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The Impact of Upzoning on Housing Construction in Auckland: Update and Extended Results

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Abstract

In 2016, Auckland upzoned approximately three-quarters of its residential land. Using a quasi-experimental framework, Greenaway-McGrevy and Phillips (2023) argue that the zoning reform generated a significant increase in residential housing permits over the five years subsequent to the policy change. This paper extends their methodology and analysis along several dimensions. First, it incorporates an additional year of data, 2022. Second, it expands the control group in the quasi-experimental framework to include rural and business zones. Third, it incorporates Special Housing Areas (SpHAs) into the analysis, which was an interim program to encourage housing supply prior to the AUP becoming operational, and allowed developers to build under the upzoned regulations of the "Proposed" AUP (PAUP) in exchange for a proportion of the development to be designated as affordable housing. Under these alternative methods for modeling the impact of the policy change, we find that the empirical evidence continues to support the zoning reform having a substantial impact on housing permits issued in Auckland.

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1 Introduction

In 2016, Auckland upzoned approximately three-quarters of its residential land under the Auckland Unitary Plan Greenaway-McGrevy and Jones (2023). Using a difference-in-differences framework that compares subsequent changes in building permits in upzoned and non-upzoned residential areas, Greenaway-McGrevy and Phillips (2023) argue that upzoning generated a significant increase in residential housing construction over the five years subsequent to the policy change.[1] A salient feature of their framework is that it accounts for displacement from control (non-upzoned) to treatment (upzoned) areas from the policy, which would otherwise generate an overstatement of policy effects if unaccounted for. This is achieved by extrapolating pre-treatment trends in control group outcomes into the post treatment period, and then specifying a set of counterfactual outcomes around the extrapolated trend. Causal inference then proceeds via set identification of treatment effects that compares observed outcomes in the treatment group (upzoned areas) to the counterfactual sets.

This paper extends the methodology and analysis in Greenaway-McGrevy and Phillips (2023) (hereafter, "GMP") along several dimensions. First, it incorporates an additional year of data, 2022. Second, it expands the control group to include building permits in rural and business zones. While business and rural areas are inherently less suitable as a control for upzoned residential areas, by expanding the control group we can allow residential construction to displace business and rural construction in the modeling framework. As we explain below, the resultant estimates are best thought of as providing a lower bound on policy impacts, as displacements are identified under the assumption that treatment and control areas are subject to identical variations in housing demand and supply (excepting those generated by the policy intervention itself). Because this assumption is an inaccurate approximation, displacements are overestimated, and treatment effects are consequently underestimated.Third, it incorporates the Special Housing Areas (SpHAs) into the analysis, which operated as an interim measure to encourage housing supply three years prior to the AUP becoming operational, and allowed developers to build under the upzoned regulations of the "Proposed" AUP (PAUP) in exchange for a proportion of the development to be designated as affordable housing. GMP remove permits issued under the SpHAs from their sample, as a disproportionate number were located in upzoned areas between 2013 and 2016, reflecting policy "leakage" prior to full policy implementation. To accommodate permits issued under the PAUP in SpHAs, we bring the treatment date forward to 2013.

Under these alternative methods for modeling the impact of upzoning, we find that the evidence continues to support the zoning reforms having had a substantive impact on housing supply. Under the expanded control groups, counterfactual scenarios that allow at least a two-and-one-half increase in permits over the pre-treatment trend are required to render estimated treatment statistically insignificant. Alternatively, using the extrapolated pre-treatment trend as the counterfactual scenario results in at least 27,000 additional dwellings by 2022, equivalent to 5.11% of the housing

[1]Following GMP, we maintain the use of "permits" in this paper. Permits are "consents" in the New Zealand parlance.

stock.[2] When PAUP-SpHA issued permits are incorporated into the analysis, the counterfactual sets required to render treatment effects statistically insignificant become even larger, as are the point estimates of permits generated under the linear counterfactual trend.

We also make several other minor improvements to the GMP methodology. We extend the period of analysis back further in time to include the peak of the previous building cycle, between 2002 to 2004. This contextualizes the amplitude and period of the current construction boom in Auckland. The period of the current cycle also assists in providing heuristics to select the period over which to specify the pre-treatment trend in the control group that provides the basis for modeling sets of counterfactual scenarios. Second, we allow the trend to be fitted over any arbitrary period prior to treatment, whereas GMP restrict the trend to fitting the first period and the treatment period. This allows the practitioner greater flexibility in specifying the credible set of counterfactual scenarios. Third, we include suburb-specific period fixed effects. These tighten standard errors, offering more precise estimates of treatment effects, but they do not change points estimates because the model is additive.

The remainder of the paper is organized as follows. The following section reviews the empirical DID model and outlines the approach for specifying counterfactual scenarios. Empirics are covered in section three. The paper ends with a discussion of our findings.

2 Model and Set Identification

Let $y_{i,j,t}$ denote the number of permits in zone j in area $i = 1, \ldots, n$ in period $t = -\underline{T}, \ldots, 0, \ldots, \overline{T}$, where $\underline{T}$ denotes the number of time series observations prior to the treatment, and $\overline{T}$ denotes the number of time series observations post-treatment. The treatment occurs in period $t = 0$. We use $j = 0$ to indicate the control group (i.e, permits in non-upzoned areas) and $j = 1$ to signify the treatment group (permits in upzoned areas). The causal impact of upzoning is then estimated using a multi-period difference-in-differences (DID) specification of the form

$$y_{i,j,t} = \alpha_{i,j} + \sum_{s=-\underline{T}, s\neq 0}^{\overline{T}} \phi_{s,i} \mathbf{1}_{s=t} + \sum_{s=-\underline{T}, s\neq 0}^{\overline{T}} \beta_s \mathbf{1}_{s=t,j=1} + \varepsilon_{i,j,t} \tag{1}$$

where $\alpha_{i,j}$ are suburb-zone fixed effects, $\phi_{s,i}$ are location i period fixed effects, and $\mathbf{1}_{s=t}$ are indicators for each time period except the treatment period, $t = 0$. $\mathbf{1}_{s=t,j=1}$ are indicators for each time period (except $t = 0$) interacted with a treatment indicator. Thus $\{\beta_s\}_{s=1}^{\overline{T}}$ represent the treatment effects over time from upzoning. The empirical estimates of these parameters capture the increase in permits in treatment areas relative to control areas in each period after upzoning is implemented. Following convention, estimates of $\{\beta_s\}_{s=-\underline{T}}^{-1}$ will be used to assess the extent to which the parallel trends assumption holds prior to treatment. The period fixed effects $\phi_{s,i}$ measure changes in permits in the control group relative to the implementation period $t = 0$ in each area i. Because the model is additive, the arithmetic average $\phi_s := \frac{1}{n} \sum_{i=1}^{n} \phi_{s,i}$ captures the average change in permits

[2] This is not an estimate of the increase in the housing stock, as we lack data on the number of dwellings demolished when parcels are redeveloped. Buildings less than three storeys can be demolished without a permit in Auckland.

in the control group relative to $t = 0$ across all areas.

2.1 Set Identification under Displacement Effects

Upzoning may shift construction to upzoned areas that might have otherwise occurred in non-upzoned areas under the counterfactual of no-upzoning. These displacement effects would manifest as negative spillovers between treatment and control groups, violating the Stable Unit Treatment Value Assumption (SUTVA) in the Rubin causal framework, and causing the estimates treatment effects to overstate policy impacts. For example, consider a spillover that generates $\delta_t \in \mathbb{R}^+$ fewer permits in non-upzoned areas – and δ_t more permits in upzoned areas in period t. The corrected treatment effect would be $\hat{\beta}_t - 2\delta_t$ and the corrected period fixed effect would be $\hat{\phi}_t + \delta_t$.[3]

Inspired by insights from Rambachan and Roth (2023), GMP argue that pre-treatment trends in control group outcomes are informative of what would have happened under the counterfactual of no policy intervention. Because $\{\phi_s\}$ capture outcomes in control areas, they use pre-treatment trends in $\{\phi_s\}_{s=-\underline{T}}^{0}$ to specify a set of counterfactual scenarios for control group outcomes in the absence of displacement effects.

For each $t = 1, ..., \overline{T}$ we bound the set of counterfactual outcomes by a linear trend fitted through $\hat{\phi}_{-t_2}$ and $\hat{\phi}_{-t_1}$, where $0 \leq t_1 < t_2 \leq \underline{T}$. Thus the counterfactual trend for $t \geq 1$ becomes

$$c_t := \frac{-\left(\hat{\phi}_{-t_2} - \hat{\phi}_{-t_1}\right)}{t_2 - t_1} t + \left[\frac{-\left(\hat{\phi}_{-t_2} - \hat{\phi}_{-t_1}\right)}{t_2 - t_1} t_2 + \hat{\phi}_{-t_2}\right]$$

Figure 3 below exhibits the counterfactual lines when $t_1 = 1$ and $t_2 = \underline{T} - 1$. The first term in the above is the slope of the trend multiplied by the time period t. The term in the square brackets captures the difference between the trend and the origin in period $t = 0$. This approach to trend fitting is more flexible than that originally proposed in GMP. There, the trend is fitted through the first observation and the period of treatment, so that $t_1 = 0$ and $t_2 = \underline{T}$, and where $\hat{\phi}_{-t_1} = 0$.

Following GMP and Rambachan and Roth (2023), it is desirable to allow a margin of error around the counterfactual, such that $c_t \pm Mt/2\overline{T}$ for some $M \in \mathbb{R}^+$. $Mt/\overline{T}$ therefore denotes the length of the counterfactual set for period t, and M denotes the set length in the final period. The set for δ_t is then given by

$$\Delta_t = \left\{\delta_t : \delta_t \in \left(2\left(c_t - \hat{\phi}_t\right) - Mt/\overline{T}, 2\left(c_t - \hat{\phi}_t\right) + Mt/\overline{T}\right)\right\} \tag{2}$$

Having articulated the set of counterfactuals in (2), we can adopt the inferential architecture supplied by Rambachan and Roth (2023). Because our counterfactual sets are convex and centrosymmetric, fixed length confidence intervals (FLCI) are consistent: For a given significance level $\alpha \in (0, 0.5]$, the coverage of FLCIs converge to $1 - \alpha$. Remaining technicalities of the method are

[3] Note that $\hat{\beta}_t = \mu_{t,1} - \mu_{t,0}$, where $\mu_{t,1}$ denotes the change in outcomes in treatment areas between t and 0, and $\mu_{t,0}$is the change in outcomes in control areas between t and 0. Correcting for displacement effects that shift δ_t permits from non-upzoned to upzoned areas, we have$(\mu_{t,TRT} - \delta_t) - (\mu_{t,CON} - \delta_t) = \hat{\beta}_t - 2\delta_t$.

provided in the Appendix.

We incrementally increase M until at least one treatment effect remains marginally statistically significant, and then report the set-identified treatment effects in graphical form. However, we express M in terms of the maximum increase in slope s relative to the linear trend permitted under the counterfactual sets,

$$M = (s-1) \cdot \frac{-\left(\hat{\phi}_{-t_2} - \hat{\phi}_{-t_1}\right)}{t_2 - t_1} \overline{T}$$

or

$$s = \frac{-(t_2 - t_1)}{\overline{T}\left(\hat{\phi}_{-t_2} - \hat{\phi}_{-t_1}\right)} M$$

In what follows we will refer to s when discussing the length of the counterfactual set.

3 Empirics

Our dataset consists of geocoded building permits issued by Auckland Council between 2000 and 2022. These permits are matched to AUP and pre-AUP planning zones to identify whether the permit was issued in an upzoned area of the city. As in GMP and Greenaway-McGrevy and Jones (2023), upzoned residential areas are identified by comparing the maximum floor-to-area ratio of the pre-AUP plan to that under the AUP.[4] The statistical area (SA) of the permit is also identified using the geocoordinate. In (1), i indexes statistical areas (SAs).[5]

3.1 Expanding the Control Group

GMP focus on four residential areas in Auckland, which fall under four different zones: Single House (SH), Mixed Housing Suburban (MHS), Mixed Housing Urban (MHU), Terrace Housing and Apartments (THA). Under their quasi-experimental approach, outcomes in upzoned residential areas are compared to outcomes in non-upzoned residential areas. Non-upzoned residential areas are therefore used as a control for upzoned residential areas, meaning that outcomes in such areas are informative of the counterfactual of no policy intervention in upzoned areas.

Residential building permits are also issued in rural and business zones. However, such areas are inherently inadequate to act as controls for upzoned residential areas. Business areas such as the CBD differ substantially from residential areas in terms of built environment and geographic area. High rise apartment buildings found in the CBD are substantially more capital intensive than the housing in residential areas, requiring significant capital outlay and financing. Housing supply shocks are therefore likely to manifest differently in business and residential areas.[6] Meanwhile, the

[4] Prior to the AUP, there were seven City and District Councils in Auckland, each with their own planning zones and restrictions. Rural and business areas rezoned as residential are classified as upzoned.

[5] We use 2018 Statistical Area 2 units.

[6] Visual inspection of the time series of permits issued in the CBD reveals substantial volatility relative to residential areas, which accords with the significant capital outlay associated with high-rise apartment building development (see Figure 9 below).

amenities and disamenities of the CBD are substantially different to those of residential areas, generating significant differences in housing demand. Business areas are consequently less informative as a counterfactual for residential areas. For example, differential trends in permits between business areas are upzoned residential areas could reflect supply shocks that disproportionately affect capital intensive housing construction, rather than the policy intervention. Rural areas are similarly inadequate to the task of acting as a control for residential areas. Rural areas lack utilities such as water and sewerage, frequently serve dual uses in housing and land-intensive production, such as agriculture, and also differ markedly from residential areas in terms of amenities and disamenities.

GMP also focus on the potential for displacement effects to cause difference-in-differences to overstate treatment effects. If construction in upzoned areas displaces construction that would have otherwise occurred in control areas under the counterfactual of no upzoning, then a simple comparison of outcomes in upzoned areas to non-upzoned areas will overstate the effect of the policy. Displacements are most likely to manifest in locations that are a suitable control for treated areas, as control areas are selected precisely because they are sufficiently similar to treated areas in order to be informative of the counterfactual. Non-upzoned residential areas are therefore highly likely to be subject to displacement effects. In contrast, in terms of both housing supply and demand, rural and business areas differ substantially from upzoned residential areas, and thus less prone to displacement. Nonetheless, it is feasible that construction in residential areas could displace construction in business and rural areas, at least to some extent. In this subsection we sequentially expand the control group sample to include rural, business excluding the CBD, and the CBD areas to allow for broader displacement effects. The latter dataset then comprises the full set of building permits for the Auckland region.[7]

In the GMP set-up, deviations between counterfactual scenarios and observed outcomes in control areas are identified as displacements. This means that, for example, changes in macroeconomic conditions that disproportionately affect high-rise apartment construction in business areas post-treatment will be incorrectly attributed to displacement effects from the policy intervention.[8] Similarly, a decrease in housing demand in the CBD due to, for example, falling tertiary sector enrollments would be incorrectly identified as a displacement effect. In other words, displacement effects are identified under the assumptions that housing in residential, rural and business areas are perfect substitutes in demand, and share identical production functions in supply, under the counterfactual of no-upzoning. Such assumptions are untenable in practice. When these conditions fail to hold, displacement effects are overestimated, and treatment effects are consequently underestimated. The exercise is nonetheless useful as it can assist in establishing lower bounds on policy impacts. Conversely, restricting the control to non-upzoned residential areas omits potential displacement effects in rural and business areas, leading to underestimation of treatment effects, and providing and upper bound on policy impacts.

[7]See the Appendix for a reconciliation with the Statistics New Zealand data.

[8]Incorporating matching into the DID framework might provide a mechanism to assign different potential control groups a weighting. We leave this avenue for future research.

3.1.1 Data

Figure 1 below exhibits permits issued in upzoned and non-upzoned areas, with the former being sequentially expanded to include permits issued in rural, business, and CBD areas.[9] As in GMP, we omit permits issued under the PAUP as SpHAs for the time being.

Several features are worth commenting on. First, in each case, all of the increase in permits from 2016 onwards occurs in upzoned areas. Second, the amplitude of the current cycle far exceeds that of the previous cycle, which peaked between 2002 and 2004.[10] Third, the nadir of the previous cycle occurred in 2009. The latter will be used as the beginning point for specifying the pre-treatment trend in the control groups. Finally, the increase in permits has notably slowed between 2021 and 2022, with the total for 2022 just exceeding that of 2021. Prior to 2022, the increase each year had exceed the previous year. It therefore appears that the current construction boom is slowing.[11]

3.1.2 Set Identification

Next we implement set-identification of treatment effects allowing for displacement effects from the control to treatment areas. As in GMP, we use an extrapolated pre-treatment trend in control group outcomes as the basis for specifying the counterfactual scenarios. However, under the generalized approach outlined above, we can fit the trend to any two periods prior to treatment.

First we consider the beginning point for the pre-treatment trend, $-t_2$. Given the cyclical nature of the construction sector, we suggest choosing the nadir of the cycle as the starting point, which occurs in 2009. Next, for the end point $-t_1$,we follow GMP and use 2015, since there is a switch in trend in the control group permits at this point when either non-upzoned residential or non-upzoned residential and rural compose the control. As discussed in GMP, the change in trend at this point in time is consistent with a displacement effect: It occurs the year before the implementation of the AUP. We note, however, that when business and/or CBD are included in the control area, the switch in trend occurs after the AUP becomes operational, in 2017. In contrast to GMP, we are free to set the treatment date as distinct from the fitted trend end point under the more general modeling architecture outlined above. We use 2016, when the AUP became operational, as the treatment date.

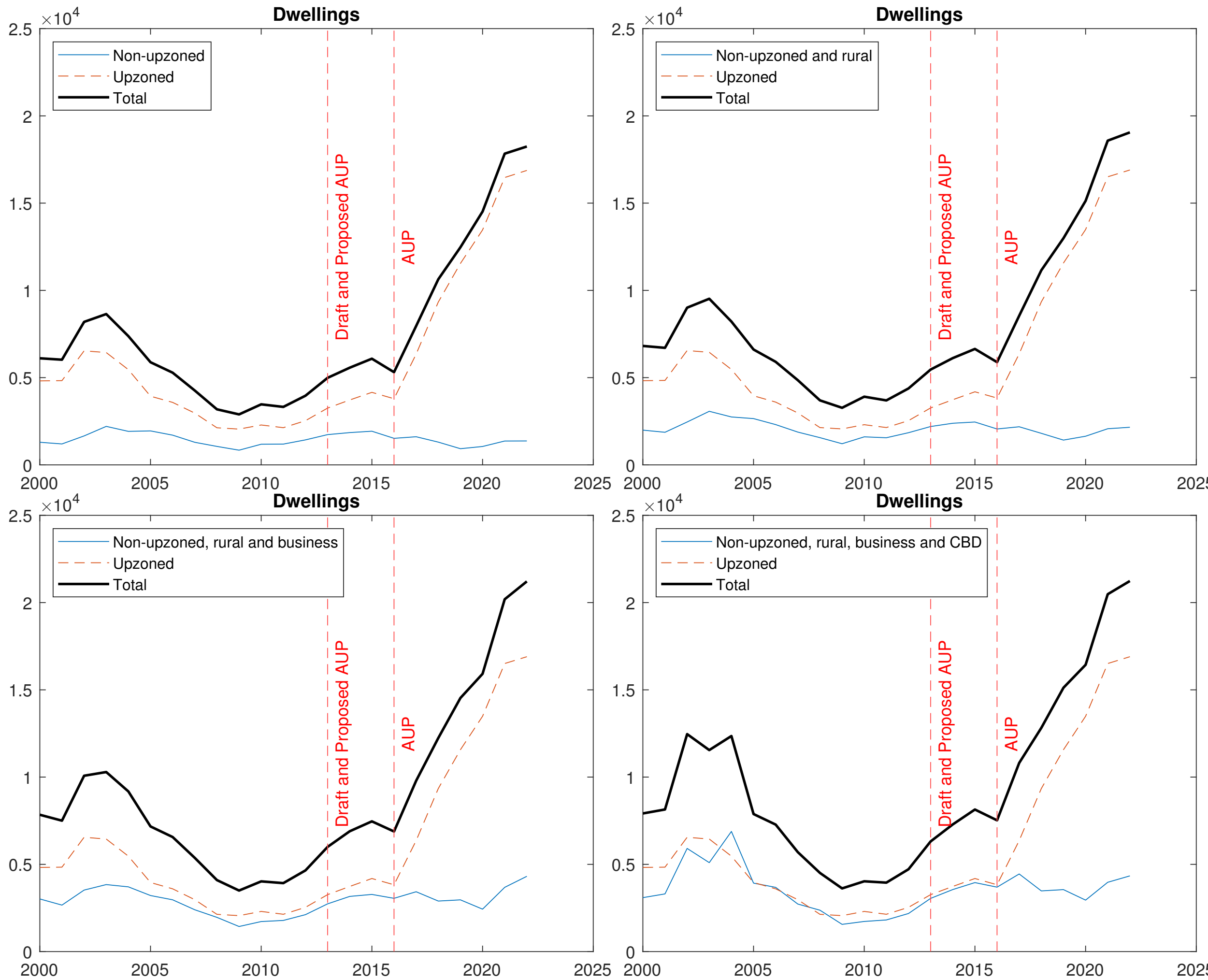
For each of the four samples, we increase the length of the counterfactual set M until we reach the point where treatment effects in a given year are on the verge of becoming insignificant. We express the size of the set in terms of the multiplicative increase s in the slope of the pre-treatment trend in the control group. For example, in the sample where only residential areas comprise the control group, the confidence set remains statistically significant even under counterfactual sets that allow a four-and-a-half times increase in the pre-treatment trend in the control area. The top panel

[9] Upzoned areas are expanded to accord to with the control sample. For example, when rural areas are included in the control, upzoned residential areas include rural areas that have been rezoned as residential. Figure 1 shows that this has negligible effect on the upzoned time series.

[10] The previous cycle involved a substantial amount of CBD construction. Media coverage from the time indicated this was to satisfy a boom in foreign tertiary students. See https://www.nzherald.co.nz/nz/apartment-boom-transforming-cbd/DBO6Z4C2MLL6KPNOLOU47UGPB4/

[11] Interest rates increased significantly.

Figure 1: Dwelling Permits, 2000 to 2022



Notes: Permits issued in upzoned residential areas ("Upzoned") and different delimitations of control areas. "Non-upzoned" refers to non-upzoned residential areas. "Business" excludes the CBD, which has its own category. Permits issued under the Proposed AUP in Special Housing Areas between September 2013 and December 2016 omitted. The first, "draft" version of the AUP was announced in March 2013, while the Proposed AUP was notified in September 2013. The AUP became operational in part in November 2016.

of Figure 2 exhibits the confidence sets while the top panel of Figure 3 exhibits the counterfactual sets in the control group. The slope of the upper bound on the counterfactual sets (in pink) is 4.5 times that of the linear trend (the dashed black line). When the control area comprises rural and non-upzoned residential areas, confidence sets remain statistically significant even when the counterfactual sets admit a near five-fold increase in the trend rate of construction. We note that a sight pre-treatment trend is evident between 2012 and 2016. When the control area comprises rural, business, and non-upzoned residential areas, confidence sets remain statistically significant even when the counterfactual sets admit a three-and-one-half-fold increase in the trend. Finally, when the control area comprises rural, business, CBD and non-upzoned residential areas, confidence sets remain statistically significant even when the counterfactual sets admit a two-and-one-half-fold increase in the trend.

3.1.3 Spillover-Adjusted Point Estimates

Next we restrict the counterfactual sets to the pre-treatment trend to produce spillover-adjusted point estimates of the increase in permits from the policy. While this restriction offers the convenience of a single number, it is of course sensitive to the specification of the trend. The resultant point estimates should therefore be interpreted with caution, and conditional on the posited specified counterfactual scenario.

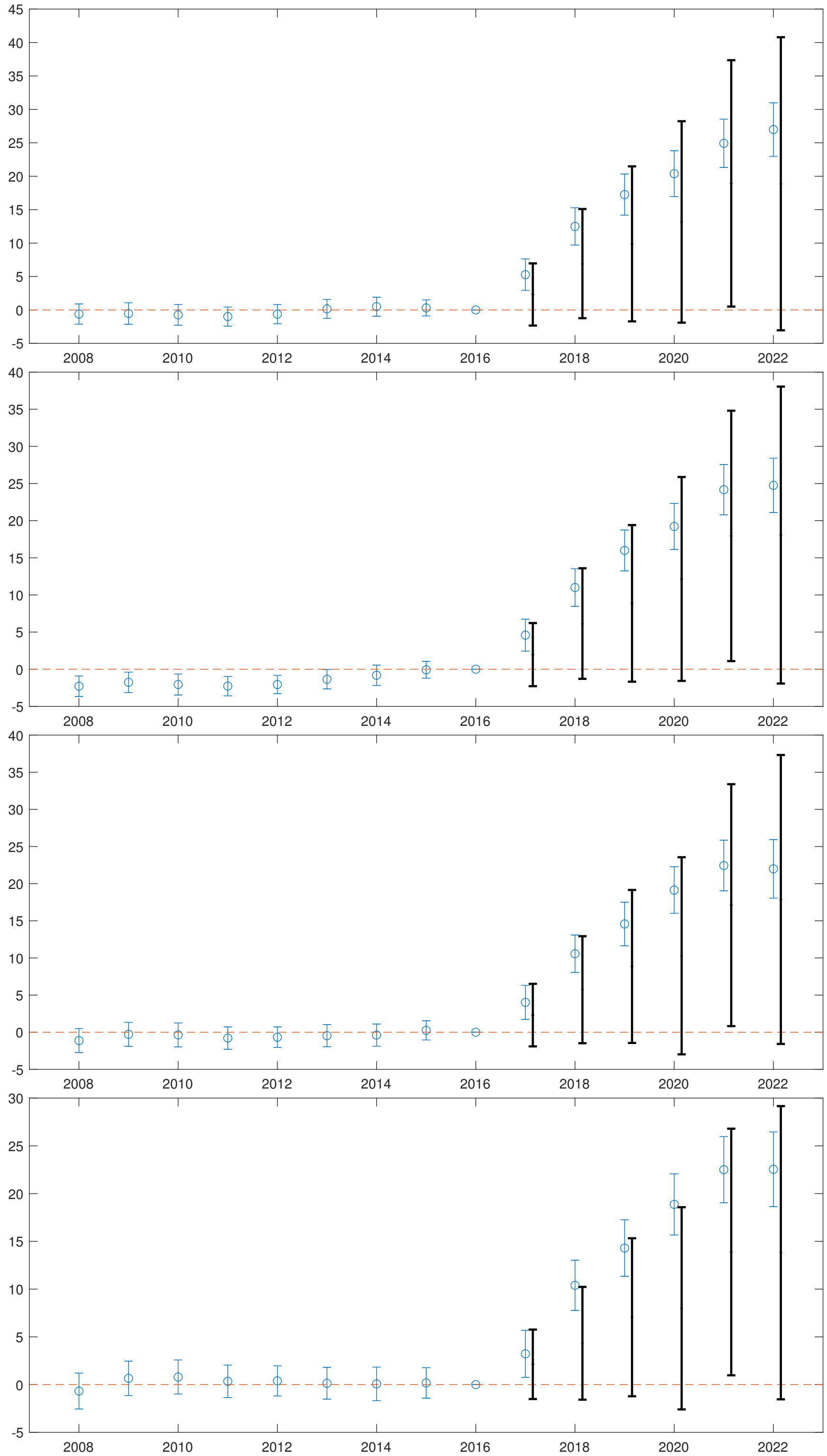
When the control area comprise only non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 34,064 permits. Thus, if, under the counterfactual of no-upzoning, permits in non upzoned areas had continued along the linear trend fitted to 2009 and 2015, upzoning generated an additional 34,064 permits in aggregate. To contextualise this figure, it corresponds to 6.42% of the approximately 530,000 dwellings in Auckland in 2016. As noted in GMP, the permits do not correspond to an increase in the overall dwelling stock, since we do not have accurate information on the number of dwellings demolished when parcels are redeveloped.

When the control area comprises rural and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 34,134 permits, or 6.44% of the dwelling stock. When the control area comprises non-CBD business, rural, and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 33,373 permits, or 6.29% of the extant housing stock. When the control area comprises CBD, business, rural and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 27,101 permits, or 5.11% of the dwelling stock.

3.2 Special Housing Areas

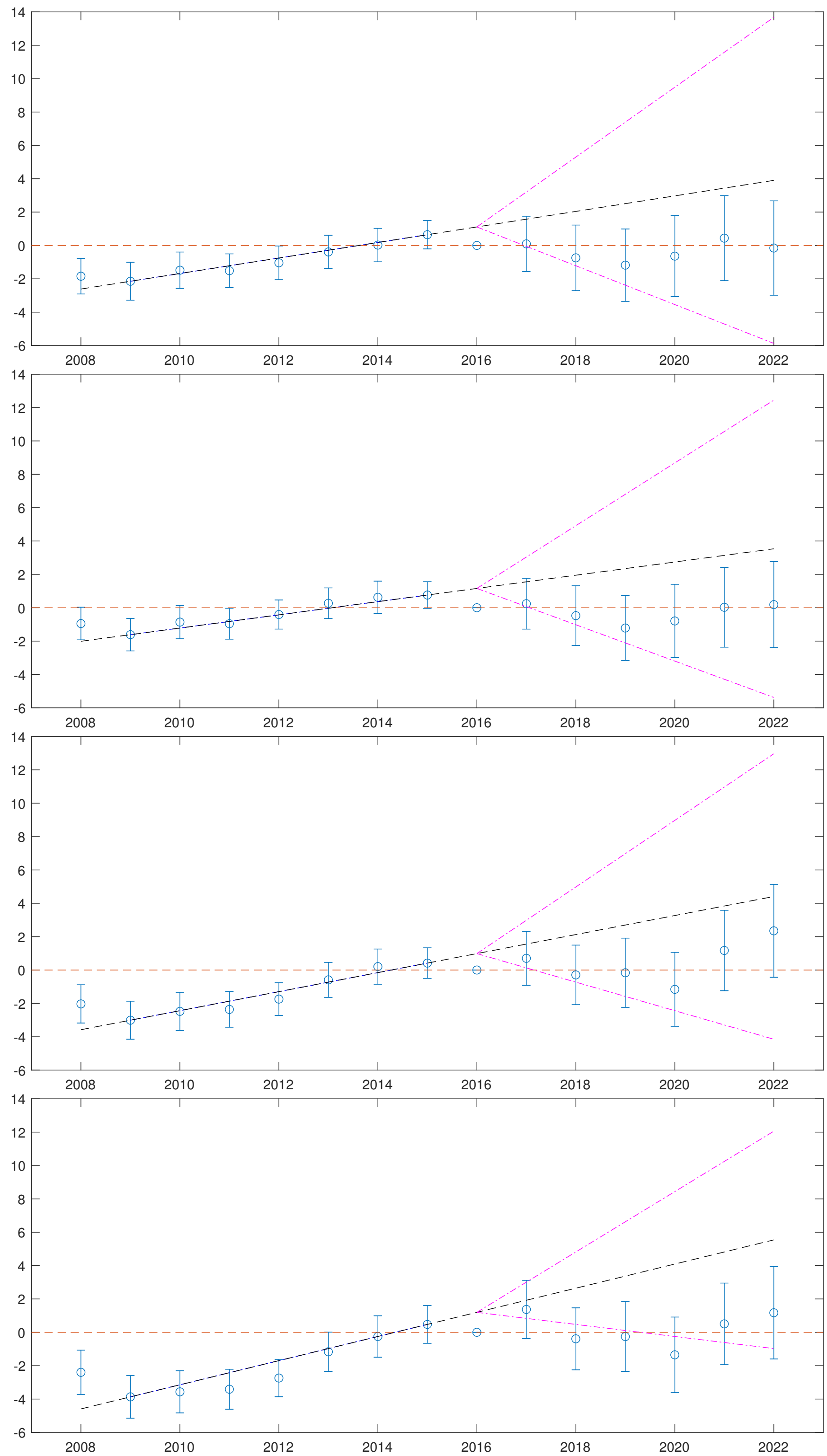
Special Housing Areas (SpHA) operated between September 2013 and 2016 in Auckland as an interim measure to encourage housing supply until the AUP became operational. The program combined upzoning under a preliminary version of the AUP with inclusionary zoning to promote affordable housing.

Figure 2: Set-Identified Treatment Effects



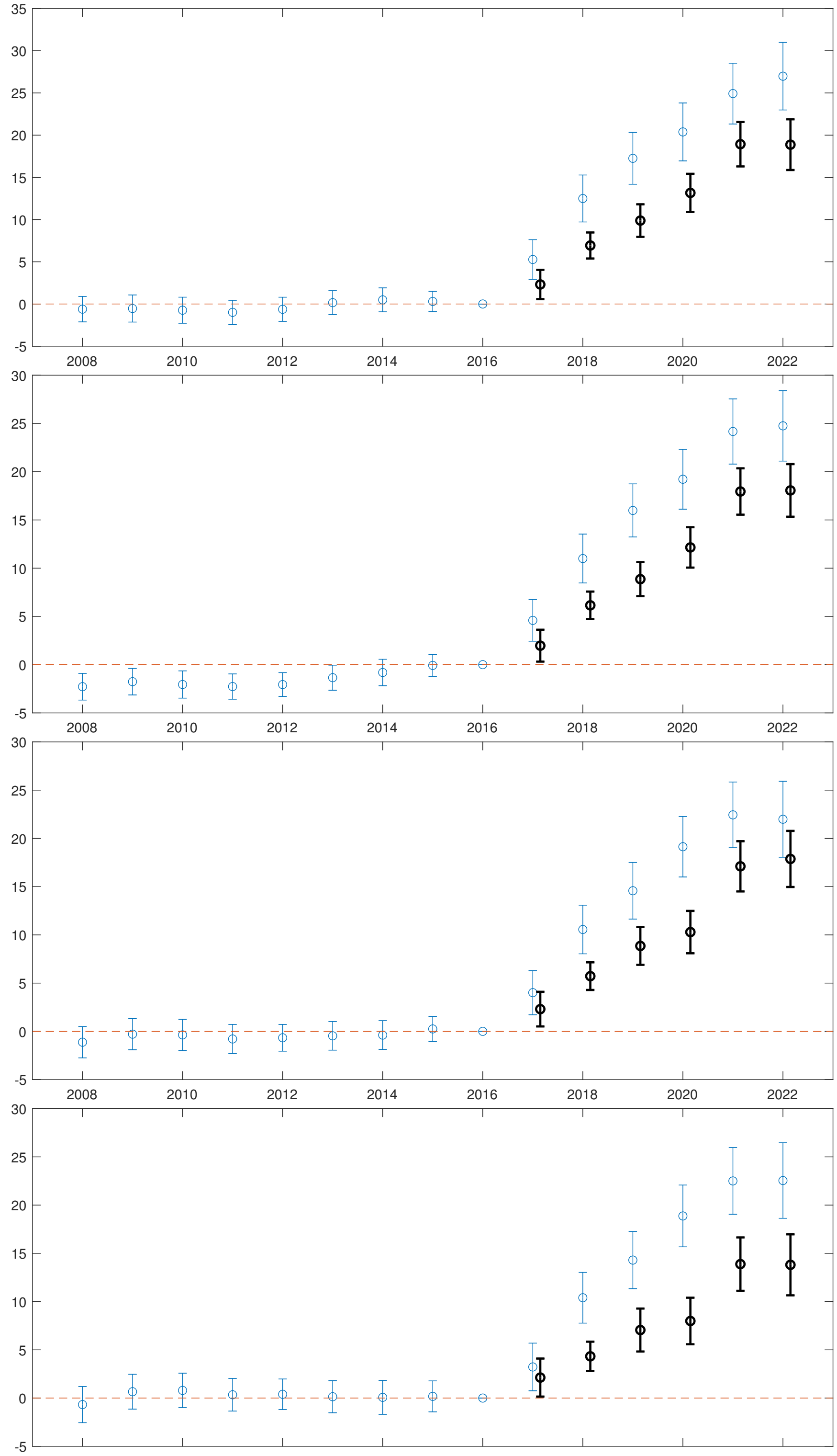
Notes: Top panel: control comprises non-upzoned residential, and $s = 4.5$. Top-middle panel: control comprises rural and non-upzoned residential, and $s = 4.75$. Bottom-middle panel: control comprises business, rural and non-upzoned residential, and $s = 3.5$. Bottom panel: control comprises CBD, business, rural and non-upzoned residential, and $s = 2.5$.

Figure 3: Counterfactual Sets



Notes: Top panel: control is non-upzoned residential, and $s = 4.5$. Top-middle panel: control is non-upzoned residential and rural, and $s = 4.75$. Bottom-middle panel: control is non-upzoned residential, rural, and business, and $s = 3.5$. Bottom panel: control is non-upzoned residential, rural, business and CBD, and $s = 2.5$.

Figure 4: Spillover-Adjusted Treatment Effects



Notes: Top panel: control is non-upzoned residential. Top-middle panel: control is non-upzoned residential and rural. Bottom-middle panel: control is non-upzoned residential, rural, and business. Bottom panel: control is non-upzoned residential, rural, business and CBD.

In the previous section, and as in GMP, permits issued under SpHAs are omitted from the sample.[12] Permits issued under SpHAs prior to the AUP disproportionately fell into areas that were upzoned in 2016, which would generate a violation of the parallel trends assumption if they are included in the sample. However, as we make clear below, SpHAs provided developers with a mechanism to build to the more relaxed regulations of the "Proposed" AUP, meaning that the SpHA program was an earlier, less intensive upzoning policy. In other words, the pre-treatment trend when SpHA permits are included does not reflect selection bias or endogeneity of the treatment, but rather policy "leakage", in the sense that developers were able to get a head start of up to three years on the AUP if they were willing to apply for SpHA status.

We first describe the implementation and nature of the SpHAs in Auckland before describing how we incorporate SpHAs into the analysis.

3.2.1 Institutional Background

In September 2013, the "Housing Accords and Special Housing Areas Act 2013" (HASHAA) was passed,[13] closely followed by the signing Auckland Housing Accord (AHA).[14] Together, the HASHAA and AHA outline the process for getting properties identified as a SpHA in Auckland. Once approved, the SpHAs were then spatially defined as places where developers could use the rules from the "Proposed" version of the AUP (PAUP), which had been notified on September 30, rather than the existing set of rules.

To qualify as a SpHA, developers had to agree to reserve at least ten percent of new dwellings for affordable housing,[15] and submit a (fast-tracked) resource consent application by a certain date, otherwise the SpHA would eventually lapse. After a lengthy hearing process, the AUP became operative in part in November 2016. As such, Sp Ha-designated developments had a head start in being able to proceed with the notified zoning changes, of up to three years. SpHAs in Auckland ended once the AUP became operational. Refer to the Appendix for a detailed timeline on the AUP and the SpHAs.

There was substantial geographical overlap between the PAUP zones and the AUP zones. For example, we estimate that approximately 93.8% of land that was zoned either THA, MHU or MHS under the PAUP were also zoned as either THA, MHU or MHS under the AUP.[16] Furthermore, zoning restrictions were relaxed further under the AUP compared to the PAUP. For example,

[12] Auckland Council building permit data contain identifiers for permits issued in Special Housing Areas.

[13] https://www.legislation.govt.nz/act/public/2013/0072/latest/DLM5369001.html

[14] https://www.beehive.govt.nz/sites/default/files/Auckland_Housing_Accord.pdf

[15] Housing had to satisfy at least one of two criteria to be classified as affordable. Either the sales price did not exceed 75 per cent of the Auckland region median house price; or the dwelling was sold or rented to households earning up to 120 per cent of the median household income for Auckland, and at or below a price such that the household spends no more than 30 per cent of its gross household income on rent or mortgage repayments. Buyers were requested to own and occupy the affordable house exclusively as their residence for no less than three years and to be a first time home buyer (Fernandez, Sánchez, and Bucaram, 2021). Fernandez, Sánchez, and Bucaram (2021) argue that the affordability requirement was never met because of a lack of enforcement mechanisms.

[16] Source: Author's calculations based on November 2016 land parcels mapped to AUP and PAUP planning zones. See Greenaway-McGrevy and Jones (2023) for a description of the parcel dataset.

minimum lot sizes were abolished under the AUP, but not the PAUP.[17]

Thus, SpHAs can be conceptualized as an early upzoning under the PAUP that was followed by a more intensive upzoning under the AUP. Incorporating SpHAs into the analysis necessitates bringing forward the treatment date, since the PAUP became operational in September 2013. Because very few SpHA permits were issued in 2013, we adopt 2013 as the treatment date, rather than 2012.[18] If the treatment date is not brought forward, the differential increase in permits in treatment areas relative to control between 2013 and 2016 will manifest as a pre-trend (a violation of the parallel trends assumption in DID), since a disproportionate amount of SpHA permits were located in upzoned areas.

Given that SpHAs operated in conjunction with the PAUP, we hereafter refer to the "PAUP-SpHA" program and permits.

3.2.2 Data

Figure 5 again exhibits permits issued in upzoned and non-upzoned areas, with the former being sequentially expanded to include permits issued in rural, business, and CBD areas, but this time permits issued under the PAUP-SpHAs are included in the sample. The inclusion of the PAUP-SpHA permits only affects totals between 2013 and 2016. Approximately 130, 525, 1000 and 1950 dwellings were permitted in SpHAs in 2013, 2014, 2015 and 2016.[19]

Total permits no longer exhibit a substantial break in trend in 2016, when the AUP became operational. However, the decomposition into upzoned and remaining areas illustrates that much of this is due to permits in upzoned areas growing at a faster rate between 2013 and 2016. Thus, much of the increase in the interim period between 2013 and 2016 is occurring in areas targeted for upzoning under the AUP. This accords with developers using the HASHAA and the AHA to get a head start on developing to the relaxed LURs of the PAUP.

3.2.3 Set Identification

Next we implement set-identification of treatment effects allowing for displacement effects from control to treatment areas as a result of the policy.

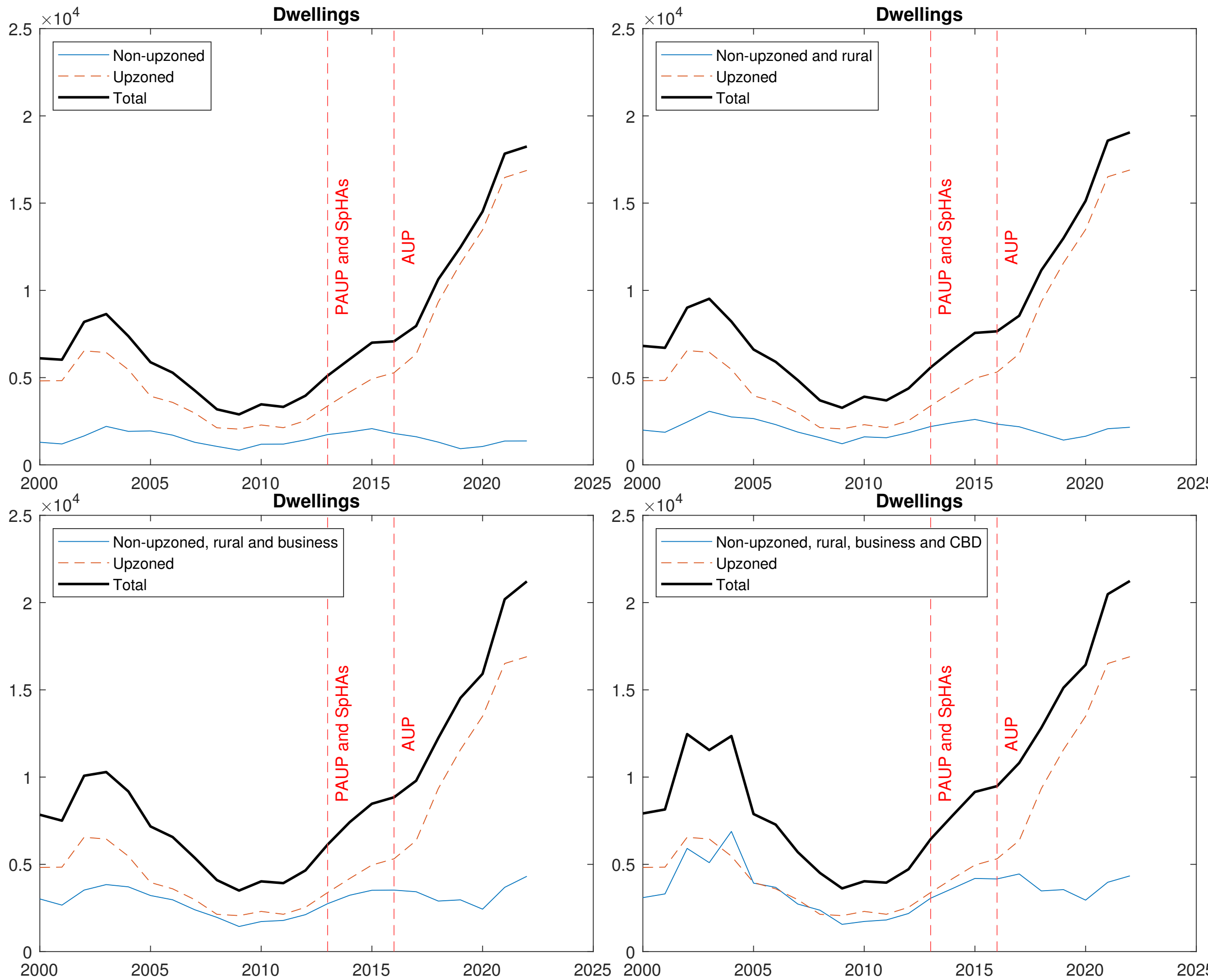
[17]Site coverage ratios, impervious surface ratios, and height restrictions were unchanged between the PAUP and the AUP. The height restriction in THA was relaxed from allowing 4 to 6 storeys to allowing 5 to 7.

[18]There is some evidence to suggest that 2012 is a more appropriate treatment date when the control consists of non-upzoned residential or non-upzoned residential and rural areas. Note that Figure 6 shows a statistically significant increase in the treatment coefficients between 2012 and 2013. This indicates that permits in upzoned areas grew faster between 2012 and 2013 compared to the control. For simplicity, we retain 2013 as the treatment date in all control-group samples.

[19]Paragraph 26 of the AHA set targets of 9,000, 13,000 and 17,000 new dwellings or sections over the first, second, and third years of the accords. However, these goals were for the Auckland region, not just SpHAs, being stipulated as created "under existing regulations or through the application of the new tools enabled through this Accord". Subsequent reports showed that the number of permitted dwellings in SpHAs made up a small number of the total permits issued. For example, the Auckland Housing Accord Third Quarterly Report for Third Accord Year estimated that 2,208 permits had been issued in SpHAs by June 2016.

See https://www.beehive.govt.nz/sites/default/files/Auckland%20Housing%20Accord%20Monitoring%20Report.pdf

Figure 5: Dwelling Permits, 2000 to 2022



Notes: Permits issued in upzoned residential areas ("Upzoned") and different delimitations of control areas. "Non-upzoned" refers to non-upzoned residential areas. "Business" excludes the CBD, which has its own category. Permits issued under the Proposed AUP in Special Housing Areas between September 2013 and December 2016 included. The Proposed AUP was notified in September 2013. The AUP became operational in part in November 2016.

As previously, for each of the four samples, we increase the length of the counterfactual set until we reach the point where treatment effects in a given year are on the verge of becoming insignificant. Figure 6 exhibits the confidence sets for treatment effects, while Figure 6 exhibits the counterfactual sets. As noted previously, we use 2013 as the treatment date, since only a small number (approximately 130) permits were in SpHAs in 2013. However, we note that when either non-upzoned residential or non-upzoned residential and rural comprise the control, there is evidence of a pre-treatment trend between 2012 and 2013, meaning that even this small number of PAUP-SpHA permits issued in 2013 were sufficient to generate a noticeable difference in construction between upzoned and non-upzoned areas.

When non-upzoned residential areas comprise the control group, the confidence set remains statistically significant even under counterfactual sets that allow 3.25 times increase in the pre-treatment trend in the control area. The half-length of the counterfactual set M in the final period is greater than that obtained in the previous section, where the treatment date was set to 2016, since the post-treatment period is 1.5 times larger here.[20] Thus, although the slope factor s is less, treatment effects remain statistically significant under counterfactual sets that are even larger when PAUP-SpHA permits are included in the sample.

When the control area comprises rural and non-upzoned residential areas, confidence sets remain statistically significant even when the counterfactual sets admit more than a three-fold increase in the trend rate of construction. When the control area comprises rural, business, and non-upzoned residential areas, confidence sets remain statistically significant under counterfactual sets that admit a two-and-one-third-fold increase in the trend. Finally, when the control area comprises rural, business, CBD and non-upzoned residential areas, confidence sets remain statistically significant even when the counterfactual sets admit a two-and-one-eighth-fold increase in the trend. Again, because the post-treatment period is 1.5 times as large when PAUP-SpHA permits are included in the sample, this implies that the lengths of the counterfactual sets are in fact greater.[21] That is, set-identified treatment effects are statistically significant under larger counterfactual sets when SpHAs are included in the analysis.

3.2.4 Spillover-Adjusted Point Estimates

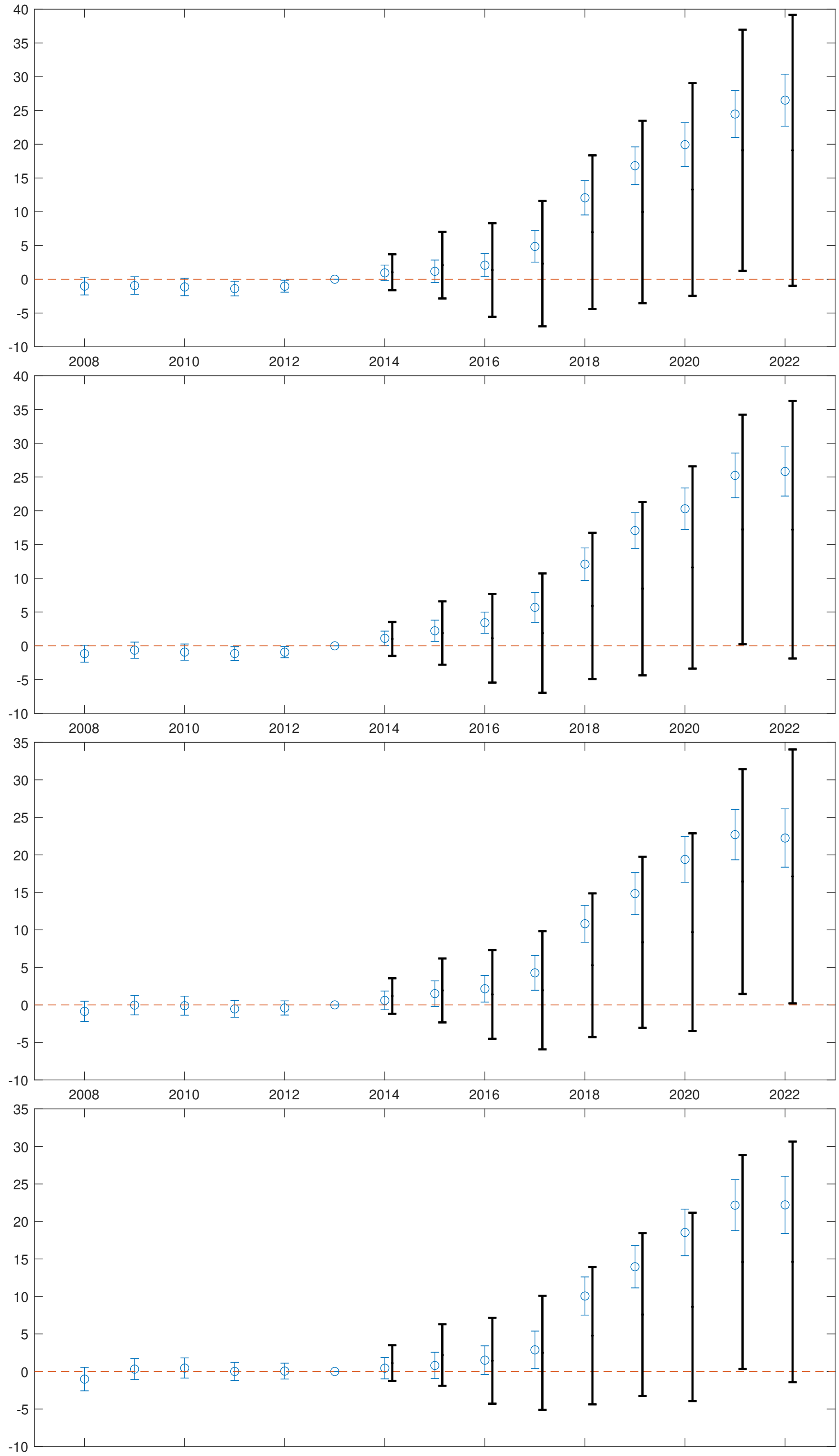
Next we restrict the counterfactual sets to the pre-treatment trend to produce spillover-adjusted point estimates of the increase in dwelling permits from the policy. As above, these figures should be interpreted conditional on the specific counterfactual articulated.

When the control area comprises non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 36,635 permits, which corresponds to 6.91% of the approximately 530,000 dwellings in Auckland in 2016. When the control area comprises rural and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond

[20] In the previous section, the slope was set to 4.5, and there were six post-treatment periods. Here the slope is 3.25, and there are nine post-treatment periods.

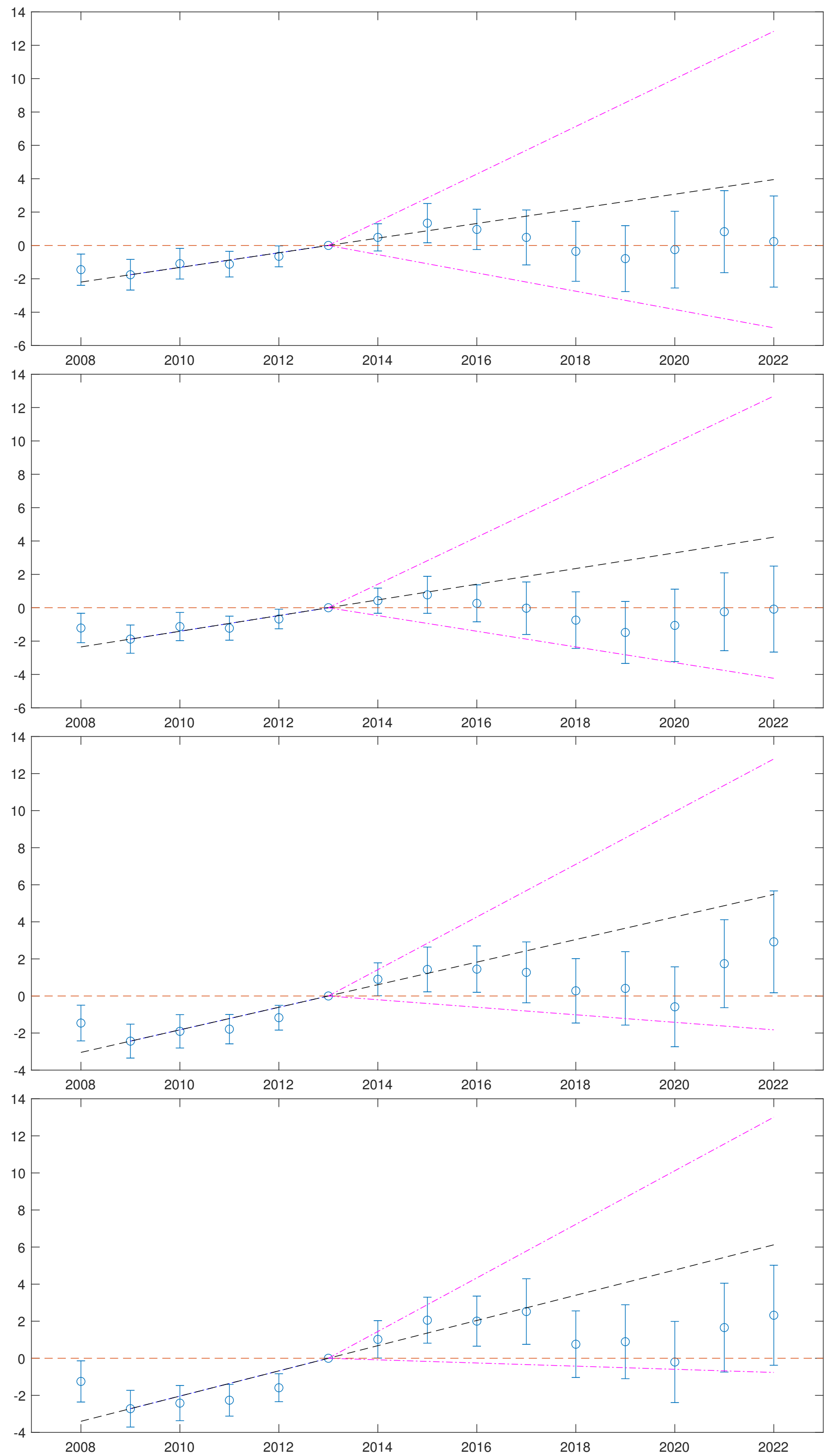
[21] In the previous section, s =2.5 when the treatment date was 2016, and there were six post-treatment periods. Here $s = 2.125$, and there are nine post-treatment periods.

Figure 6: Set-Identified Treatment Effects



Notes: Top panel: control is non-upzoned residential and $s = 3.25$. Top-middle panel: control is non-upzoned residential and rural, and $s = 3$. Bottom-middle panel: control is non-upzoned residential, rural, and business, and $s = 2.\dot{3}$. Bottom panel: control is non-upzoned residential, rural business and CBD, and $s = 2.125$.

Figure 7: Counterfactual Sets



Notes: Top panel: control is non-upzoned residential, and $s = 3.25$. Top-middle panel: control is non-upzoned residential and rural, and $s = 3$. Bottom-middle panel: control is non-upzoned residential, rural, and business, and $s = 2.\dot{3}$. Bottom panel: control is non-upzoned residential, rural business and CBD, and $s = 2.125$.

to an additional 34,830 permits, or 6.57% of the dwelling stock. When the control area comprises rural, business, and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 34,023 permits, or 6.42% of the extant housing stock. Finally, when the control area comprises rural, business, CBD, and non-upzoned residential areas, the cumulative spillover adjusted treatment effects correspond to an additional 31,628 permits, or 5.96% of the dwelling stock.

4 Discussion

The incorporation of the SpHAs generally lends support to the evidence that upzoning increased dwelling construction permits in Auckland. Set-identified treatment effects remain statistically significant under larger counterfactual sets, and point estimates of the increase in permits under linear trend counterfactuals are greater.

In contrast, the magnitude of both point- and set-identified treatment effects decrease as business and CBD areas are included in the control group. This is because the trend in control areas becomes steeper as business, and, in particular, CBD are included in the control, and because there is a drop-off in CBD permits after 2020. This results in larger displacement effects, because all of the deviations from pre-treatment trends are identified as displaced permits under the modeling assumptions. Thus, while it might seem reasonable to expect construction of capital intensive apartment buildings to tail-off with increased uncertainty stemming from the COVID-19 pandemic from 2020 onwards, under our modeling assumptions the entirety of the decline is attributed to upzoned residential construction displacing CBD apartments.

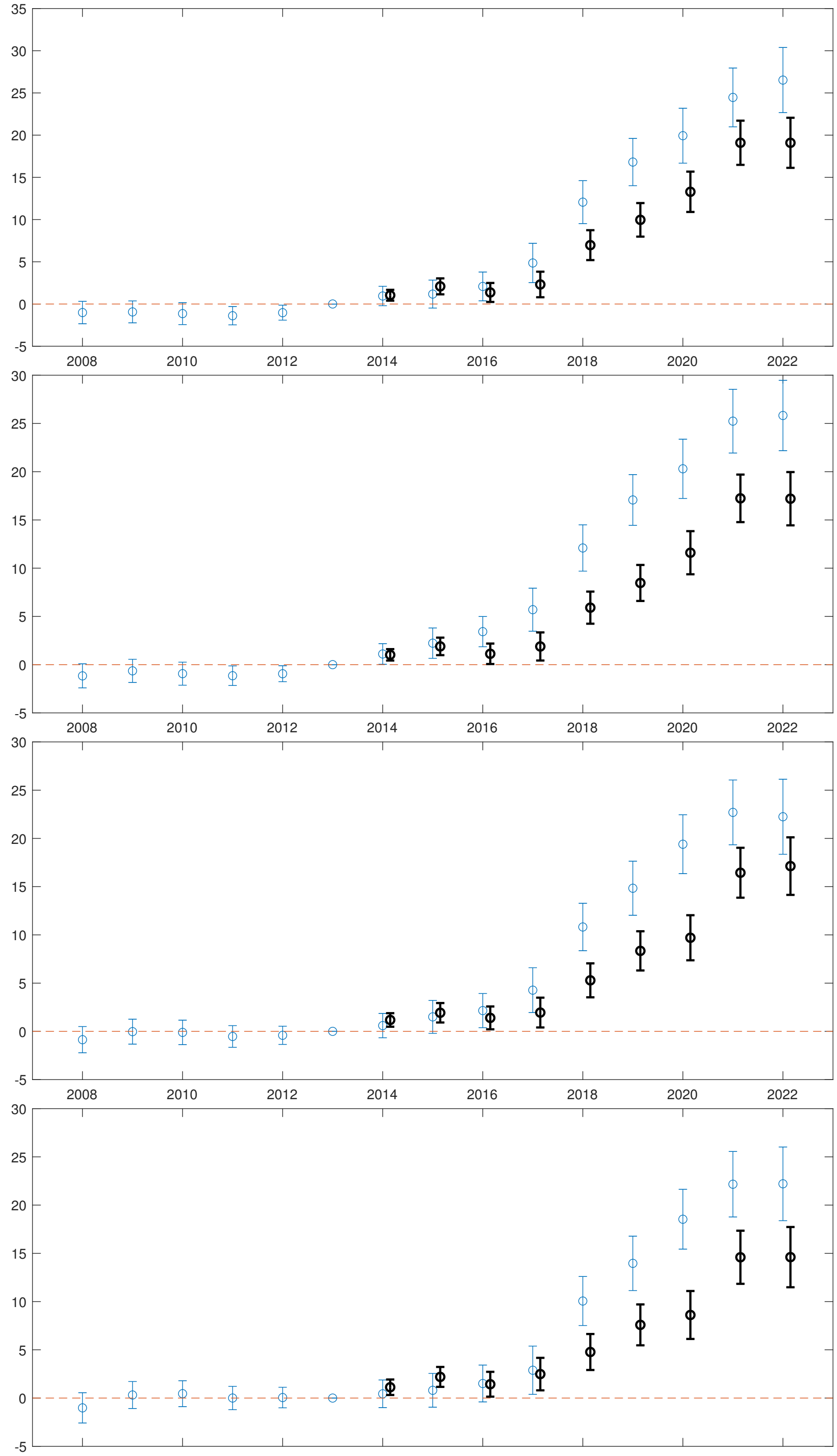
Nonetheless, even when all of the reduction in CBD permits is (mis-) identified as displaced construction, point estimates of the increase in permits under the linear counterfactual assumption remain large, equivalent to 5.11% of the dwelling stock. This provides a lower bound on the effect of the policy, since it is constructed under the untenable assumption that residential, rural and business housing are perfect substitutes and share identical production functions. When only non-upzoned residential areas comprise the control, the linear counterfactual implies an increase that is equivalent to 6.44% of the dwelling stock by 2022, providing a corresponding upper bound on policy impacts, since the figure is made under the assumption that displacement effects occur exclusively within residential areas.

4.1 To what extent are did upzoning displace rural and business housing construction?

Displacement effects are modeled under the assumption that housing in residential, business and rural areas are perfect substitutes and have identical housing production functions (under the counter factual of no-upzoning). Here we evaluate the evidence for these assumptions based on observed trends in the constituent control areas.

To do so, we consider the timing of changes in trend, if any, when the AUP becomes operational.

Figure 8: Spillover-Adjusted Treatment Effects



Notes: Top panel: control is non-upzoned residential. Top-middle panel: control is non-upzoned residential and rural. Bottom-middle panel: control is non-upzoned residential, rural, and business. Bottom panel: control is non-upzoned residential, rural, business and CBD.

GMP argue that the discrete shift in trend in non-upzoned areas in 2015, immediately before the AUP becomes operational in 2016, is consistent with a displacement effect. Specifically, permits shift from trending upward to trending downward in the year immediately before the AUP becomes operational, which is suggestive of housing in upzoned areas displacing housing in control areas as developers shift construction from non-upzoned residential areas to residential areas.

Figure 9 exhibits the time series of permits in each of the four constituent control areas: non-upzoned residential, rural, business, and CBD. Non-upzoned residential exhibits the aforementioned switch in trend in 2015, occurring one year prior to the operationalisation of the AUP.

In contrast, permits in rural areas exhibit a near constant, slightly upwards trend between 2009 and 2022. There is no discernible shift either around the announcement of the AUP and the PAUP in 2013, nor in 2016 when the AUP becomes operational. We conclude there is little evidence of substitutability between residential and rural areas.

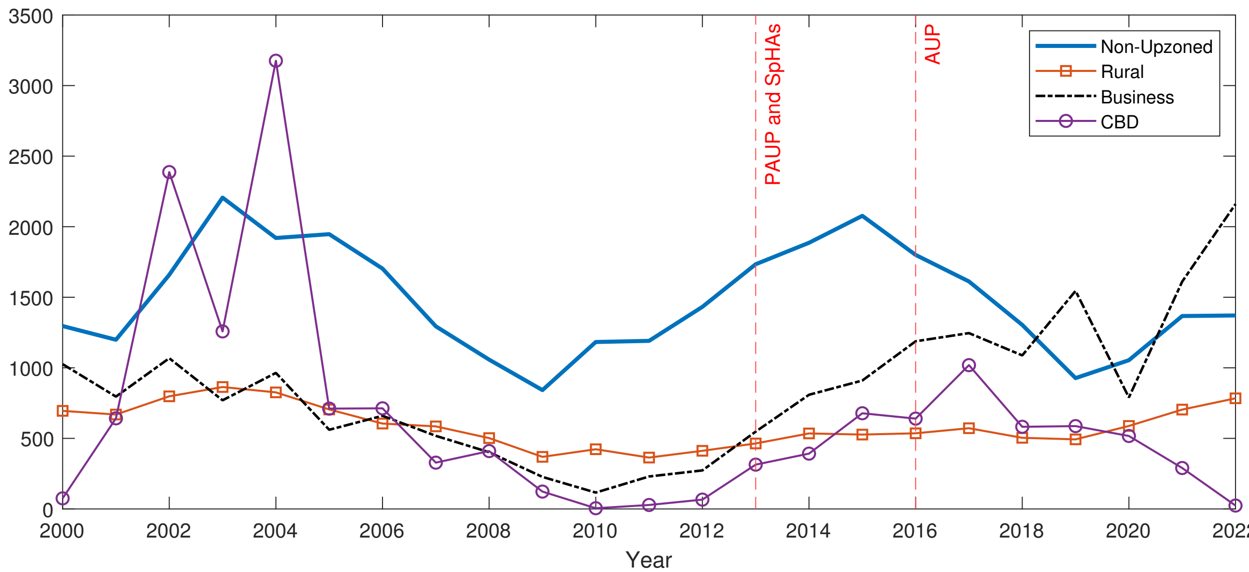
Permits in business areas (excluding the CBD) exhibit substantially more volatility than rural or non-upzoned residential, and follows a general upwards trend between 2010 and 2022. Given the absence of a break in trend around either 2013 or 2015, we similarly conclude that there is little evidence for substantial substitutability between residential and business areas.

Finally, the CBD time series exhibits the most volatility among time series, and often has no permits issued in a given year. The volatility is unsurprising given the immense financing requirements for the construction of large apartment buildings that are common in the CBD. There is a trend upwards beginning at the nadir of the latest construction cycle that peaks in 2017. Apart from 2017, the number of permits per year is relatively constant between 2015 and 2020, thereafter decreasing to zero by 2022. Increased uncertainty tied to COVID-19 and dramatic increases in interest rates from late 2021 onwards likely had a significant impact on capital intensive housing construction.

It is notable that the peak and the eventual decline in the CBD construction cycle occurs after both the announcement and implementation of the AUP. This suggests that the decrease in CBD permits is primarily driven by factors other than displacement from residential housing in upzoned areas. Taking the extended time necessary to build high-rise apartments into account, permits in the CBD would have to switch trend much earlier than 2016 if developers correctly anticipated a substantial reduction in CBD housing demand due to the AUP.[22] In addition, it would be inconsistent for CBD housing to substitute for residential housing when housing in business areas, scattered throughout the predominantly urban land surrounding the CBD, exhibits little evidence of substitutability with residential housing.

[22] There are significant differences in the time to build between residential and high-rise construction of the form commonly encountered in the CBD. For example, approximately thirty percent (288/1019) of the permits issued in 2017 were for "The Pacifica" apartment building on Commerce St. The building was completed three years later, in 2020.

Figure 9: Permits in Control Areas, 2000 to 2022



Notes: Permits in various control areas. PAUP-SpHA permits excluded.

5 Conclusion

Using a quasi-experimental framework, Greenaway-McGrevy and Phillips (2023) argue that the zoning reform generated a significant increase in residential housing permits over the five years subsequent to the policy change. This paper extends their methodology and analysis along several dimensions. First, it incorporates an additional year of data, 2022. Second, it expands the control group in the quasi-experimental framework to include rural and business zones. Third, it incorporates Special Housing Areas (SpHAs) into the analysis, which was an interim program to encourage housing supply prior to the AUP becoming operational, and allowed developers to build under the upzoned regulations of the "Proposed" AUP (PAUP) in exchange for a proportion of the development to be designated as affordable housing. Under these alternative methods for modeling the impact of the policy change, we find that the empirical evidence continues to support the zoning reform having a substantial impact on housing construction in Auckland.

6 Appendix

6.1 Set Identification

This section repeats GMP. Let $\theta = l'\tau_{post}$ be a linear combination of the treatment parameters of interest, where $l \in \mathbb{R}^{\overline{T}}$. For example, if we are interested in the treatment effect in the final period, $l = (0, ..., 0, 1)'$. Next, let $\hat{\lambda}_n$ be a relevant $m-$subvector of the estimate $\hat{\Lambda}_n = \left(\hat{\phi}_n', \hat{\beta}_n'\right)'$, where $\hat{\lambda}_n \sim \mathcal{N}(\lambda, \Sigma_n)$. That is, there exists a full column rank $\left(\underline{T} + \overline{T}\right) \times m$ selection matrix $\mathbf{J}$ such that $\hat{\lambda}_n = \mathbf{J}'\hat{\Lambda}_n$. The choice of $\hat{\lambda}_n$ depends on both the parameter of interest θ and the counterfactual set – a specific example is given below. We similarly define $\lambda = \mathbf{J}'\Lambda$, where $\Lambda = (\phi', \beta')'$ can be decomposed as follows

$$\Lambda = \begin{bmatrix} \phi_{pre} \\ \phi_{post} \\ \beta_{pre} \\ \beta_{post} \end{bmatrix} = \begin{bmatrix} \phi_{pre} \\ \phi_{post} \\ \beta_{pre} \\ \delta_{post} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \tau_{post} \end{bmatrix} =: \delta + \tau.$$

The decomposition above accords with that given for β in (2) of RR (2023). We simply extend their framework to include ϕ in the parameter space of interest.

We consider FLCIs based on affine estimators of θ of the general form

$$\mathcal{C}_{\alpha,n}(a, \upsilon, \chi) = \left(a + \upsilon'\hat{\lambda}_n\right) \pm \chi,$$

where α and χ are scalars, $\upsilon \in \mathbb{R}^m$, and $\alpha \in (0, 0.5]$ denotes a significance level. We choose a and υ to minimize

$$\chi_n(a, \upsilon; \alpha) = \sigma_{\upsilon,n} \cdot cv_\alpha\left(\bar{b}(a, \upsilon) / \sigma_{\upsilon,n}\right),$$

where $\sigma_{\upsilon,n} = \sqrt{\upsilon'\Sigma_n\upsilon}$, and $cv_\alpha(\cdot)$ denotes the $1 - \alpha$ quantile of the folded normal distribution with unit variance, $|\mathcal{N}(\cdot, 1)|$. The quantity $\bar{b}(a, \upsilon)$ denotes the worst-case bias of the affine estimator for a given a and υ, namely

$$\bar{b}(a, \upsilon) := \sup_{\delta \in \Delta, \tau_{post} \in \mathbb{R}^{\overline{T}}} \left|a + \upsilon'\left(\mathbf{J}'\delta + \mathbf{J}'\tau\right) - l'\tau_{post}\right|, \tag{3}$$

When estimating the set of treatment effects for period t, $\lambda = (\phi_{-t_2}, \phi_{-t_1}, \phi_t, \beta_t)$ is the subvector of parameters of interest. The affine estimator is then defined on $\hat{\lambda}_n = \left(\hat{\phi}_{-t_2}, \hat{\phi}_{-t_1}, \hat{\phi}_t, \hat{\beta}_t\right)$, where $\hat{\phi}_s = \frac{1}{n}\sum_{i=1}^n \hat{\phi}_{s,i}$ when suburb-level period fixed effects are employed, and $\hat{\lambda}_n \sim \mathcal{N}(\lambda, \Sigma_n)$. We consider FLCIs based on affine estimators of θ of the general form

$$\mathcal{C}_{\alpha,n}(a, \upsilon, \chi) = \left(a + \upsilon'\hat{\lambda}_n\right) \pm \chi,$$

where α and χ are scalars, $\upsilon \in \mathbb{R}^m$, and $\alpha \in (0, 0.5]$ denotes a significance level. We choose a and

v to minimize

$$\chi_n(a, v; \alpha) = \sigma_{v,n} \cdot cv_\alpha \left(\bar{b}(a, v) / \sigma_{v,n} \right),$$

where $\sigma_{v,n} = \sqrt{v'\Sigma_n v}$, and $cv_\alpha(\cdot)$ denotes the $1-\alpha$ quantile of the folded normal distribution with unit variance, $|\mathcal{N}(\cdot, 1)|$. The quantity $\bar{b}(a, v)$ denotes the worst-case bias of the affine estimator for a given a and v, namely

$$\bar{b}(a, v) := \sup_{\delta_t \in \Delta_t, \tau_t \in \mathbb{R}} \left| a + v' \left(\begin{bmatrix} \hat{\phi}_{-t_2} \\ \hat{\phi}_{-t_1} \\ \hat{\phi}_t \\ \delta_t \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \tau_t \end{bmatrix} \right) - \tau_t \right|.$$

6.2 Auckland Unitary Plan and Special Housing Area Timeline

Prior to 2010, the greater Auckland metropolitan region comprised seven city and district councils: Auckland City Council, North Shore City Council, Waitākere City Council, Manukau City Council, Rodney District Council, Papakura District Council, and Franklin District Council. On 1 November 2010, Auckland Council (AC) was formed when the eight previous governing bodies in the region were amalgamated. Legislation was also passed by the central government requiring AC to develop a consistent set of planning rules for the whole region under the Local Government Act 2010. This set of planning rules is embodied in the Auckland Unitary Plan (AUP).

Key dates in the development and implementation of the AUP are as follows:

- 15 March 2013: AC releases the draft AUP. The next 11 weeks comprised a period of public consultation, during which AC held 249 public meetings and received 21,000 items of written feedback.
- 13 September 2013: Housing Accords and Special Housing Areas Act passed, offering developers accelerated permitting process in exchange for limited affordable housing in the development.
- 30 September 2013: AC released the Proposed AUP (PAUP) and notified the public that the PAUP was open for submissions. More than 13,000 submissions (from the public, government, and community groups) were made, with over 1.4 million separate points of submission.
- 3 October 2013: Mayor of Auckland and Minister of Housing sign the Auckland Housing Accord, allowing Special Housing Area developments to use the LURs in the PAUP.
- April 2014 to May 2016: an Independent Hearings Panel (IHP) was appointed by the central government, which subsequently held 249 days of hearings across 60 topics and received more than 10,000 items of evidence.
- 22 July 2016: the IHP set out recommended changes to the PAUP. One of the primary recommendations was the abolition of minimum lot sizes for existing parcels. The AC considered and voted on the IHP recommendations over the next 20 working days. On 27 July the public could access and view the IHP's recommendations.
- 19 August 2016: AC released the 'decisions version' of the AUP, including the new zoning

maps. Several of the IHP's recommendations were voted down, including a IHP recommendation to abolish minimum floor sizes on apartments. However, the abolition of minimum lot sizes for existing parcels was maintained. This was followed by a 20-day period for the public to lodge appeals on the 'decisions version' in the Environment Court. Appeals to the High Court were only permitted if based on points of law.

- 8 November 2016: A public notice was placed in the media notifying that the AUP would become operational on 15 November 2016.
- 15 November 2016: AUP becomes operational. There were two elements of the AUP that were not fully operational at this time: (i) any parts that remain subject to the Environment Court and High Court under the Local Government Act 2010; and (ii) the regional coastal plan of the PAUP that required Minister of Conservation approval.

All versions of the AUP ('draft', 'proposed', 'decisions' and 'final') could be viewed online.

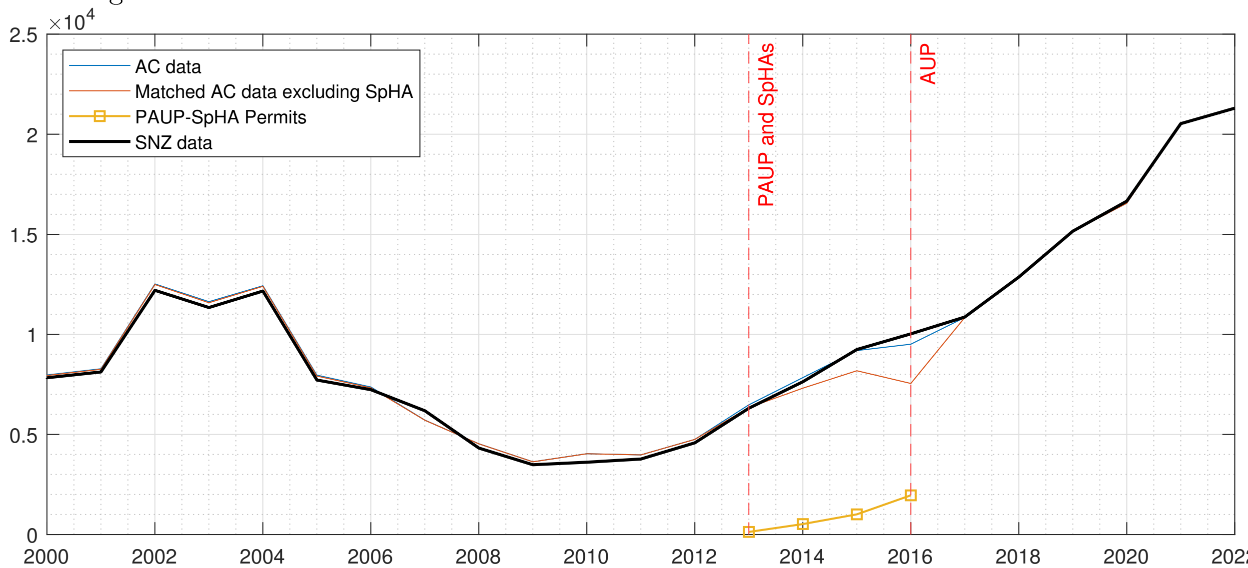
6.3 Geomatching Procedure

Permits are matched to planning zones using the geocoordinates of the consent and GIS maps of planning zones. Many geocoordinates fall outside of the parcel on road frontages. Permits that are matched to roads or open space are repaired by finding the nearest parcel and assigning the zoning of the parcel. Fewer than 2% of permits are repaired. Permits that are more than 200m from the nearest parcel are discarded. We use GIS information on parcels as of November 2016. As a robustness check, we also match consents to parcels and assign the zoning of the matched parcels. Matching is based on an algorithm that uses both the address and geocoordinate of the consent. Our findings remained unchanged, and are available upon request of the author.

6.4 Reconciliation with Statistics New Zealand Data

Here we show that that the dataset employed accords with Statistics New Zealand permits for the Auckland region. Data obtained from infoshare Table BLD139AA, last updated at 04 May 2023 10:45am.

Figure 10: Reconciliation between Statistics New Zealand and Auckland Council Data



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