of a treatment date is complicated because Lower Hutt gradually implemented a sequence of zoning reforms from the late 2010s through to the early 2020s (see section 2.2 above). We select 2018 as the beginning of the treatment period, which is the first full year after Plan Change 43 is notified in November 2017. We do this for three reasons:

- Plan Change 43 is the first widespread medium density zoning reform in the sequence. It is only preceded by a reduction in parking minimums (from generally two to one) under Plan Change 39 that was unlikely to enable significant increases in medium density housing without the subsequent relaxations in land use regulations. However, Plan Change 39 was notified in late 2016 and partially operative in 2018, meaning that the combined effects of the new medium density regulations and parking reductions are captured in the policy evaluation exercise.

[14]The charts displayed in the body of this paper will be from the main specification. Charts utilising the alternative specification are reported in the Appendix.

- Abadie (2010) recommends that beginning of the treatment period be set to the "first period in which the outcome may possibly react to the intervention". Plan Change 43 potentially influenced consent application decisions after notification, and the observed increase in consents for attached housing from 2018 onwards is consistent with Plan Change 43 influencing decisions from this point onwards.[15]
- It is also plausible that notification caused developers to delay planned construction until zoning changes were confirmed. If this occurred, setting a later treatment date would result in an overstated policy effect, as it would misidentify consents that were simply delayed until after the plan was operative as policy impacts.

Before proceeding, we note that the goal of the policy evaluation exercise is to measure the impact of the sequence of reforms, and not Plan Change 43 independently of the other zoning changes in the sequence. We cannot disentangle the combined effect of Plan Change 39 and 43, the subsequent abolition of parking minimums, and the further medium- and high- density reforms under Plan Change 56. These will all be captured in estimated policy impacts. Instead, notification of Plan Change 43 serves to determine our treatment date because it was the first widespread medium density reform in the sequence.

As discussed in section 2.2.1, there was another housing policy designed to stimulate consents during the 2010s: The Development Stimulus Package, which waived resource consent and building consent fees from 2013 through to 2018. The cessation of the policy coincides with notification of medium density zoning reform in 2018, meaning that any negative impacts from ending the policy will be mis-attributed to the zoning reforms, causing estimated policy effects to be biased downwards. If these concessions stimulated construction during the pre-treatment period, TAs with persistently higher housing construction are more likely to be selected as donors, again causing policy impacts to be underestimated in the post-treatment period. Similarly, any reduction in housing starts due to the increase in developer contributions from 2021 onwards (see section 2) will also bias estimated policy impacts downward.

We also use a later treatment date as a robustness check, setting the treatment period to begin in 2020, which is the first year after Plan Change 43 became partially operative. See section 5.1.

[15] Alternatively, if the reduction in parking minimums independently caused the increase in attached housing from 2018 onwards, then the 2018 date at least coincides with operationalisation of Plan Change 39. However, in this case setting the post-treatment period to begin in 2017 would be appropriate as this is the first full year after notification.

# 4 Results

## 4.1 Lower Hutt

We begin by analysing the directly treated unit, Lower Hutt. Our donor pool consists of 59 territorial authorities outside of the Wellington metropolitan region (Upper Hutt, Porirua City, Kapiti Coast, and Wellington City are omitted).

Table 1 exhibits the selected weights for the main and alternative specifications (see section 3.3 for a description of each specification). For the main specification, several donors are drawn upon, with the largest weight allocated to the Timaru District (0.583), which is located on the east coast of the South Island with a population of around 50,000. The largest urban area in the district is Timaru, which is home to approximately one half of the district's population and is classified as a "medium" urban area by Statistics New Zealand. The alternative specification draws upon a different set of donors, relying heavily on the South Waikato District (0.513) and the Tasman District (0.204). South Waikato is located in the North Island of New Zealand, and has a comparable rate of population growth to Lower Hutt. It's main urban centre is Tokoroa, which is home to half of the district's population and is classified as a "medium" urban area. Meanwhile, Tasman District is located on the northern tip of the South Island and has a population of around 50,000. Much of its eastern portion is part of the Nelson urban area. Richmond is the largest town in the region, accounting for about a third of the population, and is located 13km south of the city of Nelson. The "small" urban area of Motueka accounts for another 13% of the district's population.

Table 1: Donor Unit Weights for Lower Hutt

| Donors | Main Specification | Alternative Specification |
|---|---|---|
| Gore District | - | 0.108 |
| Opotiki District | 0.088 | - |
| Selwyn District | 0.003 | - |
| South Waikato District | 0.024 | 0.513 |
| Tararua District | - | 0.069 |
| Tasman District | 0.07 | 0.204 |
| Tauranga City | - | 0.001 |
| Timaru District | 0.583 | - |
| Waimakariri District | - | 0.081 |
| Waipa District | 0.075 | - |
| Wairoa District | 0.158 | - |
| Waitomo District | - | 0.004 |
| Whanganui District | - | 0.019 |

The 'main specification' matches normalised dwelling consents per thousand residents in all pre-treatment years. The 'alternative specification' matches census characteristics and normalised dwelling consents per thousand residents in census years.

Figure 5 exhibits the actual and synthetic consents per thousand residents in Lower Hutt under the main specification. There is a steady but notable divergence from 2018 onwards, with the actual consenting rate growing rapidly, while its synthetic counterpart remains at approximately the same level. Synthetic consents per thousand residents are 2 in 2018, 2.02 in 2019, 2.33 in 2020, 2.94 in 2021, 3.15 in 2022, and 1.95 in 2023. Meanwhile actual consents per thousand residents was 4.5, 5.6, 5.8, 9.5, 12.2 and 5.9 in these years.[16] The impact of the reforms peaked in 2022, generating nearly a four-fold increase in the consenting rate (= 12.2/3.15).

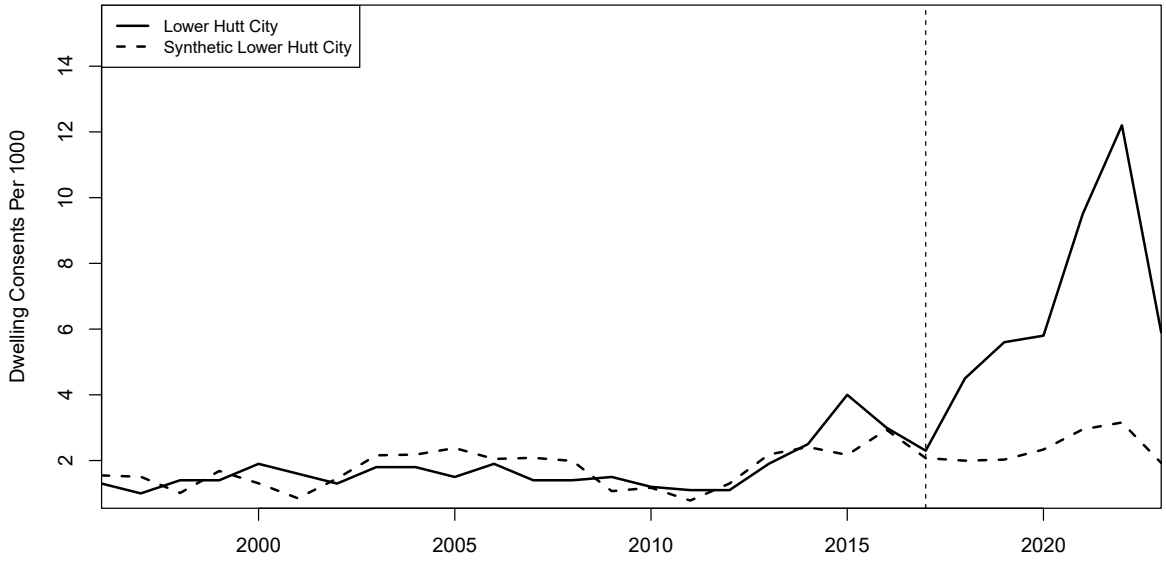
Notably, there is a substantial fall in both actual and synthetic consenting rates between 2022 and 2023. There was a decline in housing starts across New Zealand over this period that can likely be attributed to a sharp rise in interest rates over the preceding years and an economic contraction.[17] Upzoning appears to have insulated Lower Hutt from some of this cyclical decline, with its consenting rate remaining over three times larger than the synthetic counterfactual, and indicating that the widespread upzoning stimu-

[16]Lower Hutt's consenting rate reached the same level as that of Auckland in 2022 (Greenaway-McGrevy, 2023), which had upzoned in 2016.

[17]The central bank increased the official cash rate from 0.25% in mid 2021 to 5.5% in 2023. Meanwhile, GDP growth was negative in the December 2022, March 2023 and September 2023 quarters.

lated housing starts despite the macroeconomic contraction.

Figure 5: Synthetic and Actual Consents per Thousand Residents for Lower Hutt




We can also calculate the number of new consents generated by the zoning changes by taking the difference between actual and synthetic consents.[18] Approximately 3260 additional units were consented between 2018 and 2023, which is equivalent to 66% of the 4867 consents issued over this period. Reforms therefore tripled the number of housing starts over the six years since notification of Plan Change 43.

To assess whether the increase relative to the counterfactual is statistically significant, we run placebo interventions on the other donor units and implement the Abadie et al. (2010) rank permutation test. Define the Mean Squared Prediction Error (MSPE) between the synthetic and actual outcomes as:

$$R_i(t_1, t_2) = \frac{1}{t_2 - t_1} \sum_{t=t_1}^{t_2} (Y_{i,t} - \hat{Y}_{i,t}^N)^2 \tag{2}$$

The above is the MSPE between time periods $t_1$ and $t_2$. We then take the ratio of the MPSE of the intervention period relative to the pre-intervention period as a measure of the post-treatment fit of the synthetic control:

$$r_i = \frac{R_i(T_0 + 1, T)}{R_i(1, T_0)} \tag{3}$$

[18] Synthetic consents are obtained by multiplying synthetic dwellings per thousand residents by Lower Hutt's population (in 000s).

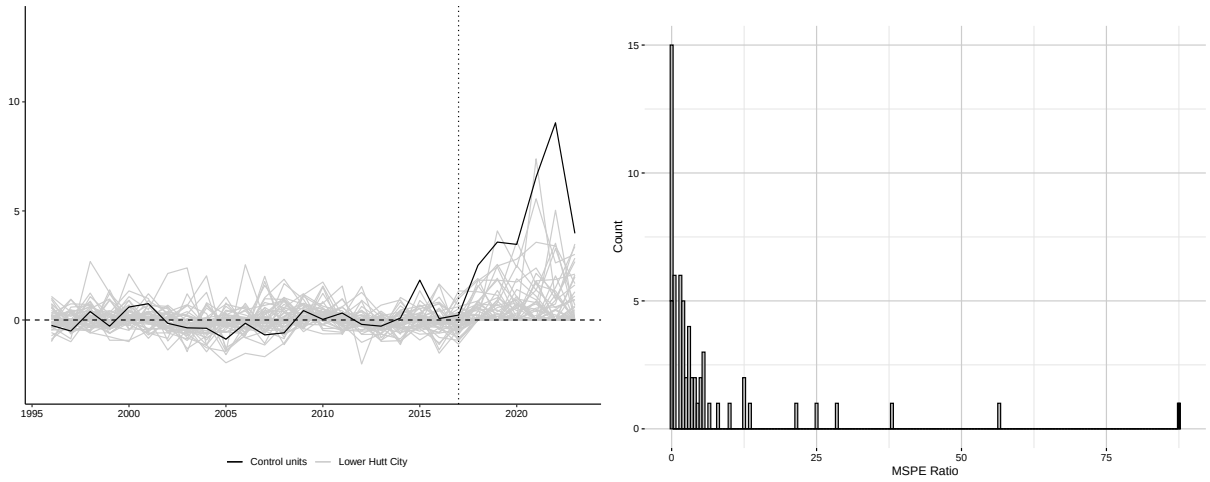
A drawback of the ratio is that it does not distinguish between positive and negative deviations from the synthetic unit, whereas many hypotheses posit a directional change from an intervention. In this case, the relevant alternative hypothesis is that intensification reforms increased consents. Increases in power can be obtained by testing for increases relative to the synthetic control, rather than differences (Abadie, 2021). We therefore define:

$$R^{+}(t_1, t_2) = \frac{1}{t_2 - t_1} \sum_{t=t_1}^{t_2} \left( \lfloor Y_{i,t} - Y_{i,t}^{N} \rfloor \right)^2 \tag{4}$$

where $\lfloor x \rfloor = 0$ if $x > 0$ and $\lfloor x \rfloor = x$ otherwise. We refer to this as the "Positive Error MSPE ratio", or PE-MSPE-R. In later sections, where we it is plausible that construction could have deviated in either direction in response to the policy, we allow for two-tailed test.

Figure 6 plots the prediction errors and the PE-MSPE-R for Lower Hutt and each donor unit. Lower Hutt has the largest PE-MSPE-R, at 87.6, meaning that if we were to assign the intervention at random, the probability of obtaining a ratio as large as Lower Hutt is 0.017 (=1/60).

Figure 6: Prediction Errors and PE-MSPE-R for Lower Hutt




Note: Prediction errors depicted on left, positive error MSPE ratios on right. Lower Hutt highlighted in black.

### 4.1.1 Alternative Specification

Figure 18 in the Appendix depicts actual and synthetic consenting rates under our alternative specification, where we match on a variety of housing, economic and demographic variables. Results are similar to those of the main specification, with the actual consenting rate far exceeding its synthetic counterpart by a substantial and growing margin between 2018 and 2022. The synthetic consenting rate peaks at

4.0 consents per thousand residents in 2022, when the actual rate is 12.2. This implies that the zoning changes caused an over three-fold increase in the consenting rate (= 12.2/4). As under the main specification, the increase is statistically significant. The PE-MPSE-R is 37.35 and is by far the largest in the donor set, corresponding to a p-value of 0.017. The implied increase in housing starts is similar to the main specification. Actual consents exceed the synthetic control by 3118, which is 64% of the 4867 consents issued in Lower Hutt between 2018 and 2023.

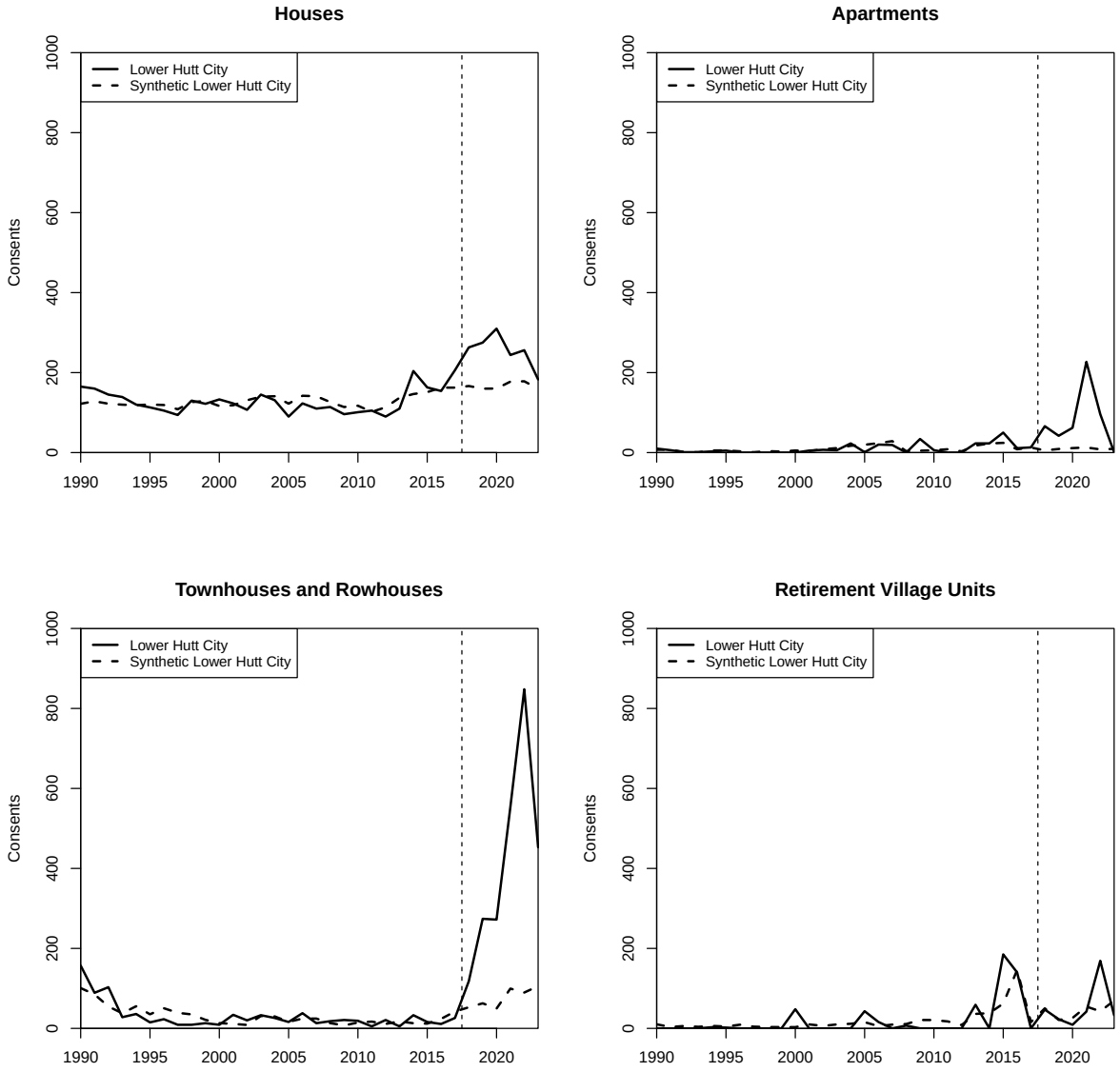
## 4.2 Results by Housing Type

In this subsection we investigate how upzoning may have affected different types of building in Lower Hutt. The outcome variable is normalised consents per thousand for the four types of housing recorded in New Zealand: houses, apartments, townhouses and rowhouses, and retirement village units.[19]

Figure 7 depicts actual and implied synthetic consents for the different housing types. We begin with townhouses and rowhouses, as these housing forms have been the main contributor to new housing supply (see section 2). Dwelling consents for townhouses and rowhouses were eight times higher than their implied counterfactual in 2022. Consents for apartments also increase relative to the synthetic control, having barely featured in Lower Hutt's housing market prior to the reforms. Consents for detached houses slightly exceed their synthetic counterfactual, although this increase is comparatively small.

[19] We refit a synthetic control based on matching consents per thousand for the relevant housing type, similar to the main specification. Donor weights are available upon request. Results for the alternative specification are similar to the main specification and omitted for brevity.

Figure 7: Synthetic and Actual Consents by Housing Type




## 4.3 Spillovers

In this subsection investigate whether the reforms in Lower Hutt have affected construction in the other constituent cities of the Wellington area. On the one hand, reforms may have displaced housing in other cities through a reallocation of construction inputs to Lower Hutt. On the other, the they may have increased housing consents in nearby cities by spurring investment in the construction sector or through single-family houses exported from redeveloped parcels. With an estimate of the spillover effect at hand,

we can then produce an estimate of policy effects of the Lower Hutt reforms on the wider Wellington metropolitan region.

To estimate the magnitude of these potential spillover effects, we generate a synthetic control for each of the four other largest TAs in the wider Wellington metropolitan region (Wellington City, Porirua City, Upper Hutt, and the Kapiti Coast District), taking the Lower Hutt reforms as the policy intervention. We exclude Lower Hutt and the three other TAs from the donor pool when conducting this exercise. This ensures that the synthetic controls are constructed from units that are less likely to be affected by intra-regional spillovers.

Table 2 reports the donor weights under the main and alternative specifications for the four TAs. Notably, there is substantial heterogeneity in the donor units selected. For example, South Waikato features for both Upper Hutt and Porirua under both the main and alternative specifications, while Tasman feature for both Wellington City and Kapiti Coast. Thames-Coromandel features heavily for Kapiti Coast under both specifications. Like the Kapiti Coast, the region is a popular holiday and retirement destination for residents of nearby cities.

Table 2: Donor Unit Weights for other Territorial Authorities in Wellington Metropolitan Region

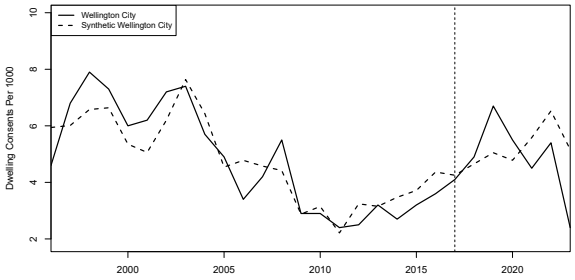
| | Upper Hutt | | Porirua | | Wellington City | | Kapiti Coast | |
|---|---|---|---|---|---|---|---|---|
| **Territorial Authority** | **Main** | **Alt** | **Main** | **Alt** | **Main** | **Alt** | **Main** | **Alt** |
| Ashburton District | - | 0.125 | - | - | - | - | - | |
| Central Hawke's Bay District | 0.164 | - | - | - | - | - | - | |
| Clutha District | 0.28 | - | - | - | - | - | - | |
| Horowhenua District | 0.08 | - | 0.208 | - | - | - | - | |
| Hurunui District | 0.074 | - | - | - | 0.106 | 0.113 | 0.177 | |
| Kawerau District | - | 0.089 | 0.105 | 0.527 | - | - | - | |
| Manawatu District | - | 0.203 | - | - | - | - | - | |
| Masterton District | 0.077 | - | - | - | - | - | - | |
| New Plymouth District | 0.025 | - | 0.191 | - | - | - | - | |
| Opotiki District | - | - | - | - | 0.505 | - | 0.272 | |
| Otorohanga District | - | - | - | 0.101 | - | - | - | |
| Palmerston North City | - | 0.132 | - | - | - | - | - | |
| Queenstown-Lakes District | - | 0.035 | - | - | - | - | - | |
| Rotorua District | - | - | - | - | - | 0.4 | 0.272 | |
| Selwyn District | - | 0.031 | - | - | - | - | - | |
| South Waikato District | 0.021 | 0.213 | 0.233 | 0.17 | - | - | - | |
| Southland District | - | 0.037 | - | - | - | - | - | |
| Tasman District | - | - | - | - | 0.311 | 0.479 | 0.109 | 0.286 |
| Tauranga City | - | - | - | - | 0.047 | - | 0.184 | |
| Thames-Coromandel District | - | - | - | - | 0.031 | - | 0.259 | 0.375 |
| Waikato District | 0.216 | - | - | 0.163 | - | - | - | |
| Waimakariri District | - | - | - | - | - | 0.008 | - | 0.066 |
| Waipa District | - | 0.119 | 0.032 | - | - | - | - | |
| Wairoa District | 0.048 | - | 0.231 | - | - | - | - | |
| Waitomo District | 0.003 | - | - | - | - | - | - | |
| Whanganui District | - | 0.004 | - | 0.039 | - | - | - | |

Donors given a weight of less than 0.2% are omitted for visual clarity. 'Main' refers to our main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to our alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

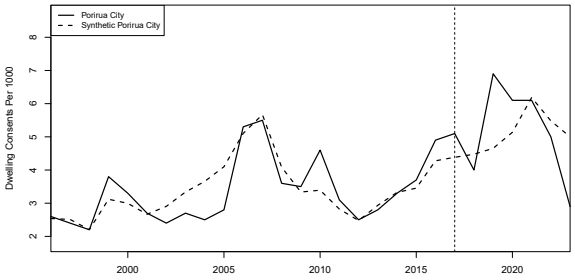
Figure 8 displays the synthetic and actual consenting rates for the four TAs under the main empirical specification.

Figure 8: Synthetic and Actual Consents per Thousand Residents for other Territorial Authorities in Wellington Metropolitan Region

(a) Wellington City

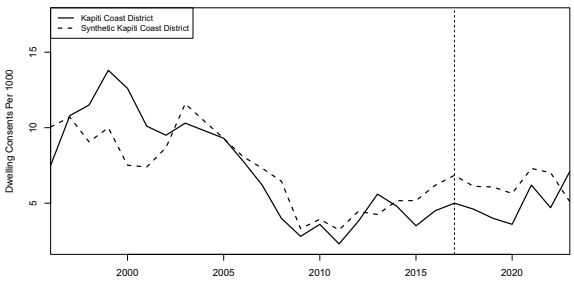



(b) Porirua




(c) Upper Hutt


(d) Kapiti Coast




To test whether these deviations are statistically significant, we conduct a two-tailed MSPE ratio test against other donors. None of the TAs rank highly. Wellington City ranks 36th out of 60 (p = 0.6), Porirua ranks 27th (p = 0.45), Upper Hutt ranks 20th (p = 0.33), and Kapiti Coast ranks 47th (p = 0.78). There is no statistical evidence to support spillovers under the main empirical specification.

Although there is no statistical evidence to support displacement effects (or spillovers more generally), it is nonetheless prudent to allow for them to ensure that estimated policy effects on the wider metropolitan region are conservative. To this end, we can use the deviations between actual and synthetic consents in the four TAs to estimate the size of spillovers. Actual consents in Porirua and Upper Hutt follow their synthetic controls closely, deviating by a cumulative total of 1 and -38 dwellings, respectively. Wellington City exceeds its synthetic control until 2020, after which it falls below its counterfactual. This could be due to displacement, but it is also plausible that this is driven in part by out-migration from the city during the COVID-19 pandemic.[20] Wellington City lags its counterfactual by a cumulative total of 491 units over the post-treatment period. Finally, Kapiti Coast trails its synthetic control throughout most of the post-treatment period, with a cumulative deficit of 394 units.

[20] Wellington City's population fell by around 1.5% from 2020 to 2022.

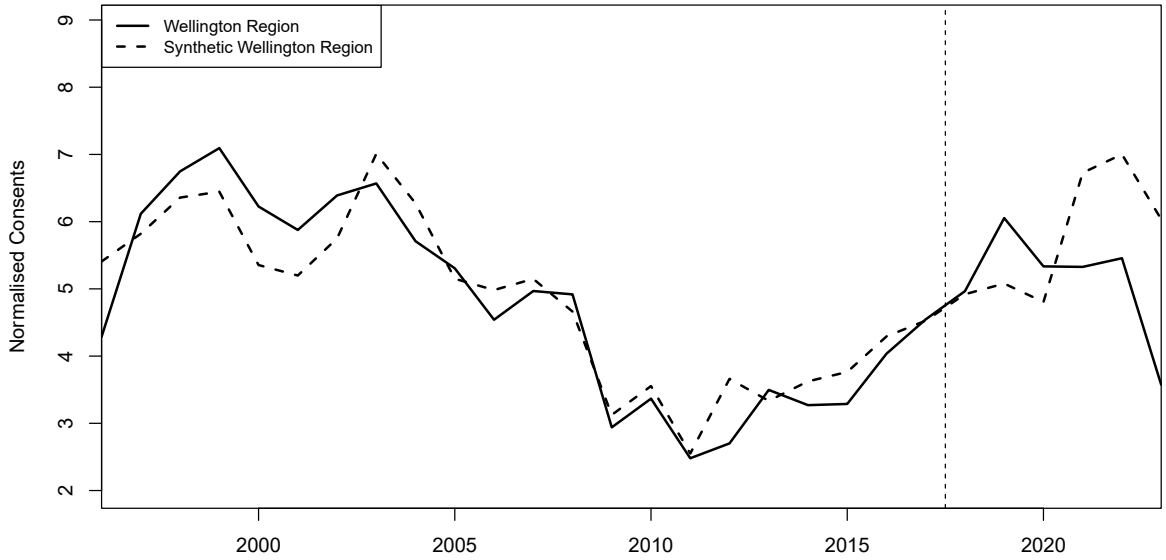
The cumulative difference across the four TAs is therefore a deficit of 921 units. If we attribute this deficit to displacement from the Lower Hutt reforms, it implies that roughly one-in-four consents in Lower Hutt displaced a consent elsewhere in the region (28% = 921/3260) and that housing starts across the Wellington metropolitan region increased by 2339 units (=3260-921). Over the six post-reform years, a total of 16,501 consents were issued in the five territorial authorities (Wellington City, Lower Hutt, Upper Hutt, Porirua and Kapiti Coast). The net increase of 2339 consents across the Wellington metro area therefore corresponds to a 16.5% (=2339/(16,501-2339)) increase in housing starts.

We also explore whether there is stronger statistical evidence for spillovers by amalgamating the four other TAs in the wider Wellington metropolitan region (Wellington City, Porirua, Upper Hutt and Kapiti Coast) and repeating the exercise.[21] Note, however, that there is substantial heterogeneity in the selected donor units when the synthetic control is fitted to the individual TAs, which is indicative of significant differences in measured outcomes. Selected donor units are likely to be pulled towards the largest TA in the group, Wellington City.

Figure 9 exhibits actual and synthetic consenting rates for the main empirical specification. Consistent with displacement effects, it shows that the actual consenting rate falls below the synthetic rate after 2020. However, the effect is statistically insignificant under the rank permutation test (p = 0.38). Nonetheless, the difference between the synthetic and actual consenting rate implies a deficit of 1488 units. Interpreting the deficit as displaced consents from the Lower Hutt reforms implies that the reforms generated a net increase of 1772 units (=3260-1488) or 12.0% (=1772/(16,501-1772)).

[21] Donor weights for this exercise are located in Appendix A.

Figure 9: Synthetic and Actual Consents per Thousand Residents for Wellington Metropolitan Region with Lower Hutt Excluded




### 4.3.1 Alternative Specification

Figure 16 in the Appendix depicts synthetic and actual consenting rates under the alternative specification for Wellington City, Porirua, Upper Hutt and Kapiti Coast. Results are similar to the main specification, with the actual consenting rate falling below its synthetic counterpart in Wellington City from 2020 onwards. P-values of the rank-permutation test continue to remain above conventional significance levels. Wellington City ranks 15th out of 60 (p = 0.25), Upper Hutt ranks 44th (p = 0.73), Porirua ranks 16th (p = 0.27) and Kapiti Coast ranks 58th (p = 0.95). Cumulative deviations between the actual and synthetic consents are -1173, 137, 138 and -407, respectively, yielding a net deficit of 1305 units relative to synthetic counterfactuals. Attributing these differences to displacement from the Lower Hutt reforms imply consents still increased by 1813 (= 3118-1305) units across the Wellington metropolitan region. This is equivalent to a region-wide increase in housing starts of 12.3% (= 1813/(16,501-1813)).

Amalgamating the four TAs (Wellington City, Porirua, Upper Hutt and Kapiti Coast) and repeating the displacement test exercise does not lead to substantively different results to those of the main specification. Figure 16 in the Appendix depicts synthetic and actual consenting rates. The difference between the actual and synthetic consenting rates is statistically insignificant under the rank permutation test (p = 0.38), and the cumulative difference between actual and synthetic consents is a deficit of 753 units. Attributing this deficit to displacement from the Lower Hutt reforms implies an increase of 2365 (= 3118-753) consents across the Wellington metro area, which is equivalent to a 16.7% (= 2365/(16,501-2365)) increase in housing starts.

To conclude, there is no strong statistical evidence that upzoning in Lower Hutt displaced construction from nearby regions over the post-reform period. If displacement occurred, point estimates of the magnitude of the effect are moderate, and imply that new dwelling consents increased across the metropolitan region by a substantial margin, of between 12 to 17%. [22]

# 5 Robustness

## 5.1 Alternative Treatment Timing

As noted in Section 2, Plan Change 43 was not partially operative until 2020. In this section, we set the first post-treatment date to 2020 as a robustness check, such that the post-treatment period covers just four years. The drawbacks of selecting this treatment date are discussed in section 3.4, the most notable being that the policy likely began to have an impact on planning decisions after notification but prior to operationalisation, and that parking reforms were already operationalised under Plan Change 39 in 2018.

This approach produces more conservative estimates, as the synthetic control draws upon donors with higher housing supply to replicate the increasing consenting rate in Lower Hutt from 2018 onwards. See Table 3.

[22] An alternative method to estimate policy impacts for the wider region is to amalgamate the five TAs into single region and fit a synthetic control using the Lower Hutt reforms as the policy intervention. A drawback of this approach is that the contribution of Lower Hutt is diluted since is accounts for a only a quarter of the resident population. For example, a 300% increase in the consenting rate would manifest as a 75% increase in the regional consenting rate, holding all else constant. In addition, Table 2 indicates there is substantial heterogeneity in the donor units for the individual TAs, suggesting that pooling may impair the accuracy of the resultant synthetic unit. Nonetheless, applying the method implies that intensification reforms accounted for 1,270 additional units, equivalent to an 8.3% increase across the region. The alternative specification implies 1,941 additional units or an 13.3% increase. The magnitude of the policy effects are comparable (albeit smaller) to the aggregated effects obtained at the individual TA level. Results are available upon request.

Table 3: Donor Weights for Lower Hutt: Treatment Date set to 2020

| **Donors** | **Main** | **Alt** |
|---|---|---|
| Horowhenua District | | 0.045 |
| Palmerston North City | | 0.595 |
| Rangitikei District | 0.522 | |
| Ruapehu District | | 0.067 |
| South Waikato District | | 0.258 |
| Tasman District | 0.082 | |
| Timaru District | 0.186 | |
| Waimakariri District | | 0.02 |
| Waipa District | 0.21 | |
| Whanganui District | | 0.007 |

'Main' refers to our main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to our alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

Figure 10 exhibits actual and synthetic consents per thousand residents. Interestingly, the actual consenting rate exceeds the counterfactual rate from 2017 onwards, consistent with Lower Hutt reforms having an impact prior to 2020. As demonstrated by Figure 11, the policy impact is statistically significant, ranking first in the donor pool (1/60, p = 0.017). The alternative specification also ranks first in the donor pool.

Figure 10: Synthetic and Actual Consents per Thousand Residents for Lower Hutt with 2020 Treatment Date

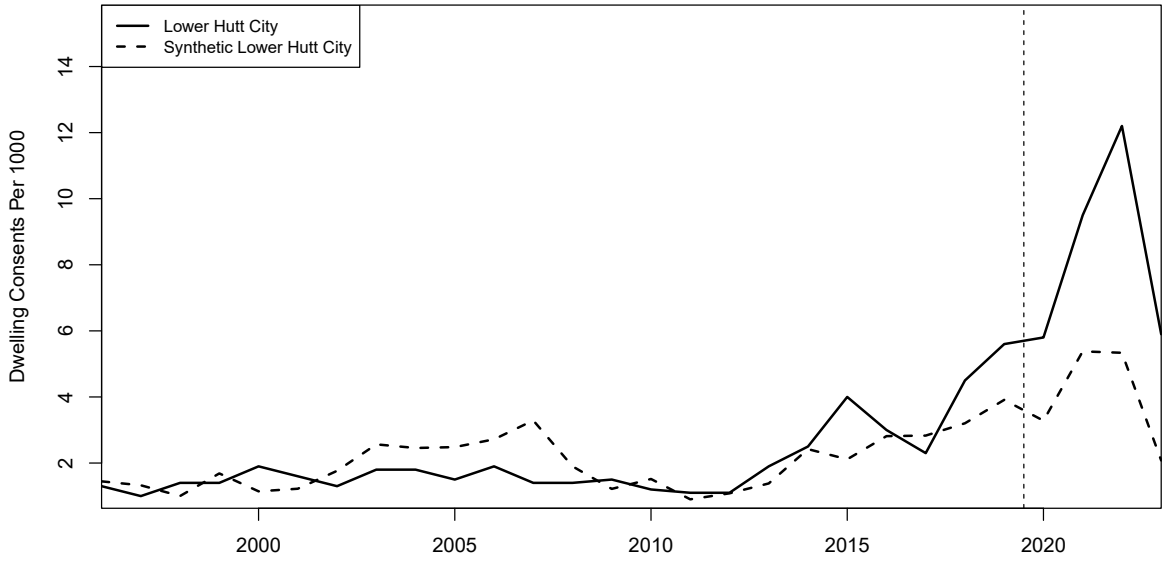
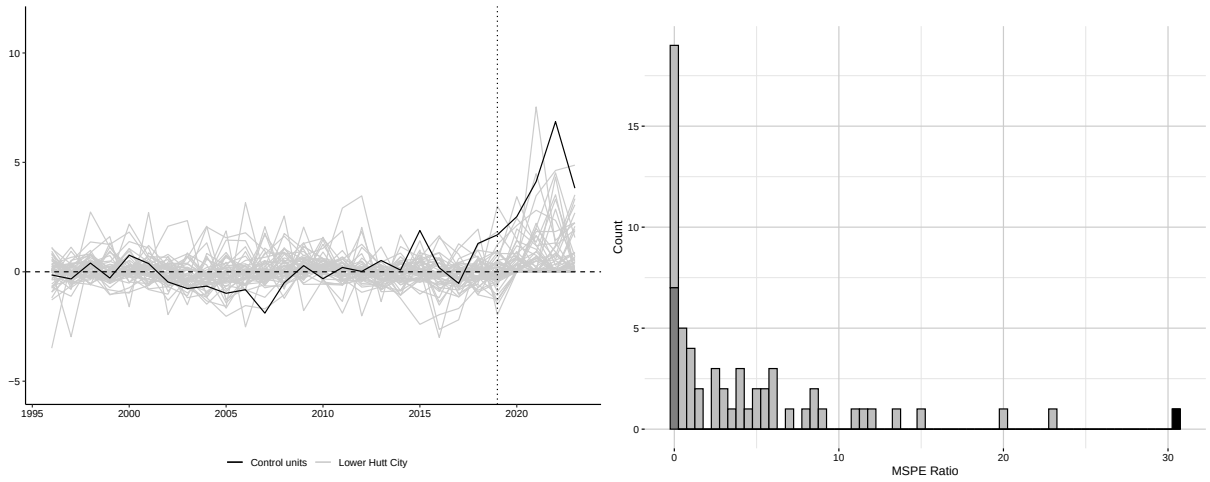



Figure 11: Prediction Errors and PE-MSPE-R for Lower Hutt with 2020 Treatment Date




Note: Prediction errors depicted on left, positive error MSPE ratios on right. Lower Hutt highlighted in black.

The synthetic consenting rate implies that 367 units were consented in 2020, 604 units in 2021, 600 units in 2022, and 237 units in 2023. Actual consents were 653, 1067, 1369, and 670 in these years. Thus, actual consents exceed synthetic consents by 1951 units over the four years, equivalent to 51.8% of all consents issued. The alternative specification finds a slightly larger effect of 2045 units over the four years, equivalent to 54.4% of all consents.

We also consider the alternative treatment timing for each of the other TAs in the Wellington region. Results are presented in Appendix B. Negative spillovers are larger than under the earlier treatment date, driven largely by Wellington City. However, the results remain statistically insignificant.

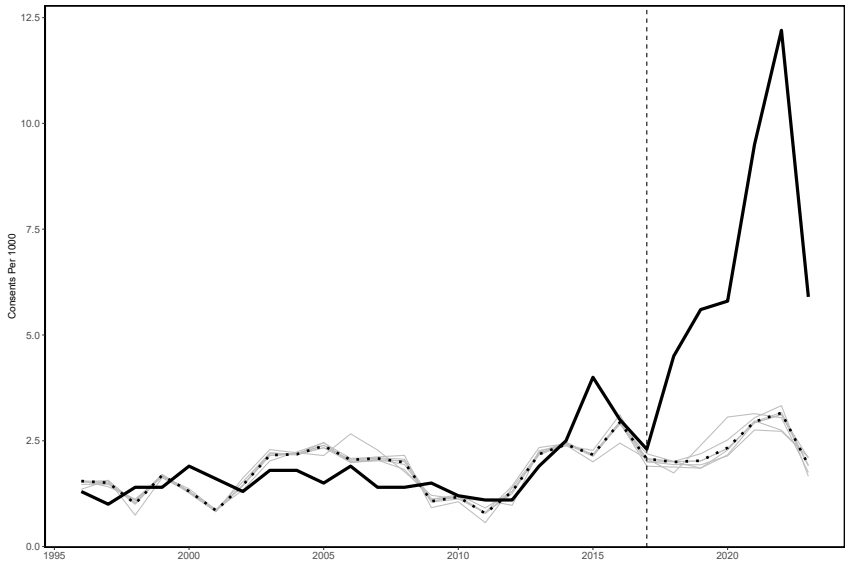
We note that region-wide effects are smaller under this choice of treatment timing, finding a 4% region-wide increase under the main specification, and no increase under the alternative specification. This is largely driven by the poor consenting performance of Wellington City over these four years, which is potentially due to the impacts of the COVID-19 pandemic.

## 5.2 Leave-one-out checks

Under the 'leave one out' robustness check, units from the donor pool are iteratively removed from the sample and the procedure repeated. The procedure provides an assessment of the extent to which the synthetic control may be dependent on any single given donor unit (Abadie et al., 2010).

Figure 12 displays our leave-one-out tests for Lower Hutt. The leave-one-out synthetic controls follow a common trend over both the pre- and post- sample period, indicating that the results are not dependent on any single TA being included in the donor set.

Figure 12: Leave-one-out tests for Lower Hutt

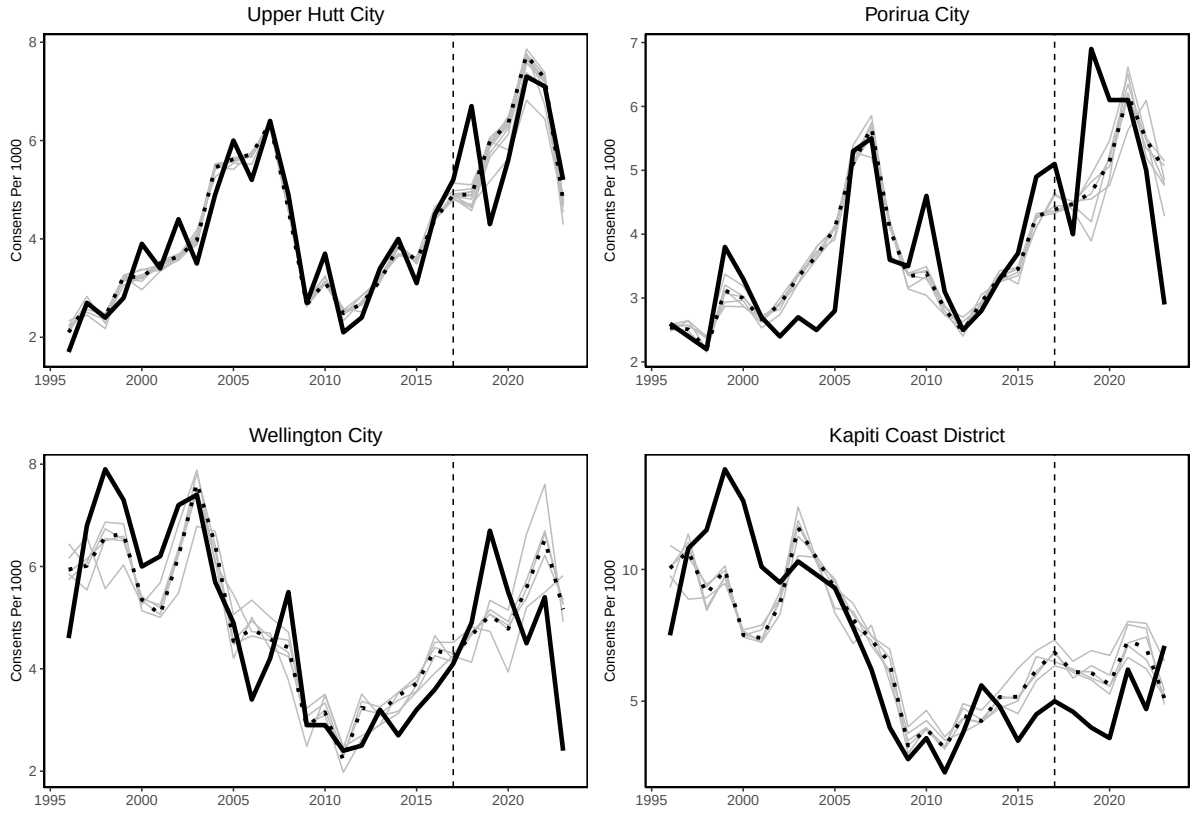



Notes: Leave-one-out replications in grey. The synthetic control for the full sample is the dotted black line.

Figure 13 exhibits leave-one-out results for each of our four other TAs in the Wellington metropolitan

region.

Figure 13: Leave-one-out tests for other Territorial Authorities in Wellington Metropolitan Region




Notes: Leave-one-out replications in grey. The synthetic control for the full sample is the dotted black line.

## 5.3 Alternative Transformations of the Outcome Variable

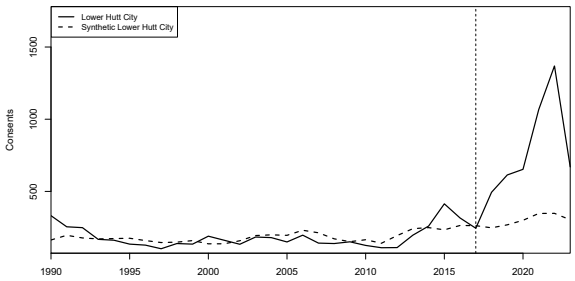
In this subsection we consider alternative transformations of the outcome variable. We repeat the synthetic control exercise, but instead use three outcome variables that are not normalised by population: dwelling consents, dwelling consents normalised by their pre-treatment mean, and log-normalised dwelling consents. For ease of comparison between variable choices, we depict implied consents in levels in Figure 14 below.

These transformations make little difference to our estimated policy effects for Lower Hutt. Our main specification finds a total effect of 2950 units when using dwelling consents, 3052 units for normalised consents, and 3274 for log-normalised consents. The alternative specification finds effect sizes of 3278 units, 3274 units, and 3212 units respectively. This suggests the size of policy effect is not sensitive to

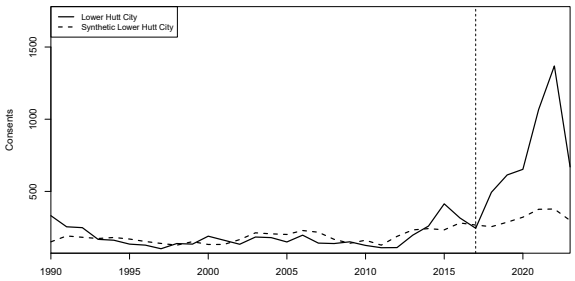
the choice of outcome variable. Moreover, under all specifications, Lower Hutt ranks first in the donor pool, indicating statistical significance.

Figure 14: Synthetic and Actual Outcomes for Alternative Outcome Variables

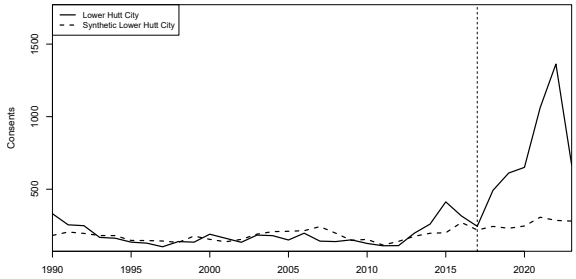
(a) Normalised Consents




(b) Consents




(c) Log-Normalised Consents




Full results for the other metropolitan Wellington TAs can be found in Appendix C. Under all of these outcome variables, region-wide impacts are large, ranging from 2641 to 4034 units. This corresponds to a range of 19% to 32.3% increase in consents over the six years since the reform.

## 5.4 COVID-19 Impacts and In-Migration

The operationalisation of the Lower Hutt reforms coincide with the onset of the COVID-19 pandemic in 2020. COVID-19, and the policy responses to it, had a variety of health, economic, and social impacts, many of which are still not well understood. The synthetic control relies on matching areas in their housing construction up until 2017, before the pandemic started. If the pandemic somehow had a disproportionately positive effect on construction in Lower Hutt, or a disproportionately negative effect on construction in the selected donor units, the comparison of actual outcomes to the synthetic counterfactual could bias estimated policy impacts.

There is little evidence that COVID had a disproportionate impact on the behaviour of most of the donor pool. Placebo interventions remain clustered around a MPSE ratio of one, suggesting that their behaviour remained similar to their chosen donors after the onset of the pandemic. Regardless, the leave-one-out

tests would identify if our effects were driven by the behaviour of a singular donor unit.

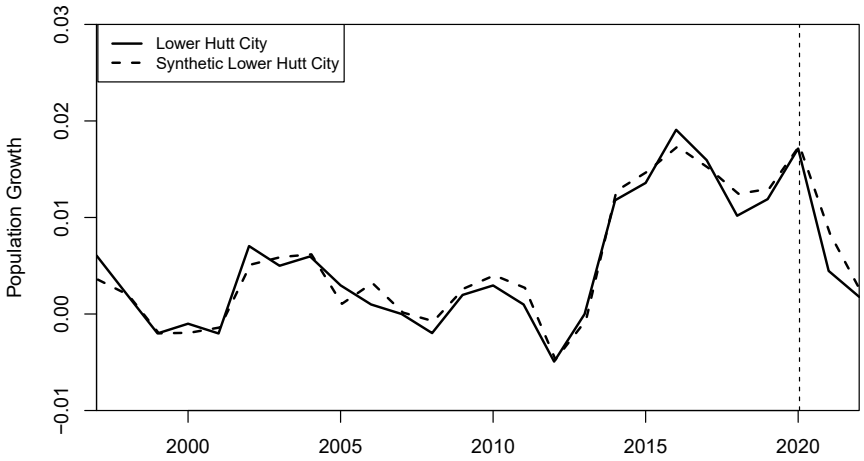
However, it is plausible that Lower Hutt uniquely experienced a shock to housing demand during the COVID pandemic through a shift in migration patterns. It has been documented across much of the Western world that housing demand shifted over this period away from the inner areas of larger cities, into suburban, exurban and rural areas, as households demanded more space and working from home became a more feasible option. If many households decided to move away from the more urbanised Wellington City into Lower Hutt, this could have increased construction activity even in the absence of zoning reform.

Such migration patterns would be evident in population estimates, and we would expect an abnormally large population shock to Lower Hutt during the pandemic. However, there is no evidence of a population shock in Lower Hutt during the pandemic. The city's population grew by just 0.6% between 2020 to 2022, which is slightly below national population growth of 0.66%. Other major TAs in the Wellington region (Upper Hutt, Porirua, and Kapiti Coast) experienced population growth in both absolute and percentage terms well within the range of other regions over this period. Thus, while Wellington City itself saw a declining population during the pandemic, it does not appear that out-migrants were moving to the suburbs or exurbs of the Wellington metropolitan region in large numbers.

To confirm this finding, we generate a synthetic control for Lower Hutt based on trends in population growth prior to COVID-19. We set the date of intervention to 2020, and our outcome variable as annualised rate of population growth. The main donors include the Rangitikei District (0.328), Opotiki District (0.228), Tasman District (0.187), and Waikato District (0.107). Figure 15 exhibits actual and synthetic population growth.

We find no statistical evidence that population growth meaningfully diverges from its synthetic control during the pandemic, and after zoning reform was fully operationalised ($p = 0.57$). Population growth slightly under-performs its synthetic counterpart, and the rate of growth decreases after the onset of the pandemic.

Figure 15: Synthetic and Actual Population Growth for Lower Hutt




This has two implications. First, it is evidence that the increase in construction in Lower Hutt is not due to an idiosyncratic population shock. If anything, insofar as population growth drives housing construction, it may suggest that the donors cause the synthetic counterfactual to overstate construction. Second, it is evidence that the increase in housing construction in Lower Hutt has not (yet) resulted in a substantial increase in in-migration.

# 6 Why did Lower Hutt Upzone?

The Lower Hutt reforms are notable because canonical theories of the political economy of urban development predict that such reforms are unlikely to occur or succeed in regions with fragmented governance structures. For instance, the homevoter hypothesis posits that homeowners, as primary voters in local elections, have a significant influence on local government policies, particularly those affecting property values (Fischel, 2001, 2004). Homeowners, viewing their homes not only as places to live but also as investments, are incentivised to vote in ways that they believe will increase or stabilize the value of their properties. This includes supporting policies like zoning regulations that restrict development or maintain the character of their neighbourhoods, and opposing policies that might negatively impact property values.

This naturally raises the question: why did Lower Hutt upzone? In this section, we attempt to provide context behind the political factors surrounding this decision. We first consider the background to the decision to upzone and Hutt City Council's stated goals from the policy, and then speculate on which factors may have had an impact on policy reforms being politically viable and successful.

## 6.1 Political Background and Stated Objectives

Lower Hutt was considering policies to increase housing supply from the early 2010s, as noted in their *Urban Growth Strategy* released in 2013. At the core of the Strategy was a recognition that Lower Hutt was experiencing low levels of growth, noting: "if Hutt City continues on a business as usual basis, the city can expect little or no population and low economic growth with the number of children and people of working age falling" (Hutt City Council, 2013). The strategy noted that Lower Hutt:

- was expected to have low population growth over the coming decades, with projected growth of just 2% by 2031, compared with 18% for the nation as a whole.
- was building insufficient housing to meet household formation rates, partly due to an ageing population, despite low projected population growth.
- had a falling employment base, a struggling retail sector, and poverty on the outskirts of the city.

As such, the Strategy expressed a need to increase housing construction, identifying 'housing intensification' as playing a key role alongside greenfield development. The Strategy aimed to add 5000-7500 homes by 2031, with around half being infill development.

Following this, the New Zealand Government released the National Policy Statement on Urban Development Capacity[23], which required councils to report on various housing objectives, including affordability and development capacity, to the Central Government. Lower Hutt was identified as a "Medium Growth Urban Area" under the policy (Ministry for the Environment, 2016).

Plan Change 43 was the policy response to both of these factors. Hutt City Council (2017a) stated that the objectives of the policy were to address:

- Housing Supply. Given that Lower Hutt had limited greenfield land for expansion and limited choice of housing sizes and types, intensification was required to accommodate a growing population.
- Housing Demand. Since 2013, Lower Hutt had experienced a modest uptick in population growth. Additionally, Wellington City had a deficit of 10,000 homes which was putting pressure on Lower Hutt through out-migration.
- Local Economy. Rising house prices and rents were argued to be reducing disposable incomes, and causing a drag on the local economy.

[23] Not to be confused with the 2020 National Policy Statement on Urban Development (Section 2).

- Infrastructure and Transport. More compact urban areas were argued to reduce reliance on cars, reduce emissions, and result in a more cost-effective use of city infrastructure.
- Legal Responsibilities. The Council was legally required to address housing affordability and provide a sufficient level of housing under the New Zealand Government's National Policy Statement on Urban Development Capacity.

The initial vote to notify the public of Plan Change 43 passed through council in 2017 with an 8-3 vote, while the final decision received an 9-3 vote in 2019 (Hutt City Council, 2017b, 2019).[24] Several of the votes against notification in 2017 expressed reservations that the policy exempted too many areas of the city from intensification and hence was not extensive enough. In the final vote in 2019, councillors against the policy expressed more traditional reservations related to a lack of infrastructure for infill development, and that the Plan Change had deviated too far away from an initial goal of intensifying transport corridors (Hutt City Council, 2019). Plan Change 56, which allowed for medium density across much of the suburban land, would go on to receive a unanimous vote from councillors in late 2023 (Hutt City Council, 2023b).

Despite the predictions of the homevoter hypothesis, there was little obvious political backlash from voters. A local election was held a month before the final vote in October of 2019, meaning voters had the option to defeat or push for significant revisions to Plan Change 43. While the incumbent mayor was ousted in the election, the newly elected mayor voted in support of Plan Change 43, and was re-elected with a larger majority in 2022 (Hutt City Council, 2024). This election also saw six new councillors elected prior to the vote on Plan Change 43 in 2019, with four voting for the policy (Hutt City Council, 2019).

Indeed, it appears that voter preferences in Lower Hutt are favourable toward zoning reform. Opinion polling conducted by Hutt City Council indicated Lower Hutt residents broadly supported Plan Change 43 and infill development in general. 84% of residents supported infill development in the General Residential Zone prior to the policy, and 82% supported the creation of the Suburban Mixed Use Zone (Hutt City Council, 2017c). This appears to indicate a greater degree of support for density than in other New Zealand cities. For instance a 2022 poll indicated that 44% of Aucklanders and 64% of Wellington residents supported housing intensification within their neighbourhood (Kantar Public, 2022a,b). These survey results suggest that the homevoter hypothesis may not be a monolith.

[24] Interestingly, the three representatives that voted against Plan Change 43 in the initial vote to notify all later voted in favour of the final decision. This included the elected mayor in 2019, who was a councillor in 2017.

## 6.2 Factors Unlikely to Explain Zoning Reform

While we cannot definitively determine what factors led to Lower Hutt pursuing zoning reform, the following explanations appear to be inconsistent with the available evidence:

**Demographics.** Research on demographic factors that predict support or opposition to zoning changes is a regrettably understudied topic. Recent research suggests that wealth may play a role. Davis et. al (2024) show that public opposition to zoning reform in Minneapolis was associated with living in single-family dwellings and suburbs with above-median house prices. We examine whether there are any unique demographic characteristics that can explain why Lower Hutt was more pre-disposed to zoning reform.

There is no clear demographic factor that explains why Lower Hutt was more likely than its peer cities to adopt zoning reform (Table 4). As noted above, Lower Hutt had a low population growth rate in the years leading up to reform, suggesting an unexpected, positive population shock cannot explain the move toward reform. Nor was Lower Hutt expected to have abnormal population growth in the following years, with an expected rate of growth of 0.4% per year after 2018, the same rate as Wellington City and Upper Hutt.

Table 4: Demographic Characteristics of Territorial Authorities in Wellington Region

| | Population | | Projected Pop Growth | | Rents | | % Aged 15-29 | | % Renters | | % Bachelor or Higher | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Level | Growth | Level | Growth | Level | Growth | Level | Growth | Level | Growth | Level | Growth |
| Lower Hutt | 108,600 | 3% | 0.4% | 0.2% | $300 | 4.5% | 24.7% | 0.3% | 34% | 2.2% | 26.1% | 5% |
| Porirua | 58,900 | 4% | 0.6% | 0.2% | $260 | 1.7% | 25.8% | 0.4% | 35.6% | 1.9% | 24.1% | 4% |
| Upper Hutt | 45,400 | 4.1% | 0.6% | 0.2% | $300 | 6.2% | 23% | 0.7% | 27.3% | 0.8% | 20.7% | 4.4% |
| Wellington | 211,200 | 2.9% | 0.4% | -0.4% | $440 | 7.5% | 32.3% | 0.5% | 41.2% | 2.3% | 46% | 5.4% |
| Kapiti Coast | 55,200 | 3.6% | 0.4% | -0.1% | $340 | 8.4% | 16.6% | 1% | 25.7% | 1.5% | 24.1% | 4.8% |

'Level' refers to the demographic statistic in the 2018 census. 'Growth' refers to the change in variable from the 2013 census. Projected Pop Growth refers to the Stats NZ projection for the annual rate of population growth for the Territorial Authority from 2018 to 2031. The 'growth' for this variable refers to the percentage point change in expected population growth rate relative to the same projections conducted in 2013. Rents are the median rent paid per week in the TA, recorded in the 2013 and 2018 Census.

We may expect areas with a disproportionate number of renters and young adults to be more likely to view zoning reform favourably. Although Lower Hutt ranks above average nationally on these characteristics, it is not unique for the region, nor are these constituencies growing at fast rates. If we were to predict zoning reform based on these demographic characteristics, we would expect either Wellington City or Porirua to be more likely to pursue these policies, as they both have a greater proportion of renters and young people.

**Regulatory capture**. Widespread zoning reform is an alternative to the piecemeal approach to housing

supply, whereby individual projects are evaluated on a case-by-case basis. Restricting development opportunities to limited areas confers economic rents to landowners. Meanwhile, extensive regulatory requirements on development applications also create barriers to entry, conferring economic rents to developers that can afford the entry costs. These rents, in turn, make the process conducive to regulatory capture. Widespread zoning reform makes development opportunities abundant, thereby diluting the economic rents that incentivise regulatory capture.

### 6.3 Potential Explanations for Zoning Reform

Given the available evidence, the following appear to be the most significant factors that explain zoning reform in Lower Hutt.

**Land Availability.** The topography of land in Lower Hutt makes continual outward expansion through greenfield development challenging. The city is constrained by the Wellington Harbour to its south, and is centred in the Hutt Valley, meaning that it is surrounded by steep and hilly terrain to the east and west. The evaluation for Plan Change 43 states that "Lower Hutt has limited land available that is suitable for greenfield residential development... developing [these] areas may have much higher costs, both to the developer (such as construction costs) or to the community (such as ongoing infrastructure costs)" (Hutt City Council, 2017c). The lack of feasible greenfield development opportunities likely constrained policymakers to pursue infill housing in order to enable additional housing supply.

**A Representative Consultation Process.** Hutt City Council engages a representative "citizens panel" on various policy decisions (Hutt City Council, 2023a, 2017a). Results from this engagement complement the more conventional voluntary submissions in the decision making process.

The citizen's panel approach circumvents the self-selection bias associated with voluntary submissions when gauging public opinion to policy options. Self-selection bias is likely to be particularly acute in relation to zoning reform because the benefits of development are diffuse while its costs are concentrated.

In addition, existing research from the United States suggests that engagement on zoning reform is not representative of the wider populace. Engagement is greater for residents who are older, male, home-owners, and oppose new housing construction (Einstein et al., 2018).

Hutt City's survey data is consistent with self-selection bias in voluntary submissions. The representative panel exhibited 69% support for the creation of the medium density zone, while feedback elicited through traditional voluntary mechanisms found just 44% in support due to differences in sample composition (Hutt City Council, 2017c).

**Widespread Financial Benefits to Landowners.** Another potential explanation is that there are financial benefits to landowners when the zoning changes are sufficiently widespread. The central premise of the homevoter hypothesis is that development decreases nearby property values due to the negative externalities associated with increased population (such as traffic and noise) and changes to the built form of the neighbourhood (obstructed views and shading). But upzoning can increase values even when it is widespread, since land with fewer restrictions is priced higher, all else equal (Bertaud and Brueckner, 2005; Greenaway-McGrevy et al., 2021).

Thus, while homeowners are financially incentivised to oppose upzoning when it is only applied to nearby parcels, they may support it when their own parcel is upzoned as well. Consequently upzoning may receive greater public support when it is widespread, because the financial benefits are distributed amoung a larger number of voters.

These financial benefits will be greater when only a single jurisdiction within a larger metropolitan area upzones, since the financial gains are limited to the landowners within the jurisdiction. In metropolitan areas with significant latent demand for housing, there may therefore be a first-mover advantage to landowners in a given municipality upzoning prior to neighbouring jurisdictions.

# 7 Concluding Remarks

Beginning in the late 2010s, Lower Hutt began a sequence of widespread zoning and parking changes to encourage housing supply and intensification. We employ the synthetic control method to evaluate the impacts of these changes. The synthetic control implies that reforms generated a three- to four-fold increase in new dwelling consents per capita, and tripled the number of consents issued over the six years subsequent to notification of the first medium density reform. It also implies that reforms increased consents across the wider Wellington metropolitan region by between 12 to 17%, depending on model specification and how potential displacement effects are accounted for.

These findings add to the growing body of evidence that zoning regulations can significantly restrict housing supply, and that easing those restrictions to allow for medium density housing can have a substantial impact on housing construction. Widespread zoning reform is therefore a powerful policy tool to stimulate housing supply, and policymakers now have several case studies to learn from as they attempt to redress housing shortages and affordability challenges throughout the developed world.

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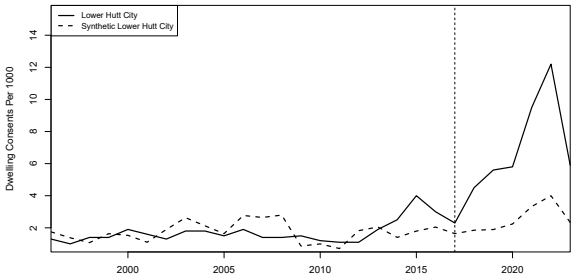
# Appendix A Additional Results

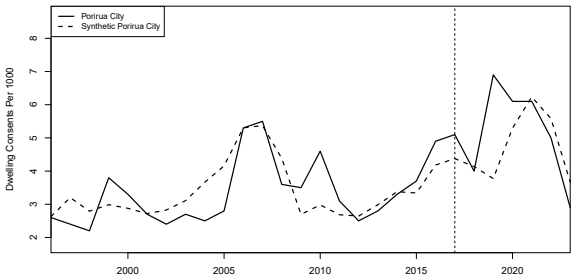
Figure 16: Synthetic and Actual Consents per Thousand Residents, Alternative Specification

(a) Lower Hutt

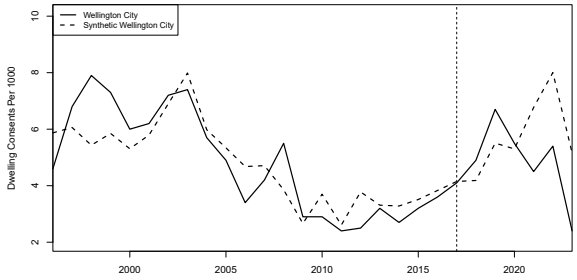



(b) Upper Hutt

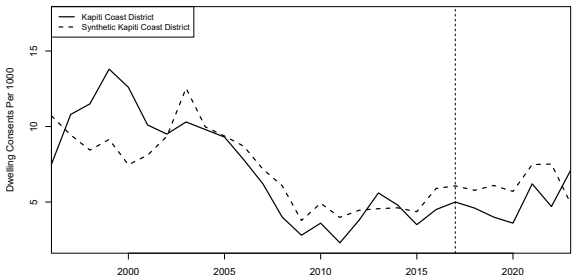

(c) Porirua




(d) Wellington City




(e) Kapiti Coast




(f) Wellington Metro Area with Lower Hutt Excluded

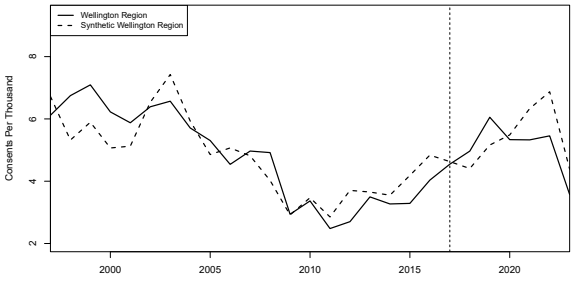


Table 5: Synthetic Consents for Territorial Authorities in Wellington Metropolitan Region

| | Lower Hutt | | Upper Hutt | | Porirua City | | Wellington City | | Kapiti Coast | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| 2018 | 217 | 201 | 223 | 229 | 264 | 244 | 983 | 884 | 337 | 319 | 2023 | 1876 |
| 2019 | 223 | 208 | 276 | 229 | 278 | 226 | 1075 | 1172 | 341 | 342 | 2193 | 2177 |
| 2020 | 261 | 250 | 297 | 236 | 311 | 321 | 1035 | 1148 | 323 | 326 | 2227 | 2281 |
| 2021 | 331 | 374 | 367 | 317 | 379 | 382 | 1206 | 1462 | 421 | 432 | 2704 | 2967 |
| 2022 | 355 | 450 | 345 | 326 | 338 | 344 | 1393 | 1708 | 406 | 434 | 2837 | 3263 |
| 2023 | 220 | 266 | 231 | 227 | 312 | 229 | 1116 | 1115 | 298 | 286 | 2176 | 2124 |
| Total Counterfactual | 1607 | 1749 | 1739 | 1564 | 1883 | 1746 | 6808 | 7490 | 2126 | 2139 | 14162 | 14688 |
| Actual Consents | 4867 | 4867 | 1701 | 1701 | 1884 | 1884 | 6317 | 6317 | 1732 | 1732 | 16501 | 16501 |
| Difference | 3260 | 3118 | -38 | 137 | 1 | 138 | -491 | -1173 | -394 | -407 | 2339 | 1813 |
| MSPE Ratio | 87.60 | 37.35 | 7.61 | 1.62 | 5.60 | 3.91 | 3.66 | 4.12 | 1.34 | 0.95 | – | – |
| p-value | 0.02 | 0.02 | 0.33 | 0.73 | 0.45 | 0.27 | 0.60 | 0.25 | 0.78 | 0.97 | – | – |

Note: Synthetic consents are presented for comparison between different Territorial Authorities. Synthetic consents are obtained from synthetic consenting rates (consents per thousand residents) multiplied by population (in 000s). MSPE ratios and p-values are based on differences between synthetic and actual consenting rates. 'Main' refers to our main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to our alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

Table 6: Donor Unit Weights for Wellington Metropolitan Region Excluding Lower Hutt

| Donors | Main | Alt |
|---|---|---|
| Hurunui District | 0.124 | - |
| Kawerau District | - | 0.024 |
| Opotiki District | 0.402 | - |
| Queenstown-Lakes District - | 0.017 | |
| Rotorua District | 0.149 | 0.294 |
| South Wairarapa District | 0.066 | - |
| Tararua District | - | 0.202 |
| Tasman District | 0.218 | 0.307 |
| Taupo District | 0.009 | - |
| Tauranga City | 0.031 | 0.108 |
| Waimakariri District | - | 0.046 |

The Wellington Metropolitan Region Excluding Lower Hutt is the amalgamation of the Wellington City, Upper Hutt, Porirua and Kapiti Coast Territorial Authorities. 'Main' refers to the main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

Table 7: Synthetic Consents for Wellington Metropolitan Region Excluding Lower Hutt

| Year | Main | Alt |
|---|---|---|
| 2018 | 1824 | 1634 |
| 2019 | 1905 | 1935 |
| 2020 | 1831 | 2091 |
| 2021 | 2573 | 2421 |
| 2022 | 2664 | 2615 |
| 2023 | 2326 | 1690 |
| Total Counterfactual | 13122 | 12387 |
| Actual Consents | 11634 | 11634 |
| Difference | -1488 | -753 |
| MSPE Ratio | 7.35 | 1.59 |
| p-value | 0.38 | 0.65 |

Note: Synthetic consents are presented for comparison between different Territorial Authorities. Synthetic consents are obtained from synthetic consenting rates (consents per thousand residents) multiplied by population (in 000s). MSPE ratios and p-values are based on differences between synthetic and actual consenting rates. The Wellington Metropolitan Region Excluding Lower Hutt is the amalgamation of the Wellington City, Upper Hutt, Porirua and Kapiti Coast Territorial Authorities. 'Main' refers to the main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

# Appendix B Additional Results under Alternative Treatment Timing

Table 8: Donor Weights for Territorial Authorities in Wellington Metropolitan Region, 2020 Treatment Date

| Donors | Upper Hutt | | Porirua | | Wellington City | | Kapiti Coast | |
|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| Carterton District | | 0.047 | | | | | | |
| Central Hawke's Bay District | 0.081 | | | | | | | |
| Central Otago District | 0.004 | | | | | | | |
| Clutha District | 0.169 | | | | | | | |
| Gore District | | 0.003 | | | | | | |
| Grey District | 0.087 | | | | | | | |
| Horowhenua District | 0.031 | | | 0.147 | | | | |
| Hurunui District | 0.023 | | | | 0.109 | | 0.181 | 0.209 |
| Kawerau District | | | | 0.344 | | | | |
| Mackenzie District | 0.006 | | | | | | | |
| Manawatu District | | 0.129 | | | | | | |
| Masterton District | 0.086 | | | | | | | |
| Matamata-Piako District | | | 0.143 | | | | | |
| New Plymouth District | | | 0.137 | | | | | |
| Opotiki District | | | | 0.464 | | 0.319 | | |
| Otorohanga District | | | | 0.021 | | | | |
| Palmerston North City | | 0.272 | | | | | | |
| Queenstown-Lakes District | 0.01 | | 0.032 | | | | | |
| Rangitikei District | | | 0.275 | | | | | |
| Rotorua District | | | | | | | 0.303 | |
| Ruapehu District | | | | | 0.143 | | | |
| Selwyn District | 0.015 | | | | | | | |
| South Waikato District | | 0.182 | | 0.283 | | 0.118 | | |
| South Wairarapa District | 0.283 | | | | | | | |
| Southland District | | 0.001 | | | | | | |
| Stratford District | | 0.082 | | | | | | |
| Tasman District | | | | | 0.379 | 0.739 | 0.002 | |
| Tauranga City | | | | | 0.044 | | 0.191 | 0.213 |
| Thames-Coromandel District | | | | | 0.003 | | 0.307 | 0.276 |
| Timaru District | 0.157 | | | | | | | |
| Waikato District | 0.048 | | 0.019 | | 0.315 | | | |
| Waimakariri District | | 0.015 | | | | | | |
| Waipa District | | 0.231 | 0.038 | | | | | |
| Wairoa District | | | 0.242 | | | | | |
| Whanganui District | | 0.005 | | | | 0.037 | | |

'Main' refers to the main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

Table 9: Synthetic Consents for Territorial Authorities in Wellington Metropolitan Region, 2020 Treatment Date

| | Lower Hutt | | Upper Hutt | | Porirua City | | Wellington City | | Kapiti Coast | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| 2020 | 367 | 411 | 253 | 301 | 330 | 350 | 1115 | 1425 | 287 | 289 | 2352 | 2775 |
| 2021 | 604 | 519 | 436 | 328 | 452 | 432 | 1259 | 1430 | 399 | 441 | 3150 | 3150 |
| 2022 | 600 | 400 | 328 | 350 | 363 | 399 | 1486 | 1744 | 366 | 397 | 3143 | 3290 |
| 2023 | 237 | 385 | 268 | 221 | 299 | 262 | 1137 | 894 | 283 | 286 | 2224 | 2047 |
| Total Counterfactual | 1808 | 1714 | 1285 | 1200 | 1443 | 1443 | 4997 | 5493 | 1335 | 1413 | 10869 | 11263 |
| Actual Consents | 3759 | 3759 | 1198 | 1198 | 1231 | 1231 | 3843 | 3843 | 1251 | 1251 | 11282 | 11282 |
| Difference | 1951 | 2045 | -87 | -2 | -212 | -212 | -1154 | -1650 | -84 | -162 | 413 | 19 |
| MSPE Ratio | 30.61 | 19.86 | 3.59 | 0.41 | 3.90 | 1.64 | 4.79 | 3.30 | 0.70 | 0.90 | – | – |
| p-value | 0.02 | 0.02 | 0.60 | 0.95 | 0.60 | 0.63 | 0.48 | 0.38 | 0.95 | 0.82 | – | – |

Note: Synthetic consents are presented for comparison between different Territorial Authorities. Synthetic consents are obtained from synthetic consenting rates (consents per thousand residents) multiplied by population (in 000s). MSPE ratios and associated p-values are calculated based on differences between actual and synthetic consenting rates. 'Main' refers to the main empirical specification, which matches normalised dwelling consents per thousand residents in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and normalised dwelling consents per thousand residents in census years.

# Appendix C Additional Results with Alternative Outcome Variables

Table 10: Lower Hutt Donor Weights with Alternative Outcome Variables

| | Normalised | | Raw Consents | | Log-Normalised | |
|---|---|---|---|---|---|---|
| District | Main | Alt | Main | Alt | Main | Alt |
| Dunedin City | 0.167 | | 0.176 | | | |
| Gore District | | 0.088 | | | | |
| Horowhenua District | | | 0.013 | | 0.193 | |
| Hurunui District | | | | | 0.001 | |
| Kawerau District | | | | 0.056 | | |
| Manawatu District | | 0.269 | | | 0.008 | |
| New Plymouth District | | | 0.015 | | 0.086 | |
| Opotiki District | 0.727 | | 0.471 | | 0.173 | |
| Palmerston North City | | | | 0.131 | | |
| Queenstown-Lakes District | | 0.034 | | | | |
| Ruapehu District | | | | 0.026 | | |
| Selwyn District | 0.089 | | 0.067 | | 0.008 | |
| South Waikato District | | 0.445 | | 0.49 | | |
| Tararua District | | 0.053 | | | | |
| Tasman District | 0.004 | | 0.099 | | 0.063 | |
| Tauranga City | 0.036 | | 0.019 | | 0.062 | |
| Timaru District | | | 0.121 | | 0.532 | 0.126 |
| Waikato District | | | 0.03 | | | 0.297 |
| Waimakariri District | | 0.024 | | 0.071 | | 0.07 |
| Waipa District | | | | | | |
| Wairoa District | | | | | 0.171 | |
| Waitomo District | | 0.029 | | | | |
| Western Bay of Plenty District | 0.012 | | 0.009 | | 0.134 | 0.319 |
| Whanganui District | | 0.015 | | 0.01 | | 0.015 |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 11: Upper Hutt Donor Weights with Alternative Outcome Variables

| Donor | Normalised | | Raw Consents | | Log-Normalised | |
|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt |
| Ashburton District | | 0.2 | | 0.069 | | |
| Carterton District | 0.106 | | 0.228 | | 0.15 | 0.191 |
| Central Hawke's Bay District | 0.254 | | 0.35 | 0.079 | 0.173 | 0.229 |
| Central Otago District | | | 0.006 | | | |
| Hastings District | 0.126 | | 0.072 | | | |
| Horowhenua District | 0.015 | | 0.037 | | | 0.157 |
| Hurunui District | 0.18 | | 0.072 | | 0.03 | |
| Kawerau District | | 0.225 | | | 0.031 | |
| Mackenzie District | | | 0.037 | | | |
| Manawatu District | | | | 0.001 | | |
| Masterton District | 0.083 | | | | | |
| Matamata-Piako District | | 0.015 | | 0.143 | | |
| New Plymouth District | | | | | | |
| Otorohanga District | | 0.001 | | | 0.029 | |
| Palmerston North City | | 0.001 | | | | |
| Queenstown-Lakes District | | 0.084 | | 0.07 | 0.001 | |
| Rotorua District | | 0.062 | | | | |
| Ruapehu District | | | | | | 0.014 |
| Selwyn District | | 0.006 | | | | |
| South Waikato District | | 0.14 | | 0.001 | | 0.037 |
| South Wairarapa District | | | | | 0.113 | |
| Southland District | | 0.16 | | | | |
| Stratford District | | 0.001 | | 0.424 | | |
| Tasman District | | | | | | |
| Waikato District | 0.199 | 0.097 | 0.176 | 0.139 | 0.474 | 0.199 |
| Waimakariri District | | | | | | |
| Waipa District | | | | | | 0.172 |
| Westland District | | | | 0.074 | | |
| Whanganui District | | 0.004 | | | | |
| Whangarei District | 0.038 | | 0.022 | | | |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 12: Porirua Donor Weights with Alternative Outcome Variables

| | Normalised | | Raw Consents | | Log-Normalised | |
|---|---|---|---|---|---|---|
| District | Main | Alt | Main | Alt | Main | Alt |
| Carterton District | 0.142 | | | 0.007 | | |
| Clutha District | | | | | 0.007 | |
| Gisborne District | 0.004 | | 0.107 | | 0.019 | |
| Grey District | 0.065 | | | | | |
| Hastings District | | | | 0.001 | | |
| Horowhenua District | 0.177 | | 0.159 | | 0.012 | |
| Kaipara District | | | 0.106 | | | |
| Kawerau District | | | | 0.1 | | |
| Manawatu District | | | 0.127 | | 0.074 | |
| Matamata-Piako District | 0.082 | 0.181 | 0.148 | 0.127 | | |
| New Plymouth District | 0.096 | | 0.152 | | 0.115 | |
| Otorohanga District | | 0.368 | 0.122 | | 0.24 | |
| Palmerston North City | | | | 0.001 | | |
| Queenstown-Lakes District | | 0.023 | 0.044 | | 0.005 | |
| Rotorua District | | | | 0.009 | | 0.081 |
| Selwyn District | | 0.011 | | 0.053 | | |
| South Taranaki District | | | | | 0.015 | |
| South Waikato District | 0.29 | 0.299 | | 0.142 | 0.175 | 0.271 |
| South Wairarapa District | | | 0.184 | | 0.073 | |
| Southland District | | | | 0.141 | | |
| Stratford District | | | | | 0.043 | |
| Tasman District | | 0.011 | | 0.124 | | |
| Tauranga City | | | | 0.035 | | |
| Waikato District | | 0.118 | | 0.031 | | 0.395 |
| Waimakariri District | | | | | 0.003 | |
| Waipa District | 0.144 | | 0.134 | 0.002 | 0.304 | |
| Wairoa District | | | | | 0.032 | |
| Whanganui District | | | 0.058 | | 0.014 | |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 13: Wellington City Donor Weights with Alternative Outcome Variables

| | Normalised | | Raw Consents | | Log-Normalised | |
|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt |
| Hamilton City | | | 0.039 | | | |
| Hurunui District | | | | | 0.16 | |
| Kaipara District | | | | | | 0.378 |
| Queenstown-Lakes District | | 0.101 | | | | 0.053 |
| Rotorua District | | 0.439 | | 0.399 | 0.098 | 0.318 |
| South Wairarapa District | | | | | 0.061 | |
| Tasman District | 0.101 | 0.46 | | | 0.02 | 0.251 |
| Taupo District | | | | | 0.071 | |
| Tauranga City | 0.23 | | 0.391 | 0.601 | 0.202 | |
| Waitomo District | | | | | 0.017 | |
| Whangarei District | 0.669 | | 0.57 | | 0.371 | |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 14: Kapiti Coast Donor Weights with Alternative Outcome Variables

| | Normalised | | Raw Consents | | Log-Normalised | |
|---|---|---|---|---|---|---|
| District | Main | Alt | Main | Alt | Main | Alt |
| Far North District | | | 0.081 | | | |
| Hurunui District | | | | | 0.245 | |
| Opotiki District | | | | | 0.284 | |
| Rotorua District | 0.364 | 0.365 | 0.311 | 0.199 | 0.247 | 0.238 |
| Tasman District | 0.056 | 0.152 | 0.092 | 0.128 | | 0.189 |
| Taupo District | 0.213 | | 0.075 | | | |
| Tauranga City | 0.023 | | 0.034 | | 0.201 | |
| Thames-Coromandel District | 0.343 | 0.482 | 0.386 | 0.642 | 0.023 | 0.523 |
| Waimakariri District | | | 0.021 | 0.031 | | 0.05 |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 15: Synthetic Consents for Normalised Consents as Outcome Variable

| | Lower Hutt | | Upper Hutt | | Porirua City | | Wellington City | | Kapiti Coast | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| 2018 | 248 | 245 | 225 | 222 | 258 | 241 | 924 | 839 | 308 | 297 | 1963 | 1844 |
| 2019 | 269 | 247 | 278 | 276 | 273 | 289 | 901 | 948 | 333 | 327 | 2054 | 2086 |
| 2020 | 300 | 240 | 325 | 260 | 285 | 300 | 888 | 924 | 320 | 313 | 2119 | 2038 |
| 2021 | 347 | 301 | 406 | 343 | 355 | 380 | 1093 | 1019 | 433 | 427 | 2634 | 2469 |
| 2022 | 348 | 298 | 358 | 354 | 348 | 342 | 1104 | 1092 | 417 | 425 | 2575 | 2512 |
| 2023 | 303 | 262 | 236 | 265 | 266 | 263 | 749 | 938 | 384 | 345 | 1937 | 2072 |
| Total Counterfactual | 1815 | 1593 | 1828 | 1720 | 1785 | 1815 | 5659 | 5760 | 2196 | 2134 | 13282 | 13022 |
| Actual Consents | 4867 | 4867 | 1701 | 1701 | 1884 | 1884 | 6317 | 6317 | 1732 | 1732 | 16501 | 16501 |
| Difference | 3052 | 3274 | -127 | -19 | 99 | 69 | 658 | 557 | -464 | -402 | 3219 | 3479 |
| MSPE Ratio | 90.51 | 79.88 | 7.46 | 2.32 | 7.11 | 4.20 | 1.54 | 1.26 | 1.52 | 1.51 | – | – |
| p-value | 0.02 | 0.02 | 0.50 | 0.67 | 0.53 | 0.47 | 0.90 | 0.82 | 0.90 | 0.78 | – | – |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 16: Synthetic Consents for Raw Consents as Outcome Variable

| | Lower Hutt | | Upper Hutt | | Porirua City | | Wellington City | | Kapiti Coast | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| 2018 | 256 | 242 | 217 | 227 | 265 | 259 | 939 | 865 | 312 | 303 | 1989 | 1897 |
| 2019 | 287 | 248 | 263 | 293 | 287 | 311 | 912 | 870 | 334 | 314 | 2083 | 2036 |
| 2020 | 322 | 256 | 308 | 292 | 303 | 329 | 916 | 945 | 320 | 303 | 2168 | 2125 |
| 2021 | 376 | 321 | 360 | 373 | 414 | 398 | 1113 | 1053 | 438 | 405 | 2701 | 2551 |
| 2022 | 378 | 288 | 331 | 360 | 349 | 362 | 1005 | 762 | 413 | 393 | 2475 | 2166 |
| 2023 | 299 | 233 | 220 | 248 | 275 | 271 | 678 | 645 | 350 | 295 | 1822 | 1692 |
| Total Counterfactual | 1917 | 1589 | 1699 | 1794 | 1893 | 1929 | 5563 | 5141 | 2167 | 2014 | 13239 | 12467 |
| Actual Consents | 4867 | 4867 | 1701 | 1701 | 1884 | 1884 | 6317 | 6317 | 1732 | 1732 | 16501 | 16501 |
| Difference | 2950 | 3278 | 2 | -93 | -9 | -45 | 754 | 1176 | -435 | -282 | 3262 | 4034 |
| MSPE Ratio | 82.54 | 71.23 | 4.92 | 3.39 | 6.40 | 2.35 | 1.31 | 1.47 | 1.60 | 1.34 | – | – |
| p-value | 0.02 | 0.02 | 0.42 | 0.38 | 0.33 | 0.52 | 0.87 | 0.77 | 0.82 | 0.78 | – | – |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.

Table 17: Synthetic Consents for Log-Normalised Consents as Outcome Variable

| | Lower Hutt | | Upper Hutt | | Porirua City | | Wellington City | | Kapiti Coast | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt | Main | Alt |
| 2018 | 244 | 221 | 222 | 225 | 249 | 247 | 921 | 874 | 329 | 298 | 1966 | 1864 |
| 2019 | 231 | 281 | 236 | 252 | 258 | 252 | 934 | 1023 | 358 | 327 | 2017 | 2135 |
| 2020 | 246 | 288 | 309 | 301 | 284 | 284 | 869 | 981 | 317 | 307 | 2026 | 2161 |
| 2021 | 307 | 344 | 371 | 328 | 377 | 416 | 1314 | 1373 | 477 | 432 | 2845 | 2894 |
| 2022 | 285 | 293 | 340 | 350 | 381 | 375 | 1279 | 1343 | 477 | 421 | 2761 | 2781 |
| 2023 | 280 | 228 | 215 | 221 | 270 | 281 | 940 | 979 | 475 | 315 | 2180 | 2024 |
| Total Counterfactual | 1593 | 1655 | 1694 | 1677 | 1819 | 1856 | 6256 | 6572 | 2432 | 2100 | 13795 | 13860 |
| Actual Consents | 4867 | 4867 | 1701 | 1701 | 1884 | 1884 | 6317 | 6317 | 1732 | 1732 | 16501 | 16501 |
| Difference | 3274 | 3212 | 7 | 24 | 65 | 28 | 61 | -255 | -700 | -368 | 2706 | 2641 |
| MSPE Ratio | 16.07 | 10.20 | 1.11 | 0.90 | 2.53 | 1.72 | 2.03 | 1.54 | 2.98 | 1.62 | – | – |
| p-value | 0.02 | 0.02 | 0.72 | 0.68 | 0.47 | 0.42 | 0.52 | 0.47 | 0.40 | 0.45 | – | – |

'Main' refers to the main empirical specification, which matches on the relevant outcome variable in all pre-treatment years. 'Alt' refers to the alternative empirical specification, which matches census characteristics and the relevant outcome variable in census years.