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Can zoning reform change urban development patterns? Evidence from Auckland

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Abstract

In 2016, Auckland implemented a large-scale zoning reform to encourage medium density infill housing. This paper describes the institutional processes preceding the reform, quantifies the changes in land use across the metropolitan area, and documents subsequent changes in residential housing starts. We show that approximately three-quarters of residential land was upzoned, predominantly in areas close to transportation network access, and between five and twenty-five kilometres of the central business district (CBD). Six years on from the reform, housing starts have increased; are located closer to the CBD, employment locations, and transportation network access points, and; are predominantly infill and attached housing. Spatial decompositions show that these patterns are exclusively driven by changes in housing starts in upzoned areas.

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1 Introduction

Zoning reform is increasingly being advocated to achieve a variety of urban policy goals, such as increasing housing supply and reducing housing costs (Glaeser and Gyourko, 2005; Freeman and Schuetz, 2017), reducing spatial inequities (Manville *et al.*, 2020), and enabling a more compact and environmentally sustainable form of urban development (Wegmann, 2020). There remains, however, little empirical evidence on the impacts of large-scale zoning reforms on housing supply and costs (Schill, 2005; Freeman and Schuetz, 2017), let alone changes on urban development patterns or spatial inequality, in part because reforms of a scale sufficient to have a substantial impact on metropolitan development patterns are scarce (Freeman and Schuetz, 2017).

However, in 2016 the city of Auckland, New Zealand, upzoned a substantial amount of its residential land under the Auckland Unitary Plan (AUP). Consents for new dwellings subsequently reached record highs, in both absolute and per capita terms, and the city's consenting rate has gone from one of the lowest in the Australasian region to the highest (Greenaway-McGrevy, 2023a). Auckland therefore provides a unique and important case study for the design and implementation of large-scale zoning reforms in other contexts.

This paper provides a narrative of the events preceding and following Auckland's zoning reform. First, we describe the institutional context underlying the AUP, the goals of the reform, and the process of implementation. Governance changes and centralisation of decision-making featured prominently in strategy and implementation. Second, we quantify the scale of the reform by estimating the amount of upzoned land, both across the city and in relation to key amenities. Using a geocoded dataset of land parcels matched to planning zones, we show that the maximum floor-to-area ratio (FAR) was relaxed on approximately three-quarters of residential land, with much of this upzoning occurring between 5 and 25 km of the CBD, and in close proximity to transportation networks and areas of concentrated employment. Finally, we examine whether subsequent changes in housing development accord with the reform's goals, which included increasing housing supply and condensing housing development. To do this, we present a conceptual framework where zoning reform increases the housing stock via an increase in housing supply in upzoned areas.

We test this prediction using an empirical model that compares changes in housing starts in upzoned areas to changes in non-upzoned areas subsequent to the reform. We fit the model to a geocoded dataset of new dwelling consents ('building permits' in the US). We show that: housing starts in upzoned areas increased substantially relative to non-upzoned areas; the spatial distribution of consents has contracted towards the CBD, transportation network access points, and employment locations, and; the contraction is due exclusively to increases in consents in upzoned areas. When viewed through the lens of the conceptual framework, these results are consistent with zoning reform causing an increase in housing and the geographic contraction in consents.

The effects of zoning reform on housing and urban development remains an important but regrettably understudied topic. A handful of studies focus on localised (or 'spot') upzonings. Freemark (2020) shows that transit-oriented upzoning in Chicago failed to stimulate construction, while Peng (2023) shows that housing supply responded slowly to a sequence of localised upzonings in New York. Dong (2021) finds that localised upzoning in Portland approximately doubled the long-term probability of parcel development, but the number of new units constructed remains small. In recent work, Stacy *et al.* (2023) show that various reforms in US cities between 2000 and 2019 generated negligible increases in housing supply, on average. In contrast, large-scale zoning reforms are found to have larger effects in a couple of papers. Gray and Millsap (2020) show that the city-wide reduction in minimum lot sizes in Houston preceded an increased concentration of development activity in middle-income, less dense, under-built neighbourhoods, while Greenaway-McGrevy and Phillips (2023) show that the AUP precipitated a significant increase in housing construction. Our paper complements the latter by detailing how the spatial distribution of land use and housing construction has changed, thereby demonstrating that the reform successfully encouraged a more spatially compact pattern of growth.

The remainder of the paper is organized as follows. Section 2 describes the institutional processes behind the AUP, including changes in local governance, it's policy objectives, and how it's structure informs our empirical work. Section 3 documents geographic variation in regulatory changes under the plan. 4 documents empirical changes in housing starts that are consistent with the the goals of the reform. Section 5 concludes by drawing lessons for policymakers considering similar large-scale zoning reform.

2 Institutional Background

Auckland is the largest city in New Zealand, with a rapidly growing population that increased from 1.16 to 1.57 million between 2001 and 2018 (source: census). Centred on a long isthmus between two harbours, it extends over 4,894 km^2 of land, including a large metropolitan area, several towns, populated islands, and a substantial amount of rural land.

Until 2010, the region comprised seven city and district councils, each developing and implementing land use plans. The four city councils (Auckland, North Shore, Manukau, Waitākere) encompassed the developed areas in the suburbs around the CBD, and the former Auckland City Council covered the CBD and central isthmus. Two district councils (Rodney and Franklin) covered predominantly rural areas, while Papakura district council administered a formerly discontiguous town to the South.

A critical antecedent to the zoning reform was the amalgamation of the seven councils to form a single jurisdiction (Auckland Council, 'AC') by an act of parliament in 2009.[1] This centralised the formerly fragmented governance structure into a single 'unitary' authority with enhanced powers to plan the metropolis as a whole. Parliament also created statutory requirements for a strategic spatial plan and a consistent set of LURs for the region.[2]

[1] *The Local Government (Auckland Council) Act 2009.* https://www.legislation.govt.nz/act/public/2009/0032/latest/DLM2044909.html [accessed 14/03/2023]

[2] The *Local Government (Auckland Council) Amendment Act 2010* https://www.legislation.govt.nz/act/public/2010/0036/latest/DLM3016073.html and *The Local Government (Auckland Transitional Provisions) Act 2010* https://www.legislation.govt.nz/act/public/2010/0037/latest/DLM3016607.html [accessed 22/03/2023]

AC released the spatial plan in 2012.[3] Motivated by sustainable development, it directed the majority of growth to occur within the existing urban area, setting a target of 60–70% of new dwellings within the 2010 'metropolitan urban limit'. AC then released consistent planning rules under the 'draft' AUP in March 2013, which included widespread relaxation of LURs to achieve the strategic goals set out in the spatial plan. After eleven weeks of public consultations, AC released a revised 'Proposed' AUP (PAUP) in September.

Prior to the notification of the PAUP, AC proposed that the central government appoint an independent hearings panel (IHP) to hear submissions and make recommended changes to the PAUP. The additional community engagement would substitute for limited appeal rights to IHP recommendations, thereby accelerating implementation by avoiding lengthy litigation (Blakeley, 2015). The government agreed and amended the facilitating legislation.[4]

The IHP received submissions between April 2014 and May 2016, and released recommended changes to the plan on 22 July 2016. A primary recommendation was the abolition of minimum lot sizes for existing parcels. AC considered and voted on the IHP recommendations over the next 20 working days. On 19 August 2016, AC released the 'decisions' version, including new zoning maps. Several of the IHP's recommendations were voted down, including the abolishment of minimum floor sizes on apartments. This was followed by a 20-day period for the public to lodge appeals in the Environment Court, while appeals to the High Court were only permitted if based on points of law. The 'final' version of the AUP became operational in part on 15 November 2016.[5]

However, the AUP had a limited effect on housing supply upon notification of the PAUP in September 2013. The Auckland Housing Accord (AHA), an interim agreement between AC and the central government, allowed developers to build under the PAUP in exchange for affordable housing provisions.[6] This agreement modified a national inclusionary zoning program called "Special Housing Areas" (SpHA), also launched in September 2013, that offered developers an accelerated consenting process in exchange for a 10% affordable housing provision.[7] The agreement expired upon operationalisation of the AUP. The total number of dwellings consented under the program was comparatively small.

Each version of the AUP ('draft', 'proposed', 'decisions' and 'final') could be viewed online by the public and disclosed new LURs that would potentially change restrictions on permissible site development, depending on zoning. Four residential zones were introduced. Listed in decreasing order of permissible site development, these were: Terrace Housing and Apartments (THA); Mixed Housing Urban (MHU); Mixed Housing Suburban (MHS) and Single House (SH). Table 2 in the Appendix summarizes various LURs for each zone, including site coverage ratios, height restrictions,

[3] https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/Documents/auckland-plan-2012-full-document.pdf [accessed 14/03/2023]

[4] *Local Government (Auckland Transitional Provisions) Amendment Act 2013*. https://www.legislation.govt.nz/act/public/2013/0064/latest/DLM5464006.html [accessed 14/03/2023]

[5] Two elements were not fully operational: any parts still subject to the Environment Court and High Court under the Local Government Act 2010; and the regional coastal plan that required Minister of Conservation approval.

[6] https://www.beehive.govt.nz/sites/default/files/Auckland_Housing_Accord.pdf [accessed 14/09/2023]

[7] The "Housing Accords and Special Housing Areas Act 2013" (HASHAA). See https://www.legislation.govt.nz/act/public/2013/0072/latest/DLM5369001.html [accessed 14/09/2023]

setbacks and recession planes. For example, five to seven storeys and a maximum site coverage ratio of 50% is permitted in THA, whereas two storeys and a coverage ratio of 35% is permitted in SH. Up to three dwellings per parcel is allowed in MHS and MHU. As we demonstrate below, the new LURs were more permissive than those of the pre-AUP plans in most residential areas. The AUP also includes two additional 'residential' zones for semi-rural areas: 'Large Lot' and 'Rural and Coastal Settlement' that apply peri-urban areas or to small settlements distant to the CBD. LURs in these zones restricted development to very low intensity, as shown in Table 2. We refer to these zones as 'semi-rural'.[8]

3 Changes in Residential Land Use

We quantify the land that had LURs relaxed under the AUP by matching individual land parcels to GIS information on planning zones. The parcel data are as of November 2016, when the AUP became operational, and contain the geocoordinates of each parcel's vertices, enabling calculation of land area, and matching to other spatial information. Contiguous parcels with identical title(s) are amalgamated into single polygons. Each parcel is matched to its AUP and pre-AUP planning zones.

To determine whether a parcel was upzoned, we require a measure of the allowable capital intensity of housing under the AUP and previous regulations. While it is relatively straightforward to derive such a measure for the AUP zones, there were approximately 115 residential zones across the seven pre-AUP council plans, each with site coverage ratios (SCRs), height restrictions, minimum lot sizes (MLS) per dwelling, setbacks and recession planes. We use the maximum floor-to-area ratio (FAR) as the measure of LUR stringency. FARs are frequently used for this purpose (Brueckner *et al.*, 2017; Brueckner and Singh, 2020; Tan *et al.*, 2020) . SCRs and height limits were near universal in all pre-AUP zones, meaning each zone's FAR can be obtained by multiplying the SCR by the number of storeys implied by the height limit.[9], [10] The majority of the pre-AUP zones also had MLS restrictions, which do not apply to extant parcels under the AUP.

We group the pre-AUP residential zones into categories based on their respective FARs (henceforth 'zoning categories'). Because we compare how LURs changed, these categories accord with the maximum FAR permitted in the four AUP residential zones. THA has a FAR of 2.5 under its five storey and 50% SCR limits. We therefore define 'Residential-High' as zones with FARs no less than 2.5.[11] MHU has a FAR of 1.35, and thus 'Residential-Medium' comprises zones with FARs greater than or equal to 1.35 and less than 2.5. MHS has a FAR of 0.8, and thus 'Residential-Medium-Low' comprises zones with FARs greater than or equal to 0.8 and less than 1.35. SH has a

[8] We also classify the 'Waitākere Ranges' zone as semi-rural, as it has similar LURs to 'Large Lot', despite being classified as 'rural' in the AUP.

[9] FARs are generally not directly regulated. Height limits are translated into storey limits based on a minimum 0.6 meters ground clearance, 2.68 meters per storey, and 1 meter for a roof. A few pre-AUP zones imposed storey limits directly.

[10] The 'Integrated Intensive Housing' zone in Manukau had a 'design code' instead of LURs. We assign it a FAR of 1.5 based on the design code. It covered only 0.0773 km^2 of land.

[11] 'High' reflects relative, rather than absolute, differences in intensities.

FAR of 0.7, and thus 'Residential-Low' comprises zones with FARs greater than or equal to 0.7 and less than 0.8. We include zones intended to preserve built or natural heritage as 'Residential-Low', unless applied to semi-rural areas. Finally, we define 'Semi-Rural' as having a FAR less than 0.7 but greater than or equal to 0.15.

We allocate each parcel to an AUP zone and a pre-AUP residential zone category. We include 'business' and 'rural and open space' categories in these assignments. We also have a 'mixed' category for a a few pre-AUP 'special area' zones that allowed various housing forms within one contiguous area. The aggregate amount of land in each AUP zone can then be decomposed into the various pre-AUP zone categories, enabling us to observe changes in land use, and the amount of land that was upzoned.

Table 1 presents the amount of land allocated to the various pre-AUP categories and AUP zones. The AUP enabled a significant increase in the amount of land allocated to medium or high intensity residential development. Prior to 2016, the total residential area with a FAR of 2.5 (equivalent to THA) or above (i.e., Residential-High) was less than half a square kilometre. The AUP introduced 25 km^2 of THA that allows a FAR of 2.5. Similarly, prior to 2016, there was 4.04 (= 3.66 + 0.38) km^2 of residential land that allowed a FAR of 1.35 (equivalent to MHU) or above. This increased to approximately 100 km^2 (= 75.49 + 24.52) under the AUP.

The final three rows of Table 1 display the total amount of residential land upzoned. Upzoned land is comprised of: (i) all residential land that previously had a FAR below that of the AUP zone; (ii) all residential land that was previously zoned rural or open space; and (iii) business land that was previously zoned residential or rural. The first row also includes land that was previously classified as mixed. The second row excludes mixed.

Between 256 and 260 of the 335 km^2 (76.4 to 77.6%) of residential land was upzoned, depending on whether land previously classified as mixed is included. Looking at the four main residential AUP zones, between 22.7 and 23.5 of the 24.5 km^2 of THA was upzoned, with the majority – 17.2 km^2 – being rezoned from Residential-Low. Meanwhile, between 73.4 and 74.6 of the 75.5 km^2 of MHU was upzoned, again with the vast majority – 59.5 km^2 – from Residential-Low. Similarly, 146.0 to 146.8 of the 150.7 km^2 of MHS was upzoned, 129.5 km^2 of which came from Residential-Low. In contrast, most SH land was not upzoned, as it was previously classified as Residential-Low. Nonetheless, approximately 13.7 km^2 of SH was previously classified as Rural or Semi-Rural, and thus was upzoned to SH.

Very little land was downzoned, in the sense that the parcel was in a more intensive residential category prior to 2016. For example, 0.26 km^2 of MHU was classified as Residential-High or Business, while 0.90 km^2 of MHS was classified as either -High, -Medium or Business.

Table 1: Changes in Land Use

City and District Plans (before 2016)	Unitary Plan (from 2016)									
	Business	Residential Zones					Total Residential Area		Rural &	Total Area
Zoning Category		THA	MHU	MHS	SH	Semi-Rural	Excl. Semi-Rural	Incl. Semi-Rural	Open Space	
Business	68.57	0.85	0.25	0.44	0.15	0.05	1.68	1.73	3.61	73.92
Residential-High	0.23	0.14	0.01	0.00	0.00	0.00	0.14	0.14	0.00	0.38
Residential-Medium	0.04	1.76	0.64	1.17	0.01	0.04	3.58	3.62	0.00	3.66
Residential-Medium-Low	0.69	2.18	3.02	2.31	1.59	0.01	9.10	9.11	0.84	10.64
Residential-Low	2.93	17.19	59.54	129.46	67.48	8.12	273.66	281.79	6.54	291.26
Semi-Rural	0.18	0.19	0.77	3.51	5.74	72.54	10.21	82.75	26.45	109.37
Rural and Open Space	18.39	1.42	10.06	13.01	7.96	7.95	32.45	40.40	3,514.35	3,573.14
Mixed	2.30	0.80	1.20	0.81	0.91	1.71	3.73	5.44	7.54	15.28
Total	93.34	24.52	75.49	150.72	83.83	90.41	334.56	424.97	3,559.34	4,077.65
Upzoned	24.77	23.54	74.59	146.80	14.61	9.66	259.53	269.19		
Upzoned excl. Mixed	22.46	22.73	73.39	145.99	13.70	7.95	255.81	263.75		

Notes: Tabulated figures are square kilometres and calculated based on land parcels. Land allocated to roading and transportation infrastructure, including ferry terminals, ports, and strategic transportation corridors, is excluded. Special purpose areas (including hospitals, airports and airfields, education, recreation and Māori use among others) are included under 'business' before and after the AUP. The AUP 'Future urban' zone is included in Rural. Semi-rural zones under the AUP include 'large lot', 'residential - rural and coastal settlement', and 'Waitākere Ranges'. Residential areas under the seven pre-AUP city and district plans are grouped according to the maximum floor to land area ratio (FAR) allowed in the zone. These groups accord with the maximum FAR permitted in the four residential zones under the AUP. Residential-High is comprised of all zones with FAR ≥ 2.5; Medium, $1.35\leq$ FAR <2.5; Medium-Low, $0.8\leq$ FAR <1.35; Low, $0.7\leq$FAR <0.8; and semi-rural, $0.15\leq$FAR <0.7. Prior to the AUP, all heritage, natural and special character zones are included in Residential-Low or Semi-Rural. Mixed areas under city and distract plans include 'special areas' in the Rodney and Waitākere Council plans that had a mix of residential building intensities allowed within the designated area. Upzoned areas are the sum of pre-AUP residential areas that had a FAR less than that permitted under the AUP, rural and open space.

Figure 1 maps the upzoned residential areas, decomposed into upzoned to THA, MHU and MHS. For clarity, we focus exclusively on residential areas, omitting parcels upzoned to business or semi-rural, . Non-upzoned residential areas comprise SH, MHS, MHU and THA zoned parcels that, prior to 2016, had a FAR greater or equal to that permitted under the AUP. The majority of this area consists of SH parcels that were not upzoned from semi-rural or rural.

In the analysis to follow, we classify residential land that was categorised as mixed pre-AUP as upzoned. As Table 1 demonstrates, this makes little difference given the small amount of mixed area.

3.1 Spatial Distribution of Upzoning

This section quantifies the amount of upzoned residential land relative to geographically-fixed points that influence household locational choice. Specifically, we measure the amount and proportion of upzoned land at different distances to: the CBD; the nearest job centre; the nearest highway on-ramp; and the nearest rapid transit (RT) station. We use network distances (the shortest path on extant road networks) from the centroid of the meshblock in which the parcel is located.[12] Job centres are areas with a disproportionately high number of employees.[13]

For each fixed point, we calculate the amount of non-upzoned and upzoned residential land within various distances. Figure 2 depicts the results, alongside the proportion of upzoned land. The supplementary material contains a figure that decomposes the upzoned areas by AUP zone.

The bulk of residential land is between 5 and 25 km of the CBD. The upzoned proportion is highest between 5 and 35 km, consistently exceeding 60%. This reflects SH areas being predominantly located either close to the CBD, under character neighbourhood protections, or far from the CBD. For example, within 2 km of the CBD, approximately 30% is upzoned, while between 2 and 4 km, less than 40% is upzoned. The majority of residential land is between 2 and 10 km of a job centre. The upzoned proportion is fairly constant, at approximately 80% or above, out to 18 km. The majority of residential land is within 1 to 6 km of a highway on-ramp or an RT station. The proportion of upzoned land is fairly uniform with respect to distance to on-ramps, whereas its decreases beyond 6 km of RT stations.

4 Changes in Housing Development

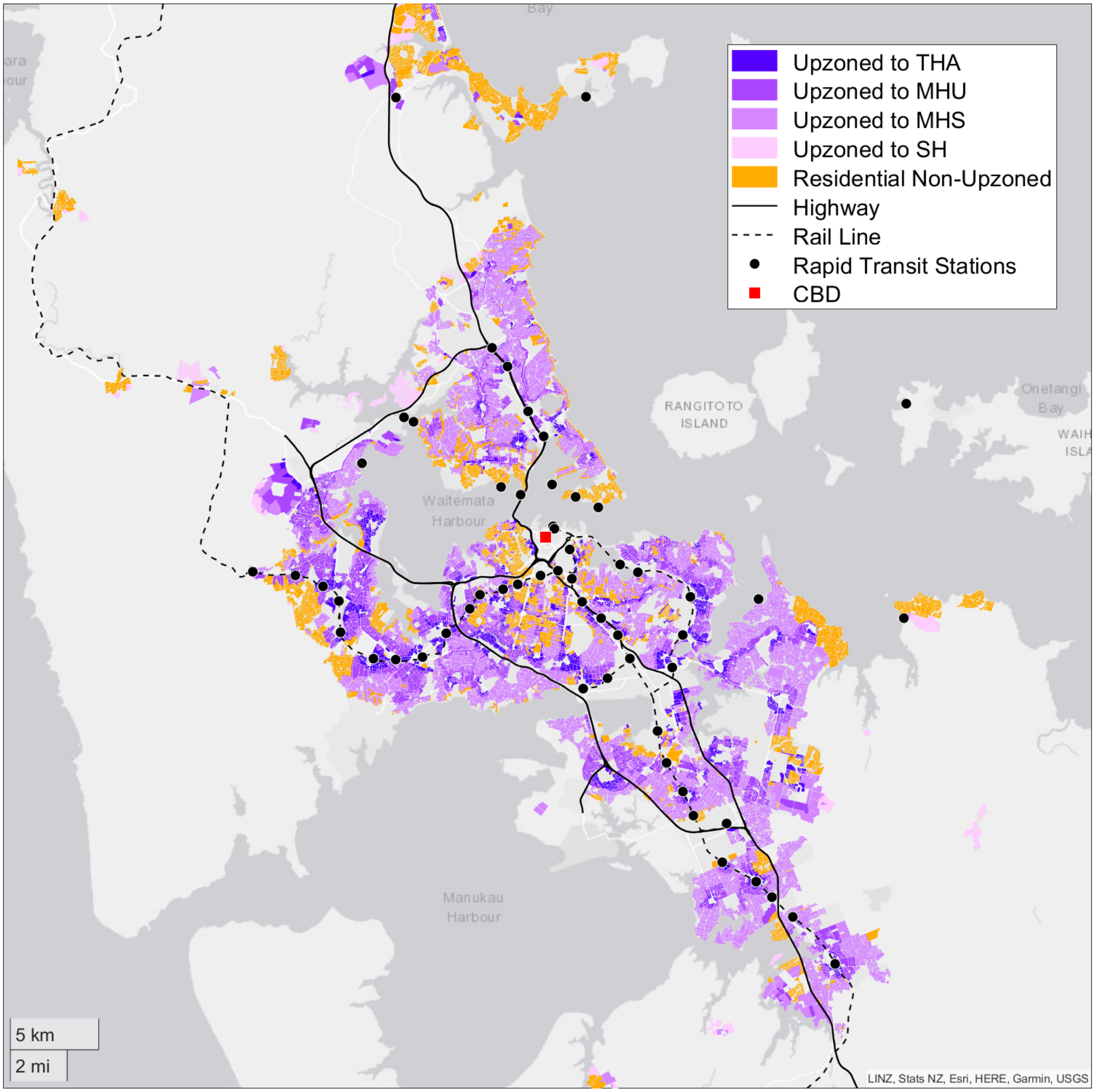
This section documents changes in housing development. We use a dataset of individual new building consents (hereafter 'consents') issued by AC and its predecessors. These are algorithmically matched to individual parcels by combining the consent's geocoordinates and address (see the supplementary material for details). The matched data span 2000-2022.

Before proceeding, we note that consents reflect housing starts, not completed dwellings. Unfortunately data collection and administration make it difficult to directly measure completions

[12] Meshblocks are the most granular geographic unit used by Statistics New Zealand. We use 2018 vintages.

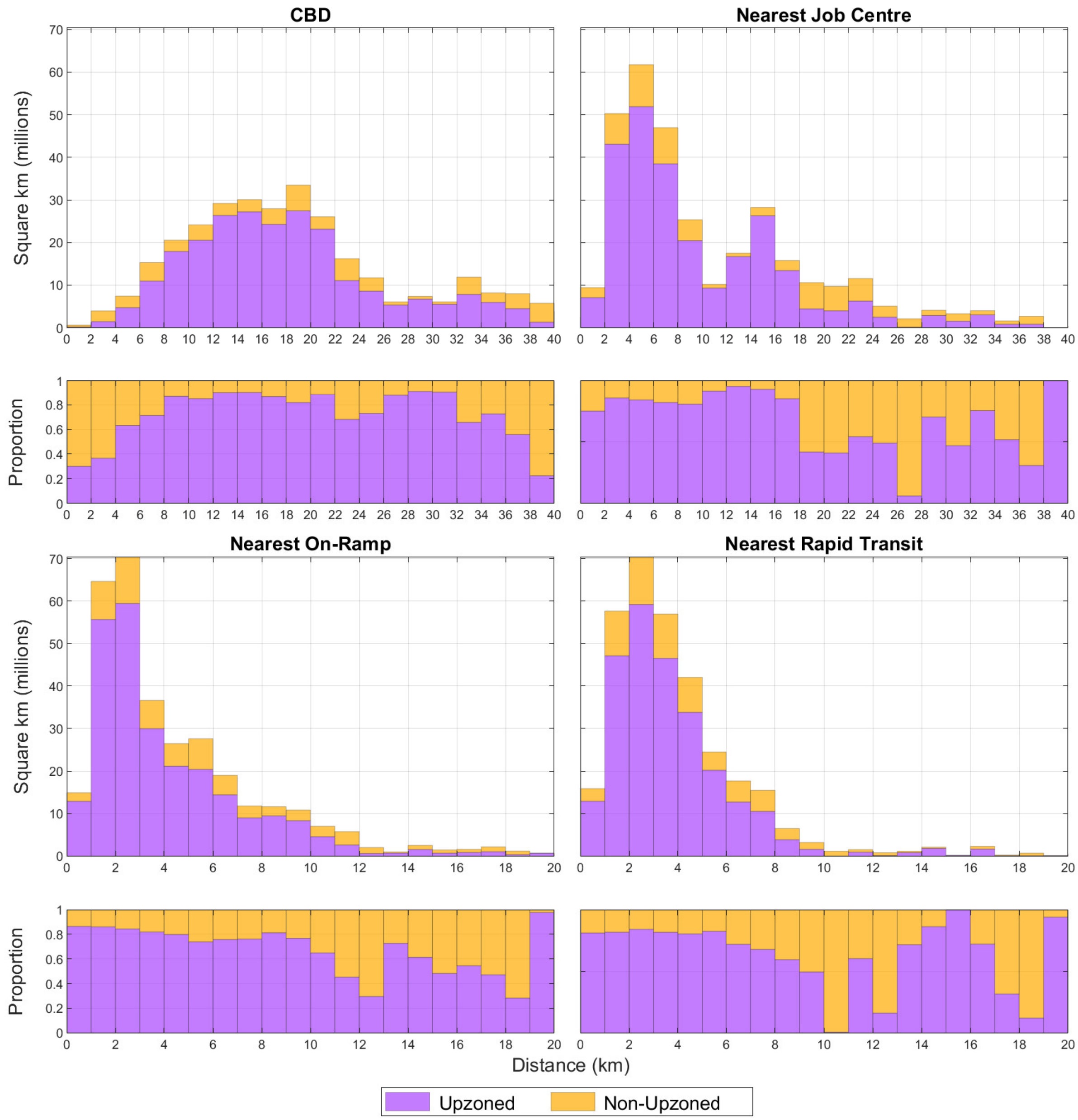
[13] We define job centres as the smallest set of Statistical Areas that contain at least a third of all employees. See the supplementary material.

Figure 1: Upzoned and Non-upzoned Residential Areas of Auckland



Notes: Rapid Transit stations include heavy rail stations, dedicated busway stations, and ferry terminals. The CBD marker is centred on the iconic 'Sky Tower' skyscraper in the CBD. Water in grey.

Figure 2: Distance between Upzoned Residential Land and Locations of Interest



Notes: Total areas (in square kilometres) and proportions of upzoned and non-upzoned residential land. Residential comprises SH, MHS, MHU and THA, and excludes semi-rural zones.

for dwellings consented prior to 2018. However, estimates from 2018 onwards suggest completion rates of over 90%, with higher rates in upzoned areas. Extensive details are provided in the supplementary material.

4.1 Conceptual Framework

Our empirical analysis is motivated by economic frameworks that conceptualise zoning reform as increasing housing supply. To conserve space, we relegate the exposition of the model to the supplementary material, providing the intuition of the model here.

In theories of urban development such as Bertaud and Brueckner (2005), LURs place lower bounds on the amount of land required to build housing. Upzoning relaxes these minimums. This reduction in input costs increases housing supply, shifting the supply curve out, and generating an increase in housing, holding all else constant.

When there is geographic variation in upzoning, supply increases are greater in locations with larger increases in minimum constraints, since comparatively less land is required to produce housing in these areas (Greenaway-McGrevy, 2023b). This observation informs our empirical strategy, as it implies that supply increases from zoning reform will manifest as increased housing construction in upzoned areas – not in non-upzoned areas. We empirically test this implication in section 4.2 using an empirical model that estimates differences in consents between upzoned and non-upzoned areas.

The increase in housing is moderated by housing demand, which varies by location under conventional models of urban development. In the canonical Alonso-Muth-Mills model, household travel times to work moderates demand. This principle can be generalised for access to other locational amenities. The straightforward corollary of these theories is that upzoning generates a shift in the geographic distribution of housing construction towards desirable amenities, provided land proximate to these geographic features is upzoned. Again, the increase in housing manifests in upzoned areas, and we empirically test this implication in section 4.3.

Consents are also affected by a variety of demand- and other supply- side factors. For example, exogenous reductions in interest rates, relaxation of mortgage lending criteria, or increases in population would increase demand for housing, while an exogenous reduction in the cost of building materials or construction workers would generate an increase in supply. Less tangible changes, such as a more relaxed attitude towards development by local government, or improvements in the management and practice of the housing construction, would also manifest as an increase in housing construction. However, these variables manifest as increases in both upzoned and non-upzoned areas, because they affect construction in both areas – not the *differential* increase in upzoned areas relative to non-upzoned, as implied by our conceptual framework, and measured in our empirical models.[14]

[14]Without the conceptual framework. Quasi-experimental approaches to causal inference present an alternative

4.2 Consents

Figure 3 presents annual consents between 2000 and 2022 decomposed into different areas, including by zoning change. Total consents increase from approximately 9,200 in 2015, the year prior to the AUP becoming operational in November 2016, to 21,000 by 2022, far exceeding the previous peak of 12,500 consents in 2002, which was driven by a construction boom in business areas (particularly the CBD).[15]

The top panel decomposes consents by zoning change. All of the increase since 2016 is in upzoned areas. In 2015, 4,700 consents were issued in areas that would be upzoned in 2016, while 4,500 were issued in areas that would not. By 2022, 16,600 were issued in upzoned areas, while 4,700 were issued in non-upzoned areas.

Most of the increase in consents since 2016 is due to increases in areas upzoned to MHS, MHU or THA. Of the 16,600 consents issued in upzoned areas in 2022, 15,300 were issued in one of these three areas.

4.2.1 Attached and Detached Housing

Zoning reforms are associated with attached housing structures, such as plexes, rowhouses, and apartments, due to their more efficient use of space. The middle panel of Figure 3 decomposes consents into attached and detached dwellings. Most of the increase since 2016 is attached dwellings in upzoned areas.

4.2.2 Infill and Greenfield Development

A key strategic goal underpinning the zoning reform was to promote housing in existing urban areas. To examine this, we bifurcate our sample into greenfield and infill development. Following Biddle *et al.* (2006), we use 'infill' development to refer to redevelopment or intensification of existing residential land, as well as residential construction on commercial zoned land.

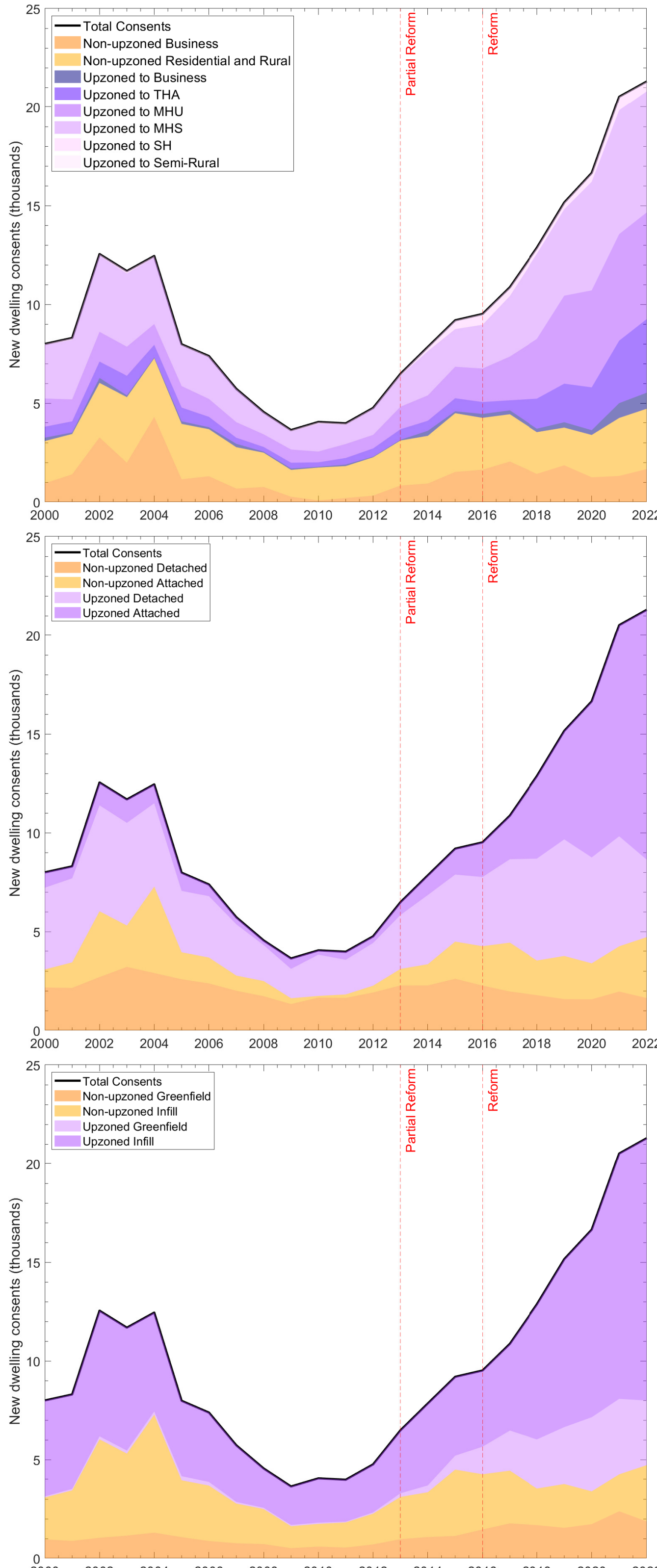
We use the "urban extent" of Auckland to delineate greenfield and infill housing development. The urban extent is a geographical measure of developed urban areas that excludes rural, peri-urban (i.e., semi-rural) and open space areas. It is constructed by AC using satellite imagery of cadastral land parcels. See Fredrickson (2014) for further description of the concept and classification methodology, and the supplementary material for a graphical depiction. For descriptive analysis, we decompose our sample into parcels inside and outside the 2016 urban extent.

The bottom panel of Figure 3 shows that there have been increases inside and outside the urban extent. Most of the increase is due to upzoned areas within the urban extent (i.e., upzoned infill), although there has been an increase in upzoned greenfield development as well.

In the analysis to follow, we focus solely on residential areas (SH, MHS, MHU and THA), as the spatial plan underpinning the AUP was focussed primarily on increasing density in residential

[15] Records begin in 1991. Annual consents for 2018-2022 inclusive exceed the previous 2002 peak.

Figure 3: Dwelling Consents by 2016 Zoning Change, 2000 to 2022



Notes: Infill is based on the 2016 urban extent. 'Partial Reform' refers to the SpHA-PAUP program, which begins in September 2013. Full zoning reform occurs in November 2016. See section 2.

areas, and most of the increase in dwelling consents are in upzoned residential areas, as shown in the top panel of Figure 3.

4.2.3 Empirical Model

Viewed through the lens of our conceptual framework, the relative increase in housing starts in upzoned areas is consistent with zoning causing an increase in housing supply. However, the differential increase between upzoned and non-upzoned areas may reflect systematic differences in long-run trends between upzoned and non-upzoned parcels, rather than the policy change itself. For example, planners may have targetted desirable suburbs or parcels for upzoning, such that the increase in consents in upzoned areas reflects a supply response to increasing demand that would have occurred under the counterfactual of no upzoning. The differential increase could also be due to time-variation in unobserved confounders occurring at the same time as the policy.

To address these potential pathologies, we fit the following regression to individual parcels

$$\begin{aligned} y_{i,t} \quad = \quad & \alpha_0 + \alpha_1 \mathbf{1}_{i \in j=1} + \sum\nolimits_{s=-\underline{T}, s \neq 0}^{\overline{T}} \phi_s \mathbf{1}_{s=t} + \sum\nolimits_{s=-\underline{T}, s \neq 0}^{\overline{T}} \beta_s \mathbf{1}_{s=t} \mathbf{1}_{i \in j=1} + \xi_0' Z_i \\ & + \sum\nolimits_{s=-\underline{T}, s \neq 0}^{\overline{T}} \mathbf{1}_{s=t} \xi_s' Z_i + \mathbf{1}_{i \in j=1} \gamma_0' Z_i + \sum\nolimits_{s=-\underline{T}, s \neq 0}^{\overline{T}} \mathbf{1}_{s=t} \mathbf{1}_{i \in j=1} \gamma_s' Z_i + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where $y_{i,t}$ is the number of consented dwellings for parcel i in year t; $\mathbf{1}_{i \in j=1}$ is an indicator equal to one if parcel i is in area j, where$j = 0$ denotes non-upzoned areas and $j = 1$ denotes upzoned; and $\mathbf{1}_{s=t}$ is an indicator equal to one if $s = t$. The period index t ranges from $t = -\underline{T}$ years prior to upzoning to $t = \bar{T}$ years post upzoning, with $t = 0$ signifying the year when upzoning occurred. We set this to 2016, when the AUP was operationalised.

The sequence of coefficients$\{\beta_s\}_{s=1}^{\overline{T}}$ capture the relative increase in consents in upzoned areas compared to non-upzoned areas for each year post-operationalisation. The testable implication of the reform-led supply response under our conceptual framework is that these coefficients are positive.

Meanwhile$\{\beta_s\}_{s=-\underline{T}}^{-1}$ reveals whether trends in consents in upzoned areas differed from trends in non-upzoned areas prior to 2016. If these coefficients are not trending up prior to operationalisation, then there was no difference in trends between upzoned and non-upzoned areas prior to the policy.

The period fixed effects $\{\phi_s\}_{s=-\underline{T}}^{-1}$ account for changes in demand-side factors that affect housing, such as exogenous changes in population, as well as supply-side factors, common to upzoned and non-upzoned areas. These parameters ensure that our parameters of interest, $\{\beta_s\}_{s=-\underline{T}}^{\overline{T}}$, capture differences in upzoned and non-upzoned areas relative to 2016.

The model also includes parcel-level covariates in the vector Z_i to account for potential confounders and parcel selection for upzoning in the planning decision. Because areas close to transportation and the CBD (excluding character areas) were targetting for upzoning, we include network distance to the nearest transportation network access point (either on-ramp or RT station) and the Haversine distance to the CBD. To account for land quality, we include the proportions of parcel area: above a 15% slope[16]; under a flood plain, flood sensitive or flood prone area; and subject to coastal inundation. Finally, we include Haversine distance to the nearest coastline as a natural amenity.

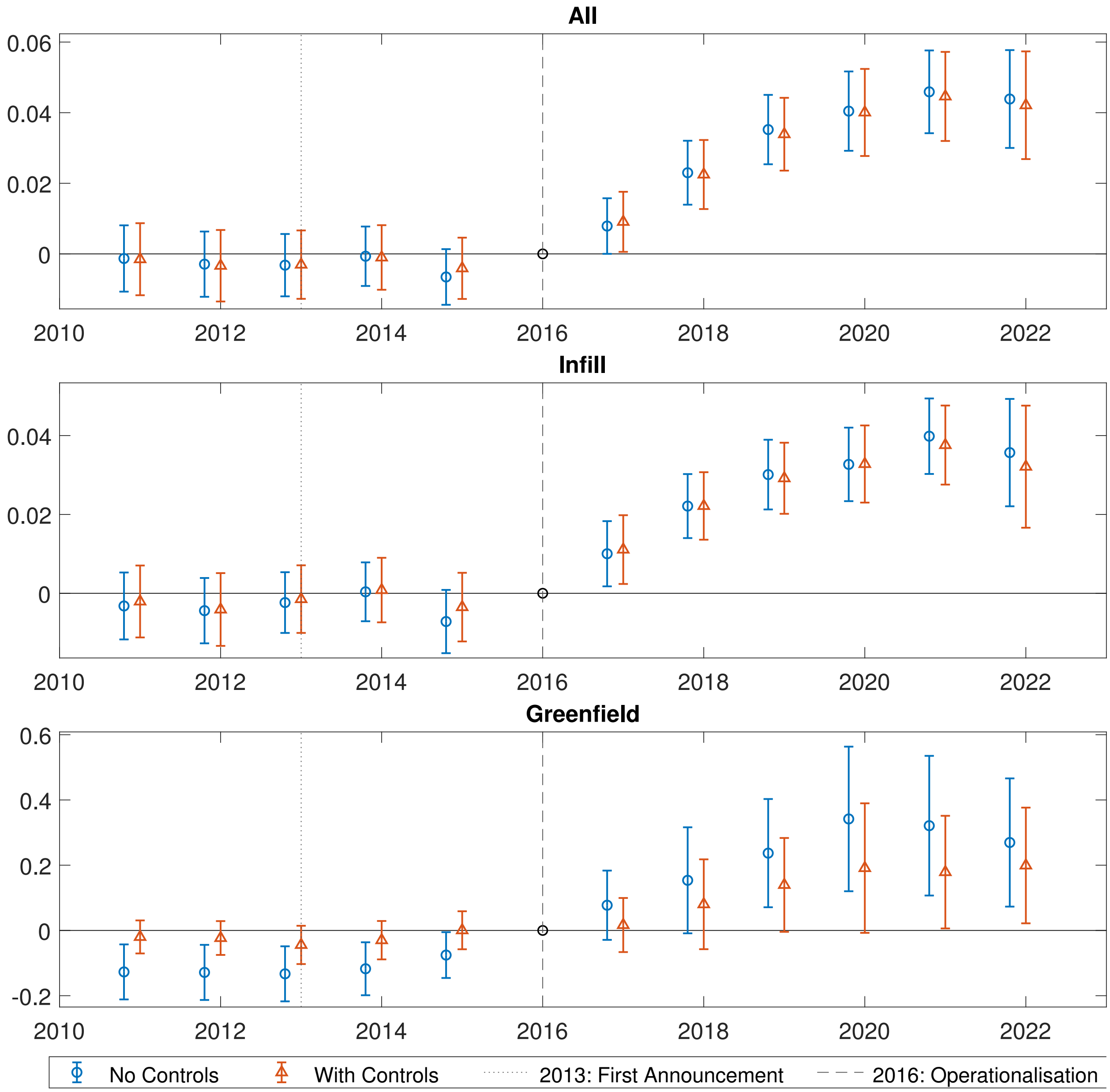
These covariates account for parcels selected for upzoning. These selection criteria may interact with variation in demand-side factors to generate changes in consents in upzoned areas that would otherwise be mis-attributed to the reform. For example, suppose that a significant increase in traffic congestion at the same time of the reform increased demand for housing close to transportation network access points, generating an increase in consents on upzoned parcels because such parcels are more likely to be close to on-ramps or RT stations.

Following the suggestion of Meyer (1995), the covariates have differential impacts in upzoned and non-upzoned areas. We provide evidence of this heterogeneity in the supplementary material to the paper. We estimate models both with and without these covariates.

Figure 4 exhibits the estimates of $\{\beta_s\}_{s=-\underline{T},s\neq0}^{\overline{T}}$ alongside 95% confidence intervals, for all consents combined, and separately for infill and greenfield development. For all consents and infill development, estimates are statistically indistinguishable from zero, and exhibit no trend, until operationalisation in 2016. Covariates are required for this to hold for greenfield. The lack of a clear trend prior to 2016 indicates that there was no difference in the trends in consents in upzoned areas and non-upzoned areas prior to the policy. Thereafter the coefficients trend upwards. For all consents, they reach 0.045 by 2022. This indicates that each upzoned parcel had 0.045 more consents issued (on average) than non-upzoned parcels in 2021. Unsurprisingly, upzoning has a much larger impact on the probability of greenfield development than infill. After conditioning on covariates, the probability of development reaches 0.19 by 2022.

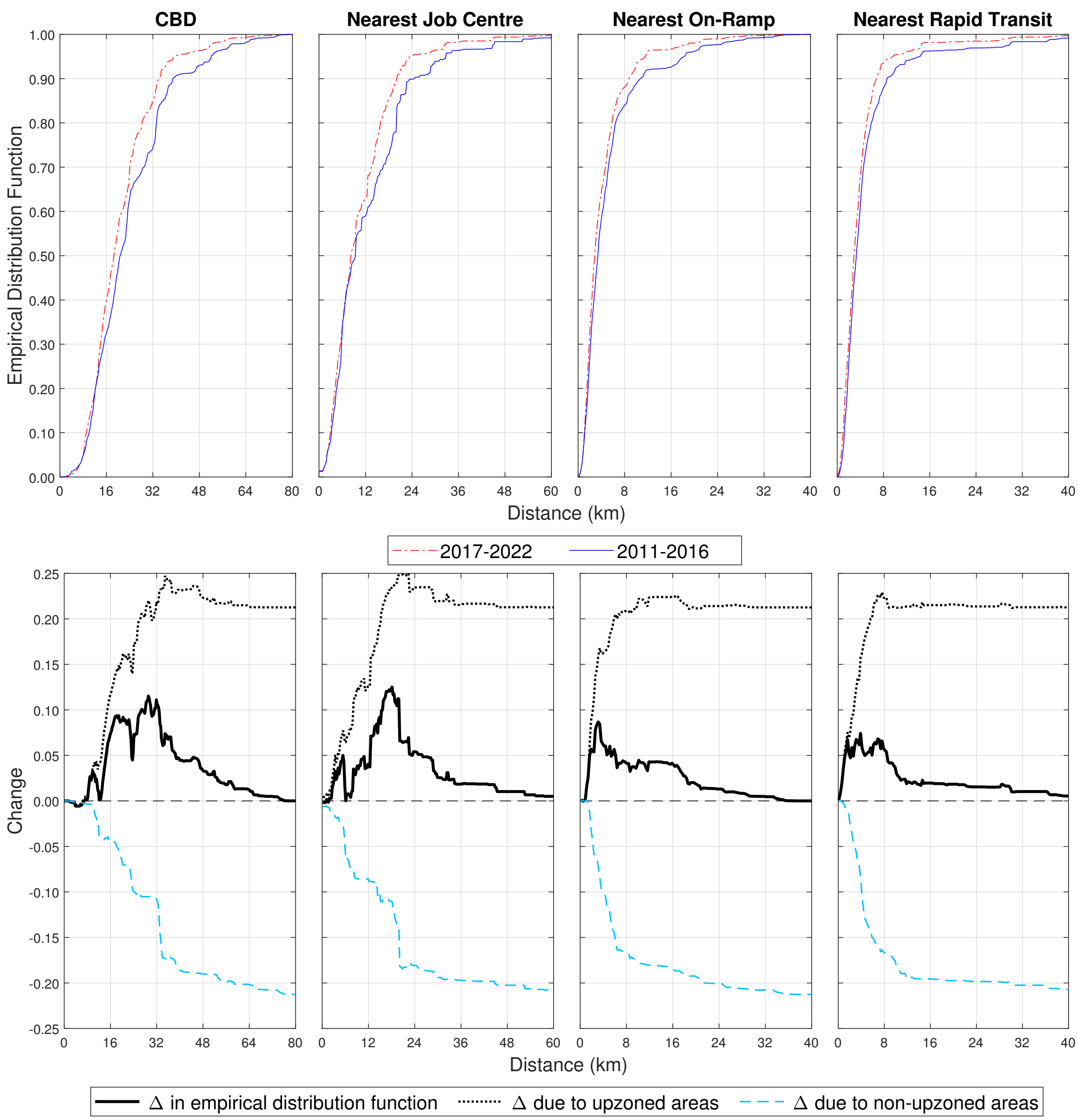
[16] Saiz (2010) uses designates under 15% slope as buildable land

Figure 4: Difference in Consents per Parcel between Upzoned and Non-Upzoned Areas, 2011 to 2022



Notes: Point estimates are average differences in consents per parcel between upzoned and non-upzoned areas. Error bars denote 95% confidence intervals. Model with covariates allows for heterogeneous coefficients between upzoned and non-upzoned areas. Standard errors are clustered by parcel and include a Conley Bartlett kernel in the cross sectional dimension (with a bandwidth of 1 km) to account for spatial dependence. See the Appendix. Infill (greenfield) denote parcels inside (outside) the 2016 urban extent.

Figure 5: Spatial Distribution of Consents before and after Upzoning



Notes: Top row: Empirical cumulative distribution functions (EDFs) of the distances between consents and various locations. Bottom row: Difference in EDFs between 2012–2016 and 2017–2021, and decomposition into upzoned and non-upzoned areas.

4.3 Spatial Distribution of Consents

Next we illustrate changes in the spatial distribution of consents relative to geographically-fixed points. To do so, we calculate the network distance between the centroid of each consent's meshblock and: the CBD; the nearest job centre; the nearest highway on-ramp; and the nearest RT station.

The top row of Figure 5 depicts the empirical (cumulative) distribution function (EDF) of the distance between consents and the various locations. The x-axis plots distance to the location. The EDF is then the proportion of consents that are within a given distance as measured on the the x-axis. Let $y_{i,s}$ denote the number of consents during period s on parcel i, and let x_i denote the distance from parcel i to a fixed point of interest (e.g. CBD). The EDF for period s is

$$F_s\left(x\right) = \frac{\sum_{i=1}^{n} y_{i,s}\mathbf{1}_{x_i\leq x}}{\sum_{i=1}^{n} y_{i,s}} \tag{2}$$

where $\mathbf{1}_{x_i\leq x} = 1$ for $x_i \leq x$ and zero otherwise. As distance increases, the EDF approaches one, as all consents are within an arbitrarily large distance of the location.

The EDF for CBD has increased, showing that residential construction is moving closer to the CBD. For example, prior to the AUP, approximately 50% of consents were within 20 km of the CBD. After the AUP, 60% of consents were within this distance. Much of the contraction is occurring in the outer suburbs. The 25th percentile barely changes, from 13.2 km prior to the AUP, to 12.6 km after. Meanwhile the 50th and 75th percentiles shift from 19.9 to 17.9 km, and from 32.1 to 25.1 km, respectively. We see a similar pattern for nearest on-ramp, RT station, and job centre: The spatial distribution of consents has contracted towards these locations.

The second row of Figure 5 depicts the difference in EDFs, namely $F_1\left(x\right) - F_{-1}\left(x\right)$, where $s = 1$ denotes post-AUP, and $s = -1$ denotes pre-AUP. Positive values indicate the distribution of consents has contracted towards the location at the corresponding percentile of the distribution. These figures demonstrate that the contractions are near-uniform, i.e., the differences in EDFs is positive at all percentiles. Only within 5 km of the CBD is the difference slightly negative, likely a consequence of the predominance of SH zoning in the inner, 'character' suburbs.

To examine whether the shift in the spatial distribution is driven by upzoning, we decompose the difference in EDFs into changes in upzoned and non-upzoned areas. Let S_U denote the subset of n_U parcels that are upzoned, and let S_N denote the subset of n_N parcels that were not upzoned, such that $n = n_U + n_N$. The difference in EDFs can be decomposed as

$$F_1\left(x\right) - F_{-1}\left(x\right) = F_{U,1}\left(x\right) - F_{U,-1}\left(x\right) + F_{N,1}\left(x\right) - F_{N,-1}\left(x\right) \tag{3}$$

where $F_{k,s}\left(x\right) = \left(\sum_{i=1}^{n} y_{i,s}\right)^{-1} \sum_{i\in k} y_{i,s}\mathbf{1}_{x_i\leq x}$ and $k \in \{U, N\}$.

For each location, the contraction in the spatial distribution is being driven by changes in upzoned areas: $F_{U,1}\left(x\right) - F_{U,-1}\left(x\right)$ is generally positive in x,while $F_{N,1}\left(x\right) - F_{N,-1}\left(x\right)$ is negative, but of smaller magnitude.

The near-uniform contraction in the distribution towards the CBD and job centres reverses an expansion prior to the AUP. Figure 13 in the supplementary material demonstrates that housing starts were expanding away from these areas prior to 2016, out to the 80th percentile of the EDFs.

5 Concluding Remarks

Auckland's zoning reform is notable for its scale and subsequent increases in housing starts. As such, it heralds lessons for potential reforms in other jurisdictions. Perhaps the most important question is: what caused the success of Auckland's reforms?

Centralisation of planning decisions features prominently in the reform, both through the prior amalgamation into a single metropolitan jurisdiction, and the central government's willingness to pass laws to accelerate implementation. Fischel's 'homevoter hypothesis' suggests that this centralisation in decision-making was instrumental to implementation. Because development has concentrated costs and diffuse benefits, homeowners oppose local housing (Fischel, 2002). Regions with fragmented governance consequently have tighter restrictions (Fischel, 2008) and suboptimal development and sprawl. The corollary is that urban planning decisions should be centralised to the level at which the relevant costs and benefits of development are internalised, which is achieved by amalgamating fractured municipalities into a single authority.

Notably, large-scale zoning reforms in North America, where metropolitan regions typically comprise multiple municipalities, have not relaxed as many restrictions as Auckland's reform, and have had a comparatively limited impact on housing development to date. Minneapolis' 2040 plan allows up to three dwellings per parcel, but does not relax restrictions on floorspace, and, as yet, has had no discernible effect on multifamily housing starts. California's HOME Act allows four dwellings per parcel, but has generated few permits, perhaps due to cities findings means to subvert the policy (Garcia and Alameldin, 2023).

However, while amalgamation is perhaps sufficient to enact successful reform, it need not be necessary. Allowing residents to collectively opt out, as occurred in Houston, may make zoning reform more politically acceptable. Direct monetary incentives from central or state government could overcome municipal opposition (Ehrlich *et al.*, 2018). Finally, hyper-localisation presents a potential solution via substantial de-centralisation, as opposed to centralisation, of zoning decisions (Foster and Warren, 2022).

6 Appendix

Table 2: Summary of Land Use Regulations by Residential Zone under the Unitary Plan

Regulation	Terraced Housing Apartments	Mixed Housing Urban	Mixed Housing Suburban	Single House	Large Lot	Rural and Coastal Settlement
Max. height	16m (5 to 7 storeys)	11 to 12m (three storeys)	8 to 9m (two storeys)	8 to 9m (two storeys)	8 to 9m (two storeys)	8 to 9m (two storeys)
Height in relation to boundary	3m up + 45° recession plane	3m up + 45° recession plane	2.5m up + 45° recession plane	2.5m up + 45° recession plane	does not apply	2.5m up + 45° recession plane
Setback (side and rear)	0m	1m	1m	1m	6m	1m
Setback (front)	1.5m	2.5m	3m	3m	10m	5m
Max. site coverage (%)	50%	45%	40%	35%	lesser of 20% or 400m^2	lesser of 20% or 400m^2
Max. impervious area (%)	70%	60%	60%	60%	lesser of 35% or 1400m^2	lesser of 35% or 1400m^2
Min. dwelling size (1 bedroom)	45m^2	45m^2	45m^2	n/a	n/a	n/a
Max. dwellings per site	does not apply	3	3	1	1	1
Min. Lot Size (subdivision)	1200m^2	300m^2	400m^2	600m^2	2500m^2	4000m^2

Notes: Restrictions are 'as of right' and can be exceeded through resource consent notification. Height in relation to boundary restrictions apply to side and rear boundaries. Less restrictive height in relation to boundary rules than those tabulated apply to side and rear boundaries within 20m of site frontage. Number of storeys (in parentheses) are obtained from the stated purpose of the height restriction in the regulations. Planners have discretion in setting height in relation to boundary and setbacks in the large lot zone, with regulations requiring "development to be of a height and bulk and have sufficient setbacks and open space to maintain and be in keeping with the spacious landscape character of the area". Maximum dwellings per site are permitted as of right. Minimum lot sizes do not apply to extant residential parcels. Impervious area is the area under the dwelling and structures such as concrete driveways that prevent rainwater absorption into the soil.

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7 Supplementary Material

7.1 Conceptual Framework

Our conceptual framework accords with canonical economic models of urban development in which housing floorspace is produced by developers using capital and land and distance to geographic amenities as the determinant of housing demand. Land use regulations constrain the floorspace that developers can produce on a given amount of land.

Housing Supply. We impose standard assumptions on the production of housing floorspace (see Duranton and Puga, 2015). Developers produce floorspace per dwelling H using capital K and land L. H is increasing in K and L, exhibits constant returns to scale, and is strictly quasi-concave. The price of capital is assumed constant and is set to unity for instructive purposes.

We define $h = H/L$, which is the floor area ratio (FAR) that developers build to. Under constant returns to scale, h can be expressed as a function of the capital to land ratio $k = K/L$. Developers choose k to maximise profits, resulting the first order condition $dh(k)/dk = 1/p$. Because $h(k)$ is concave and increasing in k, the housing supply curve is increasing in p. If L is fixed, an increase in the supply of floorspace H requires an increase in h and thus an increase in capital intensity k.

Housing Demand. Household preferences over floorspace H and a numeraire good are described by a utility function that is increasing and strictly quasi-concave. Demand for floorspace H is therefore decreasing in the price of floorspace$p$.

Household demand for floorspace H is also decreasing in distance $x > 0$ to a geographically fixed point. This means that endogenous variables of the model implicitly depend on distance x.

We let n denote the number of households at distance x,such that $nH = Q$ denotes total floorspace. Demand for Q at a given distance x reflects an intensive margin (each household consumes more floorspace as p decreases) and an extensive margin (the number of households increases as p decreases). The former is due to diminishing marginal utility. The latter reflects in-(out-) migration in response to decreases (increases) in price. Algebraically, $dQ/dp = dH/dp \cdot n + dn/dp \cdot H$, where we assume that $dn/dp < 0$.

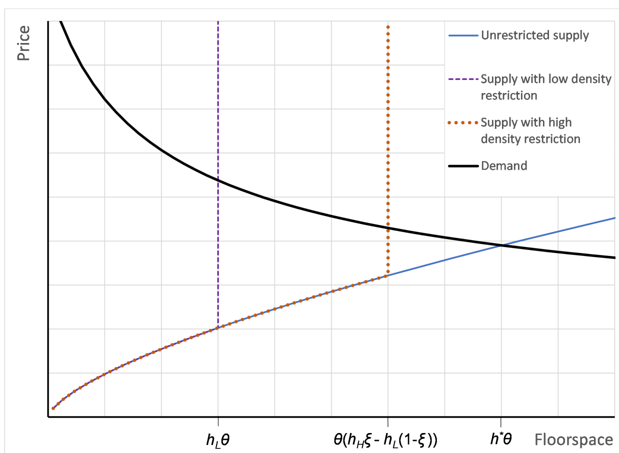
We let $\theta(x)$ denote the amount of land at distance x that can support housing. For example, in the AMM model, $\theta(x) = \theta x$, where θ is the radial arc of the city plane. $\theta(x)$ spatially delineates an area where housing demand as a function of price is constant. For instructive purposes, suppress the dependence on x and let θ denote the amount of land. Because L denotes land per dwelling, $n = \theta L^{-1}$ and $Q = \theta H L^{-1} = \theta h$.

Equilibrium. Figure 6 illustrates equilibrium, where supply (blue line) intersects demand (black line). h^* denotes the equilibrium FAR to which developers build.

Land Use Regulations. Following Bertaud and Brueckner (2005), LURs are modelled as upper bounds on h, denoted h_L. The purple dashed line in Figure 6 depicts supply of floorspace Q under this restriction. When h_L is binding, such that $h = h_L$, the aggregate amount of supplied floorspace is given by θh_L, and the number of dwellings $n_0 = \theta L_0^{-1}$, where L_0 is land per dwelling given the constraint h_L.

Now suppose that some fraction $\xi \in (0,1)$ of land θ is upzoned to $h_H > h_L$, but h_H is still binding. The red dotted line in Figure 6 depicts supply of floorspace Q under this restriction. Under the new static equilibrium, $Q_1 = \theta h_L(1-\xi) + \theta h_H \xi$, with the increase $\theta(h_H - h_L)\xi$ occurring in the upzoned area. Meanwhile, $n_1 = \theta L_1^{-1}(1-\xi) + \theta L_{H,1}^{-1}\xi$, where L_1 is land per dwelling in the area where h_L still applies, and $L_{H,1}$ is land per dwelling in the area where h_H applies. Because $n_1 > n_0$ and $L_1 \geq L_0$ (i.e., housing in non-upzoned areas cannot become less land intensive), it follows that $L_{H,1} > L_0$ since $n_1 > n_0$, and thus the increase in dwellings occurs in upzoned areas and is given by $\theta\xi(L_{H,1}^{-1} - L_0^{-1}) > 0$. These results hold even when h_H is not binding. Thus, to summarise, at distances x where h_L is binding, relaxing h_L on a fraction of the land area (i) increases housing supply, and (ii) generates an increase in housing in the upzoned area.

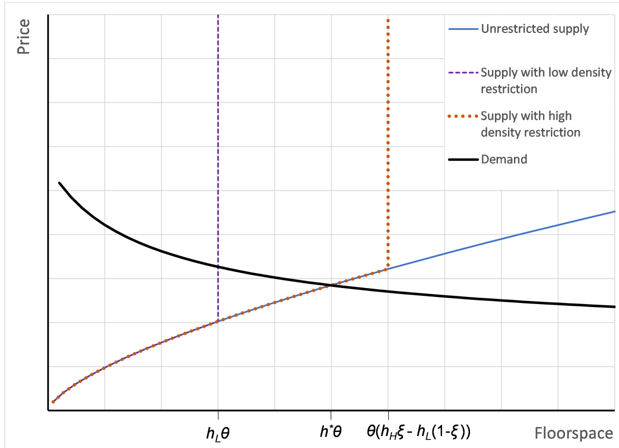
Figure 6: Conceptual Framework: Supply and Demand of Housing Floorspace



Notes: Supply and demand of housing floorspace. Supply shown under (i) no FAR restriction (blue line); (ii) a low density FAR restriction$h_L$on all land (purple dashed line), and (iii) a high density restriction h_H on $\xi_H$proportion of land and low density restriction h_L on $1 - \xi_H$proportion of land (red dotted line). θ denotes the amount of land. Under no FAR restriction, equilibrium aggregate floorspace is given by $h^*\theta$.

Distance. Housing demand is decreasing in x. For sufficiently large x, h_H is no longer binding (see Figure 7) and the unrestricted equilibrium is attained. The increase in floorspace and dwellings is smaller than in the high demand location.

Figure 7: Conceptual Framework: Location with Less Demand



Notes: Supply and demand of housing floorspace. Supply shown under (i) no FAR restriction (blue line); (ii) a low density FAR restriction$h_L$on all land (purple dashed line), and (iii) a high density restriction $h_H > h^*$ on ξ proportion of land and low density restriction h_L on $1 - \xi$ proportion of land (red dotted line). θ denotes the amount of land. Under no FAR restriction, equilibrium aggregate floorspace is given by $h^*\theta$.

7.2 Geomatching Consents to Parcels

Consents are matched to parcels through the following algorithm: 1. Find the LINZ parcel of the geocoordinate of the consent and check whether the road number and first word of the road match. If these do not match: 2. Find all the LINZ parcels within 1250m of the geocoordinate of the consent and search for a match based on the road number and first word of the road address. If no match is found: 3. Check whether the address contains a number or letter to indicate a subdivision or cross lease (such as 10B or 2/10). If not, proceed to step 5. If so, the remove the additional and check whether the road number and first word of the road match the address of the parcel at the geocoordinate of the consent. If there is no match: 4. Find all the LINZ parcels within 1250m of the geo-coordinate of the consent and search for a match based on the road number and first word of the modified road address. If no match is found: 5. Identify the LINZ parcel of the geo-coordinate of the consent. Check whether the name of the road in the address of the LINZ parcel matches the road name of the address given in the consent. If there is no match: 6. Identify the nearest LINZ parcel of the geo-coordinate of the consent and assign this parcel. Parcels coded to 'Water', 'Strategic Transport Corridor Zone', 'Road', 'Coastal - General Coastal Marine Zone', 'Coastal - Coastal Transition Zone', 'Green Infrastructure Corridor', or any of the 'Open Space ' zones are removed from the set of parcels.

7.3 Estimated Completion Rates

'Code of compliance' (CCC) certification is commonly used as a measure of building completions in New Zealand. CCCs indicate that the building works have been satisfactorily inspected by the local council to certify that the work has been completed to the required local and national building codes and regulations.

Experimental estimates of completion rates for New Zealand as a whole produced by Statistics New Zealand (SNZ) exceed 90%. Using CCC issuance as completion results in a 91.2% completion rate over the ten years to December 2018.[17] However, dwellings can be inhabited without a CCC. The final inspection provides another measure of completion, since this occurs after the dwelling is up to a habitable standard (the interior wall linings, plumbing and fixtures are all in place). Using the final building inspection as a measure of completion results in a completion rate of 92.9%.[18]

SNZ does not provide experimental estimates of completions for Auckland by itself. Auckland Council (AC) does not produce estimates of the proportion of consented dwellings that are completed over a given time frame. The institutional features of administrative data collection and collation in New Zealand make it difficult to directly link completions to consents over our entire sample period. Specifically, and as explained in more detail in the following subsection, matching consents to code of compliance certificates (CCC) is only feasible from June 2017 onwards, when a unique identifier links CCCs back to the original consent. This identifier also allows matching consents to first and final building inspections.

We match consents to CCCs from 2018 onwards using the method described in the following subsection.

7.3.1 Consent to CCC matching

Local councils collect data on planned construction activity that requires a building consent as part of the consenting process. This data is provided to SNZ, who collate and clean the data to produce standardised individual and aggregate data on planned construction at the regional and national level. SNZ acts as the central repository for this data. While the original (often paper) consents still exist in the archives of the relevant local council, the datasets of total consents externally reported by these councils are generally the SNZ cleaned data. The consent data used in this study are the SNZ cleaned data, supplied by Auckland Council (AC).

Data on the issuance of a CCC for consented building work are collected internally by AC and were provided to the authors. This data was also previously provided to SNZ to be combined with similar information from other councils and to inform the SNZ experimental completion statistics. Due to the significant lag between a consent being issued and it's subsequent CCCs being awarded, these datasets have historically been treated as separate. The historic focus of the CCC data has been to determine the length of time it takes for a CCC to be issued. While the council CCC data records when a consent was first issued, it only does so for consents that go on to receive a CCC. Hence this dataset alone is insufficient to determine completion rates. Matching the CCC data to the SNZ consents data is required.

However, prior to June 2017, there is no unique identifier (ID) for each consent and CCC.

[17] Seehttps://www.stats.govt.nz/experimental/experimental-building-indicators-march-2022-quarter/ [accessed 05/09/2023].

[18] Until 2017, SNZ surveyed developers to measure completions, resulting in a completion rate above 95% in recent years. Seehttps://www.stats.govt.nz/experimental/experimental-dwelling-estimates/ [accessed 05/09/2023]

The omission of an ID precludes accurate matching of consents to CCCs. This is because it is impossible to tell if a CCC refers to a parent or child consent, or to a staged development. For example, a developer may obtain a consent to build a new dwelling with a corresponding child consent to undertake significant preparatory earthworks. Without the unique ID, it is very difficult to determine if any subsequently issued CCC refers to the child or parent consent. The CCC for the earthworks could have been issued even if the building was not constructed. Consequently, the CCC is no longer a reliable indicator that the dwelling was actually completed. Similarly, if a developer obtains consent to build 5 dwellings and stages the development, the first CCC issued for the first completed dwelling may be applied to all 5 consent records, showing up in the data as 5 completed properties, regardless of whether the remaining dwellings even get built.

Consequently, it is not possible to match CCCs to consented dwellings prior to June 2017. However, we can match CCCs to consented dwellings for consents issued from the 1st of June 2017 onwards, as each consent is assigned a unique building consent ID from this date. Matching consents to CCC records is based on the unique building consent ID and verified using property address and consent issued date. The unique identifier also allows us to match consents to first and final inspections.

Estimates of the percentage of consented dwellings that have attained a CCC within 1, 2, 3, 4, and 5 years of the consent issue date are presented in Table3. Given the time-frame under investigation, longer time-periods are only available for consents issued earlier in the sample. We also report the percentage of consented dwellings that have received their first and final inspections.

Table 3: Completion Rates, 2018 onwards

Area	Consent Issued in:	Total Consents Issued	Percentage of total consents issued with a:														
			first inspection within:				by 06/23	final inspection within:				by 06/23	CCC issued within:				by 06/23
			1 year	2 years	3 years	4 years		1 year	2 years	3 years	4 years		1 year	2 years	3 years	4 years	
Upzoned	2018	9,317	95.55	96.73	96.81	96.81	96.81	80.61	90.44	93.59	94.98	95.02	75.94	88.05	91.27	93.74	93.81
	2019	11,389	94.82	95.65	95.72	95.72*	95.72	78.27	88.59	92.19	92.39*	92.39	70.85	85.19	89.02	89.52*	89.52
	2020	13,257	96.22	97.26	97.33*		97.33	78.43	89.70	90.39*		90.39	73.27	85.06	86.23*		86.23
	2021	15,894	95.21	95.33*			95.33	69.63	73.06*			73.06	58.86	62.41*			62.41
	2022	16,113	70.00*				70.00	22.27*				22.27	15.63*				15.63
Non-Upzoned	2018	3,478	91.06	92.18	92.21	92.21	92.21	70.44	85.16	86.69	87.81	87.95	59.69	83.67	85.42	86.37	86.46
	2019	3,707	94.07	94.52	94.69	94.69*	94.69	76.32	87.32	89.02	89.21*	89.21	67.14	85.00	88.00	88.08*	88.08
	2020	3,333	92.08	92.47	92.47*		92.47	67.84	80.05	80.29*		80.29	65.65	73.54	73.72*		73.72
	2021	4,178	95.96	96.00*			96.00	68.12	77.38*			77.38	59.33	69.10*			69.10
	2022	4,626	85.39*				85.39	30.85*				30.85	23.17*				23.17
All	2018	12,795	94.33	95.49	95.56	95.56	95.56	77.84	89.00	91.72	93.03	93.10	71.52	86.86	89.68	91.74	91.81
	2019	15,096	94.63	95.38	95.46	95.47*	95.47	77.79	88.28	91.41	91.61*	91.61	69.94	85.14	88.77	89.17*	89.17
	2020	16,590	95.39	96.30	96.35*		96.35	76.30	87.76	88.36*		88.36	71.74	82.75	83.72*		83.72
	2021	20,072	95.36	95.47*			95.47	69.32	73.96*			73.96	58.96	63.81*			63.81
	2022	20,739	73.43*				73.43	24.19*				24.19	17.31*				17.31

Notes: Proportions calculated as of June 2023. '*' indicates that the evaluation period was incomplete as of June 2023. For example, for consents issued in 2022, there is only a full year of data for those consents issued prior to July 2022. Consents with CCCs but missing first and/or final inspections use the CCC issue date for the missing dates.

7.4 Conley Clustered Standard Errors

Let x_i denote a $T \times m$ matrix of regressors and let $\hat{e}_i$ denote a $T \times 1$ vector of regression errors. Then the covariance matrix is $\left(\sum_{i=1}^{n} x_i x_i'\right)^{-1} \hat{\Omega} \left(\sum_{i=1}^{n} x_i x_i'\right)^{-1}$

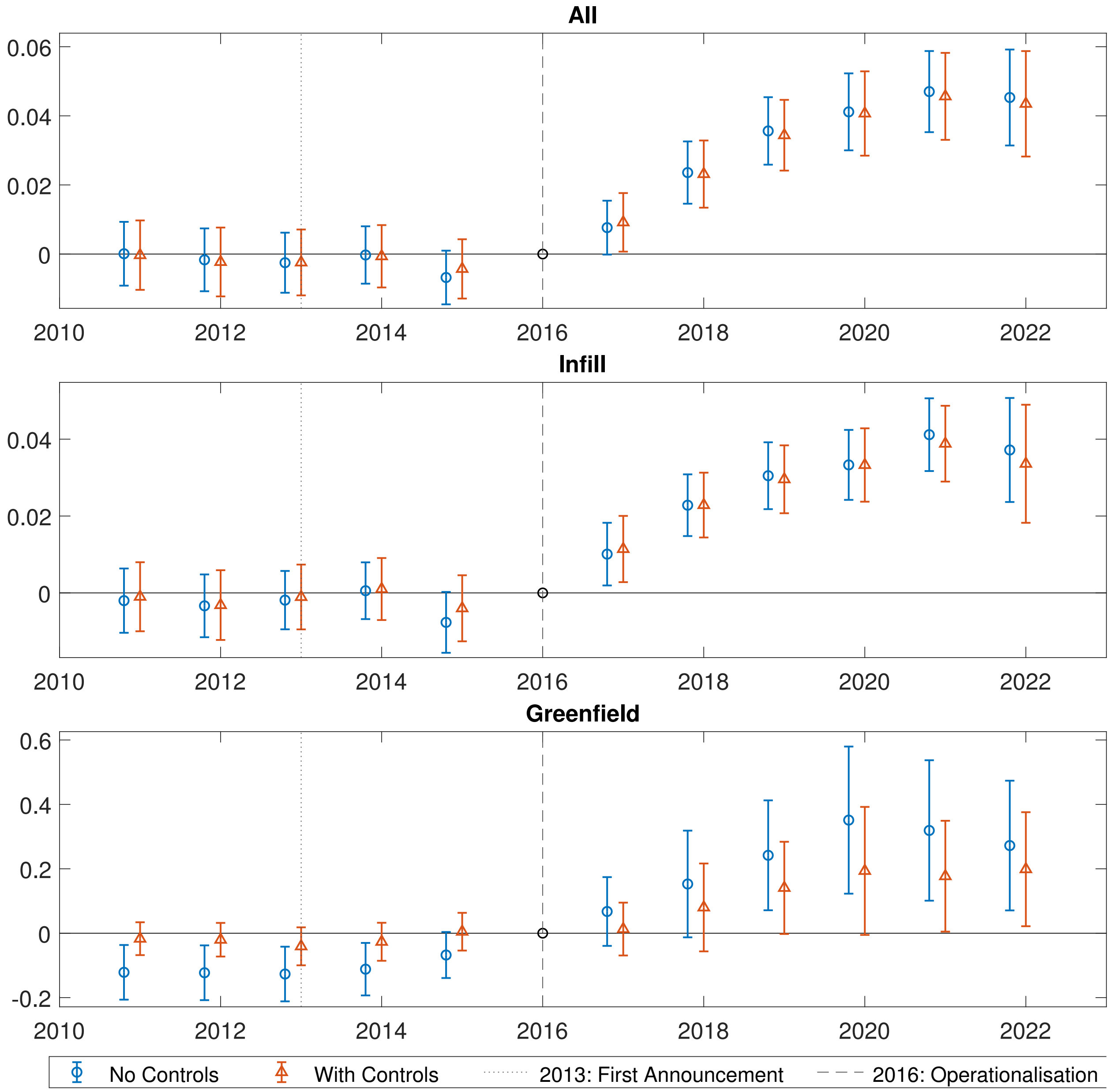
$$\hat{\Omega} \quad = \quad \sum\nolimits_{j=1}^{n} \sum\nolimits_{i=1}^{n} k_{i,j} x_i' \hat{e}_i \hat{e}_j' x_j$$

for the Bartlett kernel $k_{i,j} = max\left(1 - \frac{d_{i,j}}{b}, 0\right)$, where $d_{i,j}$ is the Haversine distance between i and j, and b is the bandwidth.

7.5 Additional Upzoned-Non-upzoned Differential Results

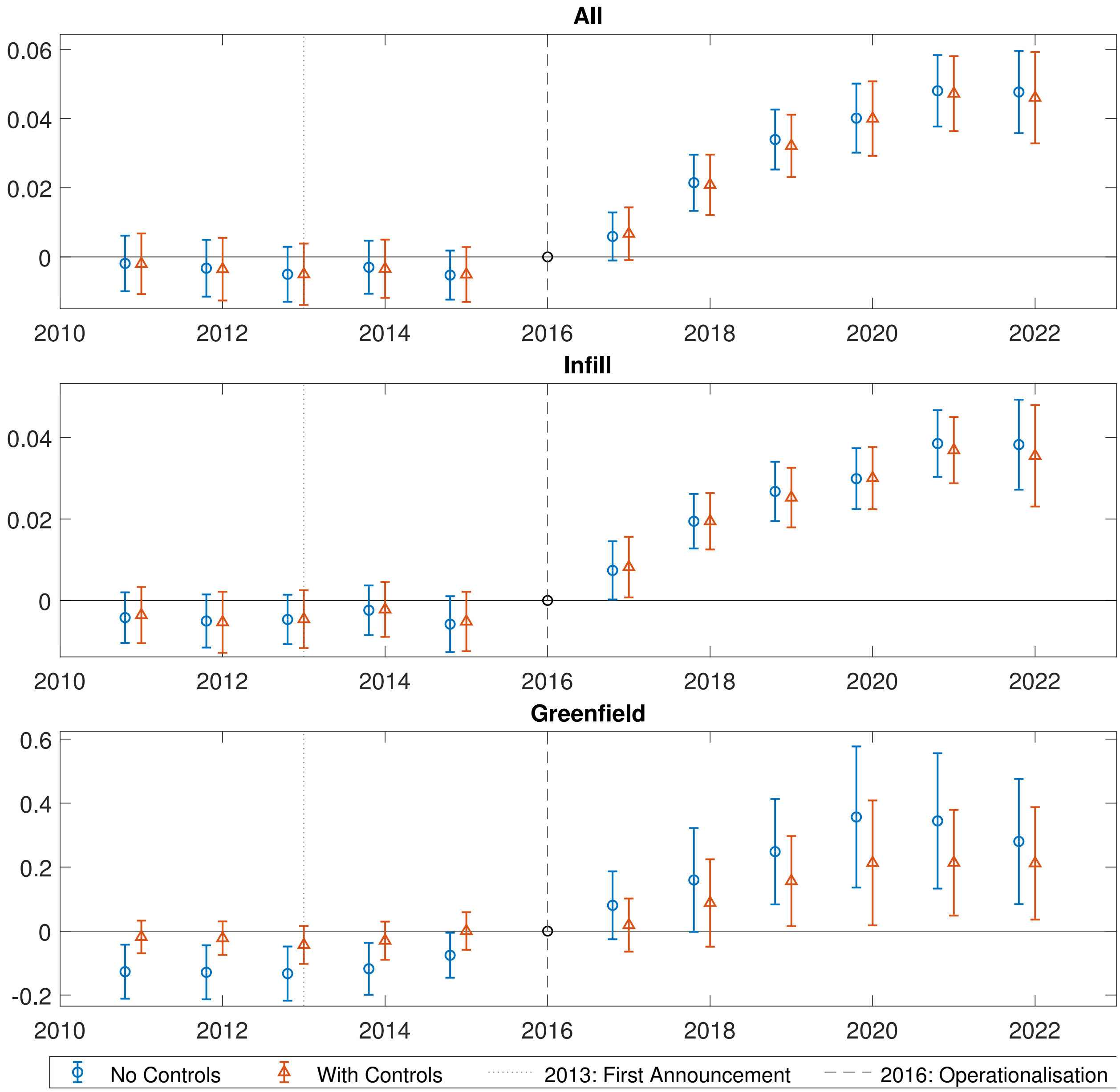
This subsection presents results for estimation of (1) with different samples.

Figure 8: Difference in Consents per Parcel between Upzoned and Non-Upzoned Areas, Indeterminate Zones Excluded



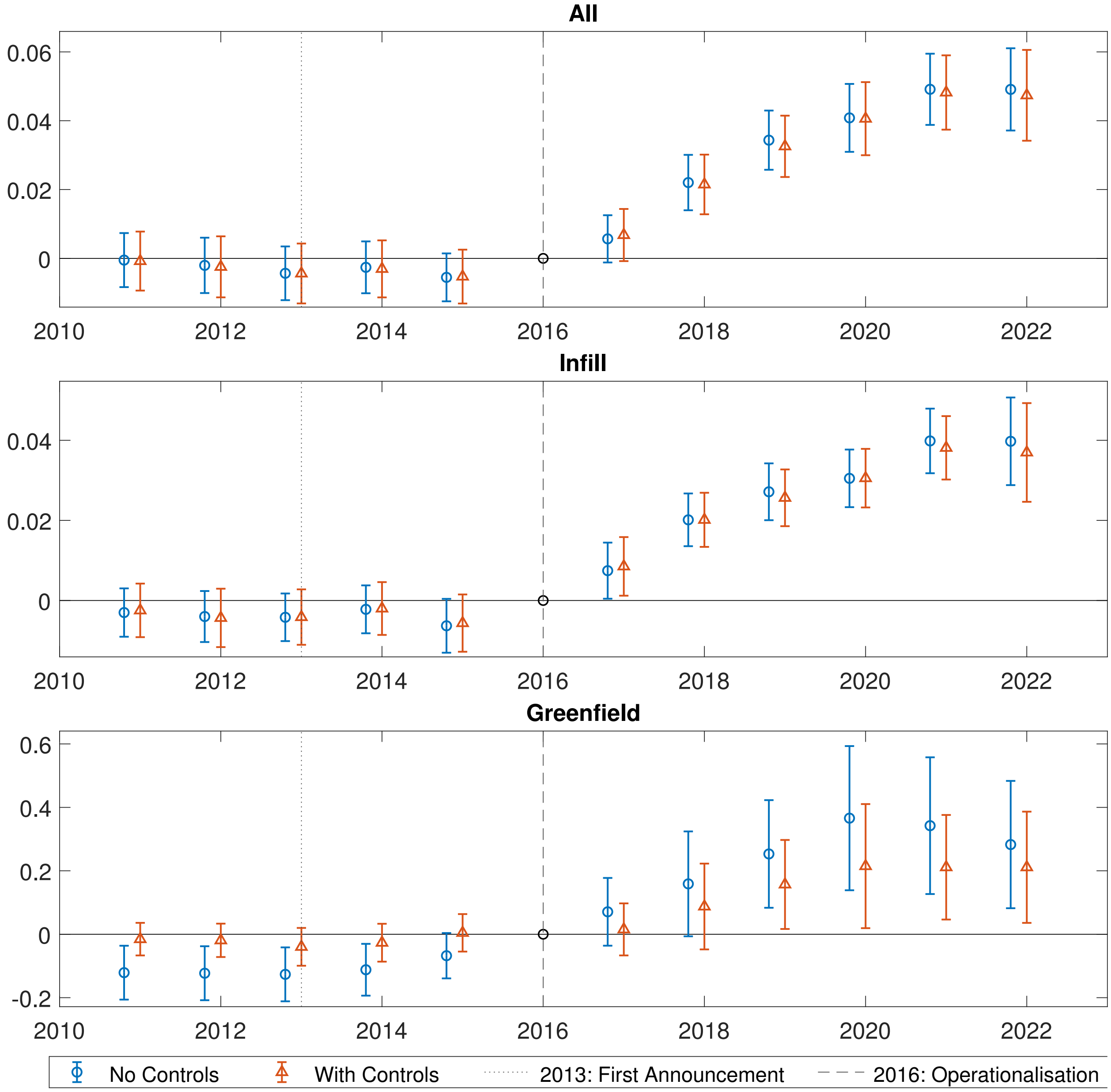
Notes: Sample excludes parcels that were indeterminate FAR classification prior to the AUP. Point estimates are average differences in consents per parcel between upzoned and non-upzoned areas. Error bars denote 95% confidence intervals. Model with covariates allows for heterogeneous coefficients between upzoned and non-upzoned areas. Standard errors are clustered at the parcel level to account for time series heteroskedasticity and dependence, and include a Conley Bartlett kernel in the cross sectional dimension (with a bandwidth of 1 km) to account for spatial dependence. Vertical dotted and dashed lines denote the first announcement of the AUP in 2013 and its operationalisation in 2016.

Figure 9: Difference in Consents per Parcel between Upzoned and Non-Upzoned Areas, Downzoned Areas Excluded



Notes: Sample excludes parcels that were indeterminate FAR classification prior to the AUP and downzoned parcels. Point estimates are average differences in consents per parcel between upzoned and non-upzoned areas. Error bars denote 95% confidence intervals. Model with covariates allows for heterogeneous coefficients between upzoned and non-upzoned areas. Standard errors are clustered at the parcel level to account for time series heteroskedasticity and dependence, and include a Conley Bartlett kernel in the cross sectional dimension (with a bandwidth of 1 km) to account for spatial dependence. Vertical dotted and dashed lines denote the first announcement of the AUP in 2013 and its operationalisation in 2016.

Figure 10: Difference in Consents per Parcel between Upzoned and Non-Upzoned Areas, Indeterminate Zones and Downzoned Areas Excluded



Notes: Sample excludes downzoned parcels. Point estimates are average differences in consents per parcel between upzoned and non-upzoned areas. Error bars denote 95% confidence intervals. Model with covariates allows for heterogeneous coefficients between upzoned and non-upzoned areas. Standard errors are clustered at the parcel level to account for time series heteroskedasticity and dependence, and include a Conley Bartlett kernel in the cross sectional dimension (with a bandwidth of 1 km) to account for spatial dependence. Vertical dotted and dashed lines denote the first announcement of the AUP in 2013 and its operationalisation in 2016.

7.6 Additional Tables and Figures

Table 4 displays the number of consents issued in the five years before and after the AUP. The number of consents doubles, increasing from approximately 42,000 over the 2011 to 2016 period, to 97,000 in the 2017 to 2022 period. There is also a substantial increase in the number of attached (or multi-family) dwellings, which increase from approximately 12,000 to 57,000. This increase pushes the share of attached dwellings up from 29.6 to 53.9%. Decomposing consents into zoning categories, there is substantially more construction occurring in the Residential-High (THA), Medium (MHU), and Medium-Low (MHS) areas post-AUP. To confirm that this increase is driven, in part, by the compositional shift in the amount of land in higher zoning categories (see Table1), we also decompose consents into upzoned and non-upzoned areas. Consents in upzoned areas increased by approximately 50,000, while non-upzoned areas increased by 5,000, confirming that almost all of the overall increase in consents is occurring on upzoned parcels.

The bottom panel of Figure 3 presents consents decomposed into infill and greenfield areas, showing that most of the increase in upzoned areas is infill development. However, there has also been a sizeable increase in greenfield development in upzoned areas.

Table 4: New Dwelling Consents, 2011–2022

By Zoning Category

Zoning Category	District and City Plans (operational before 15 Nov 2016) Consented Dwellings, 2011-16			Unitary Plan (operational after 15 Nov 2016) Consented Dwellings, 2017-22		
	Attached	Detached	Total	Attached	Detached	Total
Business	5,419	798	6,217	10,332	1,220	11,552
Residential-High or THA	61	213	274	12,369	1,616	13,985
Residential-Medium or MHU	720	1,417	2,137	16,635	9,276	25,911
Residential-Medium-Low or MHS	628	742	1,370	13,624	16,785	30,409
Residential-Low or SH	3,501	19,738	23,239	2,031	6,452	8,483
Semi-Rural	32	1,912	1,944	216	1,098	1,314
Rural and Open Space	779	3,936	4,715	1,526	4,183	5,709
Mixed	615	1,263	1,878			
Total	11,755	30,019	41,774	56,733	40,630	97,363

By Zoning Change

Zone change (November 2016)	District and City Plans (operational before 15 Nov 2016) Consented Dwellings, 2011-16			Unitary Plan (operational after 15 Nov 2016) Consented Dwellings, 2017-22		
	Attached	Detached	Total	Attached	Detached	Total
Upzoned to Business	422	197	619	1,608	561	2,169
Upzoned to THA	1,378	1,531	2,909	11,025	1,507	12,532
Upzoned to MHU	1,864	3,964	5,828	15,058	8,771	23,829
Upzoned to MHS	1,135	8,703	9,838	13,349	16,182	29,531
Upzoned to SH	30	1,296	1,326	425	2,170	2,595
Upzoned to Semi-Rural	3	77	80	12	81	93
Total Upzoned	4,832	15,768	20,600	41,477	29,272	70,749
Non-upzoned	6,308	12,988	19,296	13,543	10,354	23,897
Indeterminate	615	1,263	1,878	1,713	1,004	2,717
Total	11,755	30,019	41,774	56,733	40,630	97,363

Notes: See notes to Table 1. Areas classified as 'Mixed' prior to the AUP comprise the 'Indeterminate' zoning change category.

Table 5: Greenfield and Infill Consents by Zoning Change, 2011–2022

Zone Change (November 2016)	Greenfield: District and City Plans (prior to Nov 2016) Consented Dwellings, 2011-16			Greenfield: Unitary Plan (from Nov 2016) Consented Dwellings, 2017-22		
	Attached	Detached	Total	Attached	Detached	Total
Upzoned to Business	107	68	175	192	473	665
Upzoned to THA	138	258	396	620	265	885
Upzoned to MHU	407	560	967	2,025	3,068	5,093
Upzoned to MHS	65	2,525	2,590	2,159	6,252	8,411
Upzoned to SH	18	1,181	1,199	369	1,980	2,349
Upzoned to Semi-Rural	3	77	80	12	81	93
Total Upzoned	738	4,669	5,407	5,377	12,119	17,496
Non-upzoned	761	9,077	9,838	2,848	7,919	10,767
Indeterminate	510	987	1,497	577	389	966
Total	2,009	14,733	16,742	8,802	20,427	29,229

Zone Change (November 2016)	Infill: District and City Plans (prior to Nov 2016) Consented Dwellings, 2011-16			Infill: Unitary Plan (from Nov 2016) Consented Dwellings, 2017-22		
	Attached	Detached	Total	Attached	Detached	Total
Upzoned to Business	315	129	444	1,416	88	1,504
Upzoned to THA	1,240	1,273	2,513	10,405	1,242	11,647
Upzoned to MHU	1,457	3,404	4,861	13,033	5,703	18,736
Upzoned to MHS	1,070	6,178	7,248	11,190	9,930	21,120
Upzoned to SH	12	115	127	56	190	246
Upzoned to Semi-Rural	0	0	0	0	0	0
Total Upzoned	4,094	11,099	15,193	36,100	17,153	53,253
Non-upzoned	5,547	3,911	9,458	10,695	2,435	13,130
Indeterminate	105	276	381	1,136	615	1,751
Total	9,746	15,286	25,032	47,931	20,203	68,134

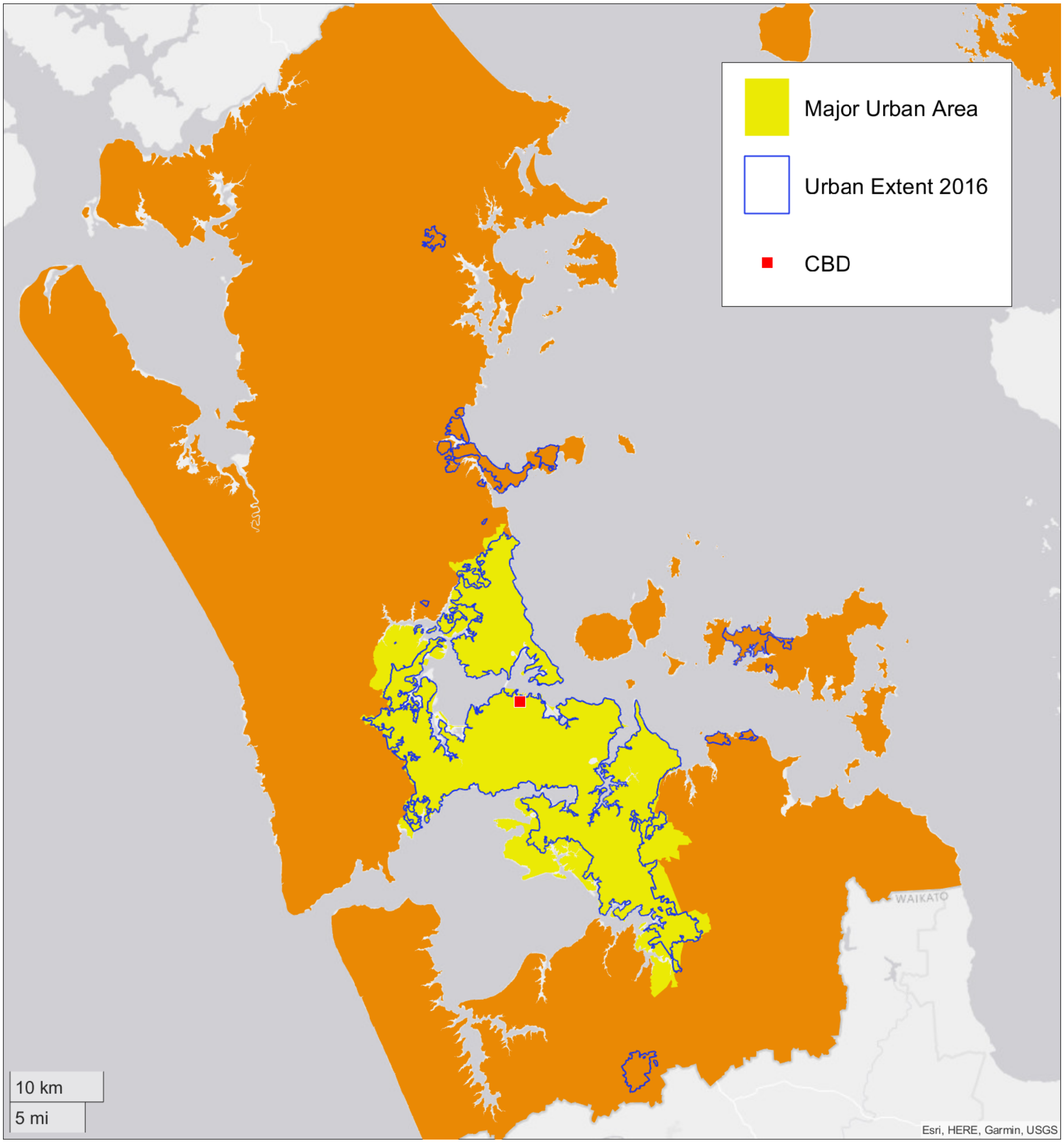
Notes: Infill (greenfield) development occurs within (outside) the urban extent (UE). 2010 UE is used for consents issued 2011–2016; 2016 UE for 2017–2022.

Table 6: Statistical Areas ordered by total employment

			Proportion of Total Employment	
Code	Name	Total Employment	Proportion	Cumulative Proportion
145900	Penrose	25,737	0.0348	0.0348
118600	North Harbour	24,459	0.0331	0.0680
152300	East Tamaki	24,165	0.0327	0.1007
147900	Auckland Airport	23,658	0.0320	0.1327
133300	Quay Street-Customs Street	16,884	0.0229	0.1556
138500	Newmarket	15,462	0.0209	0.1765
133200	Queen Street	15,306	0.0207	0.1972
131300	Wynyard-Viaduct	15,234	0.0206	0.2178
155500	Manukau Central	15,000	0.0203	0.2382
147700	Mount Wellington Industrial	13,257	0.0179	0.2561
157600	Wiri West	12,654	0.0171	0.2732
132700	Hobson Ridge North	11,583	0.0157	0.2889
126600	Takapuna West	10,632	0.0144	0.3033
136400	Parnell West	10,416	0.0141	0.3174
123500	Wairau Valley	10,008	0.0135	0.3310
136000	Eden Terrace	9,804	0.0133	0.3442
133700	Shortland Street	9,609	0.0130	0.3572
132400	Victoria Park	9,390	0.0127	0.3700
144200	Ellerslie West	9,153	0.0124	0.3823
136100	Grafton	8,190	0.0111	0.3934
145500	Onehunga-Te Papapa Industrial	7,941	0.0108	0.4042
128700	Rosebank Peninsula	7,707	0.0104	0.4146
127500	Henderson Central	7,653	0.0104	0.4250
126800	Takapuna Central	7,500	0.0102	0.4351
117300	Albany Central	7,182	0.0097	0.4449
125100	Henderson Lincoln East	6,474	0.0088	0.4536
133500	Grey Lynn East	6,174	0.0084	0.4620
156000	Botany Junction	6,126	0.0083	0.4703
134800	Auckland-University	5,139	0.0070	0.4772
133900	New Lynn Central	5,079	0.0069	0.4841
150100	Otahuhu Central	5,079	0.0069	0.4910
166000	Pukekohe Central	5,070	0.0069	0.4979
152700	Middlemore	4,989	0.0068	0.5046

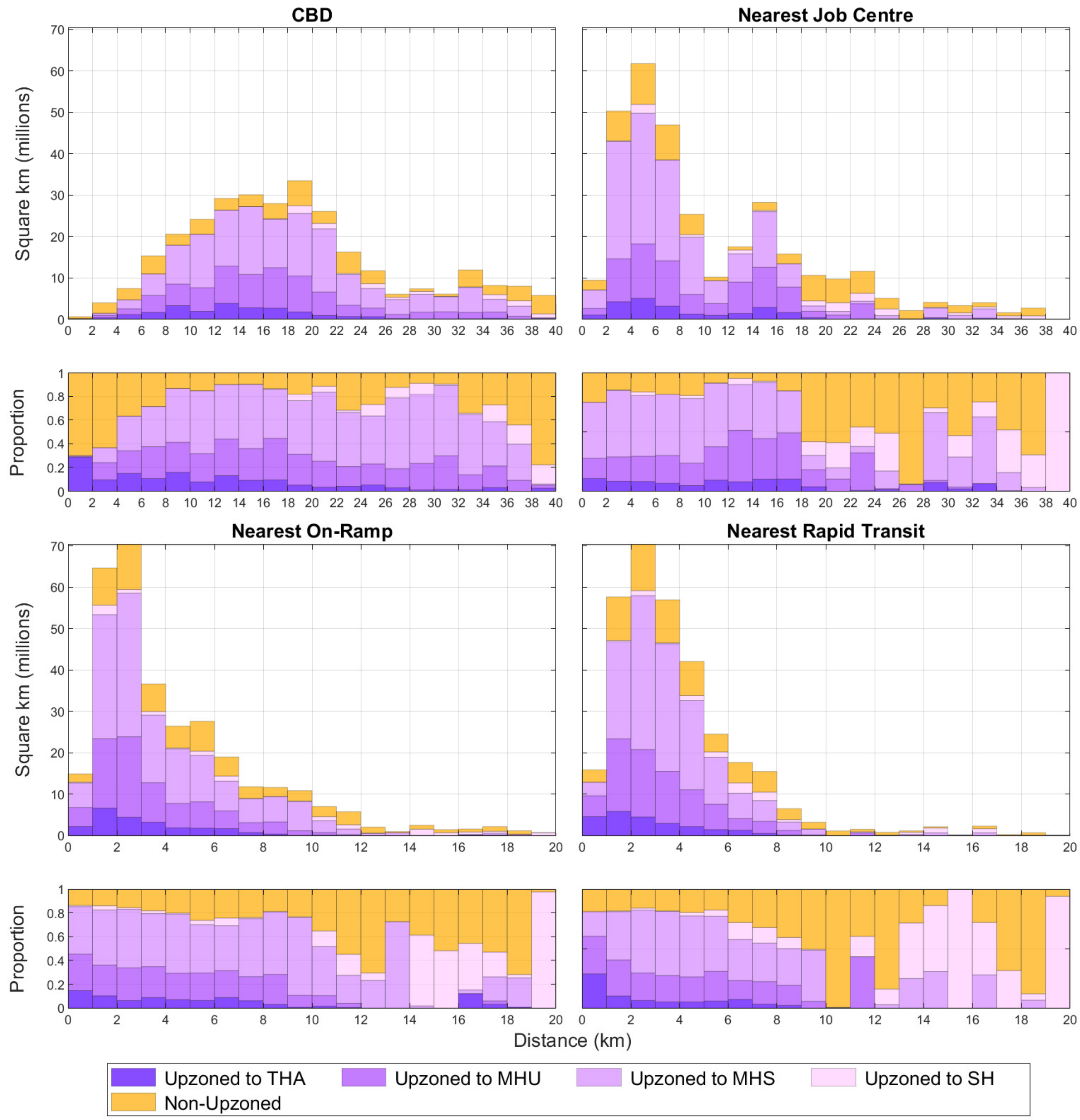
Source: 2018 census based on 2018 Statistical Area 2 (SA2) units. Total employment includes self employed individuals. For brevity, the top 32 out of 553 Statistical Areas are tabulated.

Figure 11: Auckland Region



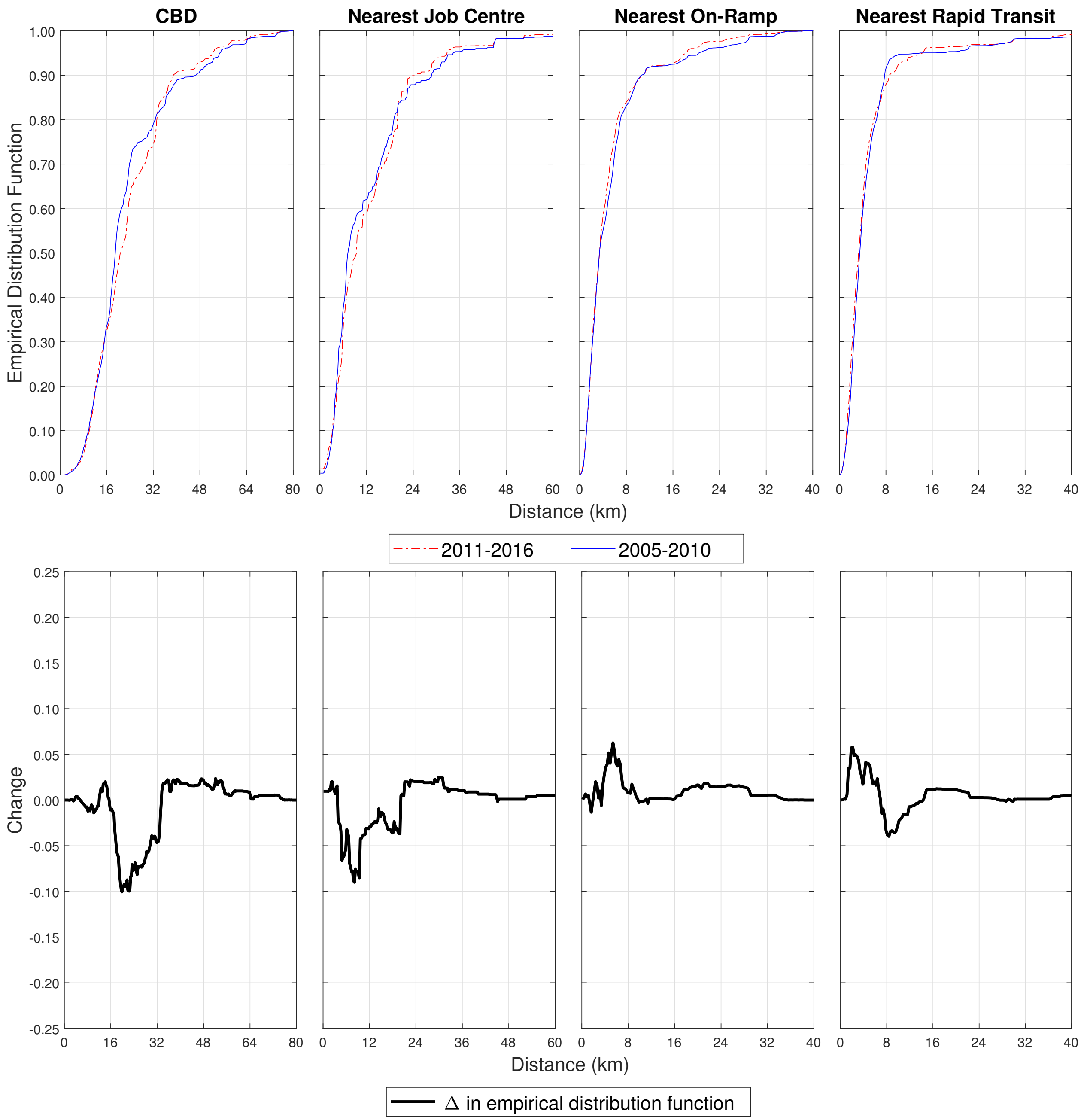
Notes: Auckland region with 2016 Urban Extent and Major Urban Area.

Figure 12: Distance between Upzoned Land and Locations of Interest



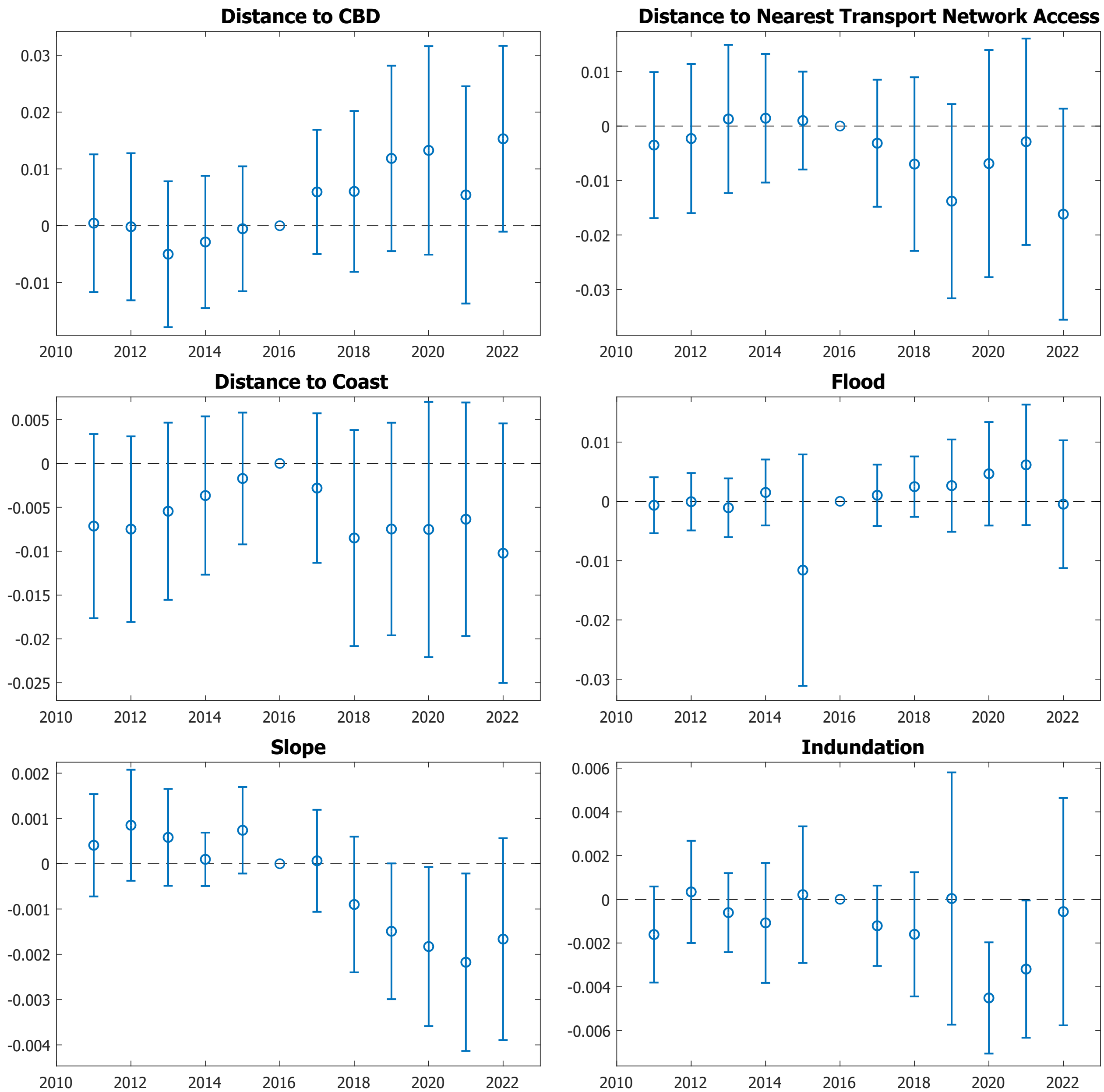
Notes: Total areas (in sq km) and proportions of upzoned and non-upzoned residential land. Residential comprises SH, MHS, MHU and THA, and excludes semi-rural zones.

Figure 13: Spatial Distribution of Consents prior to Upzoning



Notes: Top row: Empirical cumulative distribution functions (EDFs) of the distances between consents and various locations. Bottom row: Difference in EDFs between 2005–2010 and 2011–2016.

Figure 14: Heterogeneous covariate coefficients



Notes: Estimated coefficients (circles) and 95% confidence intervals (error bars) on covariates interacted with upzoning and year indicators.