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The welfare effects of character protections on neighbourhoods*

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Abstract

We extend the monocentric model to examine the effects of character protections on household welfare. Protections indirectly generate amenity values for residents but require floor area ratio (FAR) restrictions on housing development, presenting a trade-off between welfare-increasing amenities and welfare-decreasing floorspace constraints. Welfare effects become negative when the associated FAR restrictions of character protections are sufficiently tight. This is more likely when protections apply to neighbourhoods that have high demand due to proximity to non-character amenities or employment locations. Calibrating the model to Auckland, we find negative welfare effects, equivalent to a reduction in representative household income of $391 to $1,375 per year.

Keywords: Character Protections, Land Use Regulations, Redevelopment, House Prices.

JEL Classification Codes: R14, R31, R52

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1.0 Introduction

Many cities around the world restrict redevelopment within certain areas to preserve the built-form character of particular neighbourhoods.[1] These policies attract praise from preservation groups that consider character neighbourhoods to be inherently valuable or aesthetically desirable, and criticism from proponents of urban intensification when these character neighbourhoods occupy areas where housing demand is high, such as inner suburbs that are proximate to business districts.

Character controls are justified on the basis that owners of the affected buildings are not adequately compensated for the amenity value of preservation: A substantial proportion of the amenity benefits are public, while the costs of preservation are private. Restrictions on redevelopment therefore preserve positive externalities by preventing individual property owners from removing their own built character and free-riding on the character amenities of their neighbours (Coulson and Lahr, 2005; Holman and Ahlfeldt, 2015). However, such restrictions can also impede city growth by limiting the supply of housing in protected areas, thereby encouraging urban sprawl (Been *et al.*, 2016). In the worst case, redevelopment restrictions are imposed by incumbent residents to entrench a low density urban form in spite of high demand, using a system of local governance that apportions no weight to the welfare of potential residents excluded by the restrictions (Manville and Monkkonen, 2021).

This paper develops a framework for assessing the welfare effects of character preservation on city residents. Our analysis incorporates two features inherent to character restrictions. First, they indirectly generate positive amenity externalities for local residents of the protected neighbourhood (Holman and Ahlfeldt, 2015). Second, they potentially reduce the supply of dwellings in protected areas through restrictions on redevelopment (Been *et al.*, 2016). The net effect of character protections on the welfare of all residents is ambiguous because they indirectly generate amenity value by restricting the redevelopment potential of protected properties. By definition, amenities increase the welfare of affected individuals, all else equal. But restrictions on housing (re)development reduce welfare because they result in smaller, more expensive dwellings, and longer commutes (Bertaud and

[1]For example, Berlin, Chicago, London, New York and Rotterdam have restrictions on redevelopment in order to preserve historic character. See Ahlfeldt and Maennig (2010), Noonan and Krupka (2011), Koster *et al.* (2012), Ahlfeldt *et al.* (2015) and Been *et al.* (2016). While character protections often focus on preserving specific historic development patterns and heritage properties, they can also encompass non-historic elements, such as single-family zoning or the 'natural' character of an area.

Brueckner, 2005). Policymakers therefore require a framework for understanding and comparing the trade-offs of character protections on the welfare of city inhabitants.

We study the impact of character restrictions on urban development and welfare using a monocentric model of urban development in the tradition of Alonso (1964), Mills (1967) and Muth (1969). Our model incorporates both amenities and restrictions on housing development as location-specific features that can vary across the disk of the city. Amenities directly increase the utility of residents in locations where the protections apply. Housing development is restricted by lower bounds on the amount of land used in the production of housing floorspace. These bounds mimic floor (to land) area (FAR) restrictions and are equivalent to the height restrictions used in Bertaud and Brueckner (2005), and they are permitted to vary according to different zones across the disk. Character areas are modelled as zones that have redevelopment restrictions, including FAR maximums, that indirectly generate locational amenities. Our modelling assumptions ensure that the model is amenable to calibration using observable data in order to quantify welfare effects.

In practice, maximum FAR restrictions are a component of character protections that proscribe various forms of redevelopment. Generally these restrictions result in less redevelopment in character areas because the form and fabric of the existing buildings must be retained to preserve the built form of the neighbourhood. However, some intensification may occur though 'building back', or development of backyards into a separate dwelling, provided it does not adversely impact the visual character of an area. In addition, several smaller dwellings can be created by partitioning a character property into apartments or flats. It is also worth noting that special character controls cannot prevent several households from cohabitating within the same dwelling, as frequently occurs among young adults, which is equivalent to an increase in dwelling density from a modelling perspective.

Development is characterised as being restricted, but not prohibited, within character areas in our model. Modelling development restrictions as an upper bound on the FAR, and not the number of dwellings per area unit of land, appears concordant with these set of regulations, as it would prohibit, for example, building three storey buildings in character areas, but not the splitting of houses into several units, or building a second dwelling behind existing dwellings. As we discuss below in more detail, restricted redevelopment is critical to understanding the ongoing welfare impacts of character protections, because it does not place an upper bound on dwelling density within affected areas.

We assess the impact of character protections under various static equilibria that correspond to different regulatory regimes. In equilibrium, welfare increases for households in character areas from locational amenities are exactly offset by welfare losses from higher house prices and smaller dwellings in high amenity locations, such that households located in character areas are not better off than households outside character areas. We assume that character protections are fully binding, so that a removal of protections indirectly reduces amenity. We also assume there is no cost to the protections other than their associated FAR restriction, so they are unambiguously welfare enhancing for all households when their attendant FAR restrictions are a non-binding constraint on the supply of floorspace – i.e. when developers would not build more than the maximum permissible floorspace in the absence of development restrictions. This is because the smaller dwellings in high amenity areas generate a more compact city, increasing the welfare of *all* households because commutes are shorter. These welfare gains from character amenities would be reduced if frictions restrict the ability of floorspaces per dwelling to adjust downwards in high amenity suburbs. In the extreme case where there is a binding minimum lot size per household, such that there are no increases in density allowed in high amenity areas, there are no ongoing welfare gains to residents.

The negative welfare impacts of character protections become manifest if the attendant FAR restrictions are binding, meaning that developers would choose to exceed the maximum FAR if permitted. Locations with protections continue to have smaller dwellings and higher dwelling prices. But the net effect of the protections on welfare can be negative because the binding FAR restrictions expand the size of the city, increasing commuting costs, reducing dwelling sizes and increasing house prices across the whole city. This reduces the utility of the representative household.

The net effect of character provisions on welfare therefore depends on a number of variables, including the distance of the protected areas to locations of high demand, the aggregate housing demand to live in the city to access the wages and other available amenities, and the stringency of the redevelopment restrictions in the affected areas. In practice, model calibration may be required to assess these trade-offs. We calibrate the model to Auckland, New Zealand, to assess the welfare impacts of character protections compared to a medium density zoning. We find that the restrictions reduce representative household welfare by an amount that is equivalent to between 1.327% and 0.377% of average household income, or between $391 and $1,375 per year.

Monocentricity is a prominent assumption of AMM models that affects potential welfare losses from redevelopment restrictions, particularly when restrictions are imposed in locations of high demand, such as those close to the central business district (CBD). Conventional descriptions of the AMM model locate all jobs in the CBD, necessitating workers to commute into the centre of the city for employment. This is an assumption that often bears little resemblance to empirical patterns. However, as outlined in Glaeser (2008), the monocentric model is observationally equivalent to a set of models in which employment is dispersed across the city and wages decrease linearly as the distance between the place of work and the CBD increases. Thus, the AMM model is monocentric in the sense that workers commute *towards* the CBD, but not necessarily all the way to it. To assess the appropriateness of this condition in Auckland, we examine average wages by location-of-work, showing that wages decrease with distance to downtown. Imposing the linear relationship required by the form of observational equivalence proposed by Glaeser (2008) yields a healthy R-squared between 50 and 65%. Data on commuting patterns further buttress evidence of this monocentricity by showing that workers generally commute towards the CBD, with approximately 56% of all commutes headed towards a location within 30 degrees displacement of the CBD, and only 19% of commuters headed on a bearing that takes them away from the CBD.

Our paper builds on several strands of the extant literature. The trade-off between amenities and redevelopment that motivates our model is consistent with the ambiguous price effects of character protections documented in numerous empirical studies. A substantial amount of research documents a positive price premium for properties located within controlled areas (Leichenko *et al.*, 2001; Coulson and Leichenko, 2001; Noonan, 2007; Thompson *et al.*, 2011; Zahirovic-Herbert and Chatterjee, 2012; Lazrak *et al.*, 2014; Holman and Ahlfeldt, 2015; Warren *et al.*, 2017; Franco and Macdonald, 2018)). However, character premiums are often negative when measured relative to comparable parcels that can be redeveloped (Been *et al.*, 2016; Bade *et al.*, 2020). Like Bertaud and Brueckner (2005) and Kulish *et al.* (2012), our model incorporates restrictions on the capital intensity of housing production into the Alonso-Muth-Mills (AMM) framework to model LURs. However, we use the version of the AMM used in Greenaway-McGrevy (2024) that allows these restrictions on housing development to vary in different areas of the city, thereby mimicking different residential zones. Like Cho (2001), amenities are permitted to vary across the city disk within our framework. These amenity flows vary according to zone in our model. The incorporation of spatial variation in zoning and attendant amenities into a tractable model of urban development is a contribution to the extant literature, since models of urban development that incorporate development restrictions and amenities have heretofore been lacking (Larson *et al.* 2022, footnote 5).

Our application also contributes to ongoing debates over policy responses to housing shortages and unaffordable housing in Auckland and New Zealand more broadly, since the welfare benefits from removing character protections accrue from lower house prices (as well as larger dwellings and shorter commutes). Housing in the region has become highly unaffordable in the past decade (Greenaway-McGrevy and Phillips, 2021), in part due to constraints on supply (Housing Technical Working Group, 2022). But the abolition of character protections is not a panacea. While house prices would be lower under the counterfactual of medium density, the magnitude of the price reductions implied by the calibrated model are nowhere near what would be required to restore affordability. That said, the responsiveness of housing supply moderates the effects of demand-side shocks such as reductions in interest rates (Chadwick Meltem *et al.*, 2022) or speculative behaviour,[2] since locations with tighter restrictions on supply will experience larger increases in prices in response to a positive demand shock. Supply reform, including careful evaluation of the costs and benefits of character protections, must therefore be considered as part of a broad-based policy solution to ongoing housing problems. We also note that upzoning to allow high (as opposed to medium) density housing structures, such as apartment buildings, will have larger price effects.

The remainder of the paper is organized as follows. Section two presents the model. Section three presents that application, including descriptive data analysis on Auckland to support the fundamental premises of the model. Section four concludes.

2.0 Model

The model is based on the conventional absentee landlord monocentric AMM model. We first present the model with a simple formulation of location-specific amenities that is amenable to calibration exercises. We then introduce FAR restrictions following Bertaud and Brueckner (2005). This approach is then extended to examine zoning in different areas of the city based on the approach in Greenaway-McGrevy (2024). Our exposition follows Greenaway-McGrevy (2024) with

[2] Restraints on housing supply enable speculation because scarcity is necessary to sustain rational asset bubbles (Tirole, 1985).

modifications to incorporate amenities.

The city lies on a flat plane and comprises a central business district (CBD) surrounded by suburbs that house workers. Land around the CBD suitable for housing development spans θ radians. Workers reside in the suburbs and commute to the CBD to earn wages. Their preferences over housing floorspace H and a consumption numeraire C are described by a utility function $U(H, C)$ that is increasing in both arguments and strictly quasi-concave.[3] Households living at distance $x \in [0, \infty)$ from the CBD incur a commuting cost tx to earn the wage W. Households are freely mobile between home locations and maximise utility subject to the budget constraint $W - tx = C + P(x) H$, where $P(x)$ denotes the floorspace rent (hereafter 'dwelling prices'). Under these assumptions, both $P(x)$ and floorspace $H(x)$ are decreasing in x and convex (Duranton and Puga, 2015).

Because we are interested in how regulations affect the intensity of housing development, we employ a version of the model that admits substitution between land and capital in the production of floorspace. We impose standard assumptions. Developers produce floorspace $H(x)$ using capital K and land L. $H(x)$ is increasing in K and L, exhibits constant returns to scale, and is strictly quasi-concave. The rental price of capital is assumed constant and is set to unity. The rental price of land (hereafter 'land prices') is endogenous and denoted $R(x)$. Developers are perfectly competitive and maximise profits. We define $h(x) = H(x) / L(x)$ as the FAR that developers build to at x. Under constant returns to scale, $h(x)$ can be expressed as a function of the capital to land ratio $k(x) = K(x) / L(x)$.

The conventional model is closed by: (i) setting land rents at the edge (or radius) of the city, $\bar{x}$, equal to exogenous agricultural rents, i.e., $R(\bar{x}) = \bar{R}$; (ii) the conventional population constraint

$$\int_0^{\bar{x}} \tfrac{h(x)}{H(x)} \theta x dx = N,$$

where N is the number of dwellings in the city; and (iii) and the within city iso-utility condition (utility is equal at all locations), i.e. $U = \bar{U}$.

[3]Homogeneous agent models such as this are appropriate for simulating long-run equilibria under different regulatory regimes. Heterogeneous agent models require calibration of the parameter space describing preferences based on an existing city, which is the product of past policies, technologies, regulations, and accidents of history, and these relationships may not hold when alternative scenarios are considered (Larson *et al.*, 2022, p.2 and p.4).

2.1 Utility and character amenities

Household utility is also increasing in an amenity $b = b(x)$ that is location-specific. Following Ahlfeldt *et al.* (2015), we model amenities multiplicatively in the utility function. We assume utility is Cobb Douglas, such that $U = U(H, C) = bH^{\alpha}C^{1-\alpha}$. Utility maximisation and the iso-utility condition yields

$$P(x) = (W - tx)^{\frac{1}{\alpha}} (1-\alpha)^{\frac{1-\alpha}{\alpha}} \alpha \left(\frac{\bar{U}}{b}\right)^{-\frac{1}{\alpha}} = \frac{b(x)^{\frac{1}{\alpha}} (W - tx)^{\frac{1}{\alpha}} (1-\alpha)^{\frac{1-\alpha}{\alpha}} \alpha}{\bar{U}^{\frac{1}{\alpha}}} \tag{1}$$

and

$$H(x) = (W - tx)^{-\frac{1-\alpha}{\alpha}} (1-\alpha)^{-\frac{1-\alpha}{\alpha}} \left(\frac{\bar{U}}{b}\right)^{\frac{1}{\alpha}} = \frac{\bar{U}^{\frac{1}{\alpha}}}{b(x)^{\frac{1}{\alpha}} (W - tx)^{\frac{1-\alpha}{\alpha}} (1-\alpha)^{\frac{1-\alpha}{\alpha}}} \tag{2}$$

where $\bar{U}$ in the above denotes maximised utility (equal at all locations). Thus, locations with more amenities have higher dwelling prices and smaller dwellings.

We assume that floorspace production is Cobb-Douglas of the form $H(K, L) = AK^{\gamma}L^{1-\gamma}$ for some $\gamma \in (0, 1)$ and $A > 0$. In the absence of FAR restrictions, dwelling density is

$$\frac{h(x)}{H(x)} = \frac{\bar{R}}{\alpha(1-\gamma)} \frac{(W - tx)^{\frac{1-\alpha(1-\gamma)}{\alpha(1-\gamma)}}}{(W - t\bar{x})^{\frac{1}{\alpha(1-\gamma)}}} \frac{b(x)^{\frac{1}{\alpha(1-\gamma)}}}{b(\bar{x})^{\frac{1}{\alpha(1-\gamma)}}} \tag{3}$$

under profit maximisation. Note that this implies that dwelling density increases where $b(x)/b(\bar{x}) > 1$.

2.2 FAR restrictions and zones

Because we are interested in how regulations affect the intensity of housing development, we employ regulations that restrict developers to a maximum floor area ratio (FAR) on $h(x)$. We therefore refer to it as a FAR restriction. It is equivalent to the height restrictions employed by Arnott and MacKinnon (1977), Bertaud and Brueckner (2005) and Kulish *et al.* (2012).

Bertaud and Brueckner (2005) and Kulish *et al.* (2012) model LURs as constraints on height. For example, $h(x) < \hat{h}$ for some $\hat{h} > 0$ that is selected by a policymaker. Under constant returns to scale, this is equivalent to a constraint on the capital intensity of the property, $k(x)$. In the framework of Arnott and MacKinnon (1977), Bertaud and Brueckner (2005) and Kulish *et al.* (2012), the FAR restriction $\hat{h}$ applies uniformly across the city. The constraint is binding on locations sufficiently close to the CBD, i.e. where $x < \hat{x}$. At such locations, dwelling density is given by $\frac{\hat{h}}{H(x)}$. Incorporating the Cobb-Douglas utility function with multiplicative amenities and Cobb-Douglas floorspace production, we can solve for this as

$$\frac{\hat{h}}{H\left(x\right)} = \hat{h}\frac{b\left(x\right)^{\frac{1}{\alpha}}}{b\left(\bar{x}\right)^{\frac{1}{\alpha}}}\frac{\bar{R}^{1-\gamma}\left(W-tx\right)^{\frac{1-\alpha}{\alpha}}}{\left(1-\gamma\right)^{\left(1-\gamma\right)}\alpha\gamma^{\gamma}A\left(W-t\bar{x}\right)^{\frac{1}{\alpha}}} \tag{4}$$

Density is therefore greater for locations x such that $b\left(x\right)/b\left(\bar{x}\right) > 1$. Note, however, that since $\gamma < 1$, the effect of amenities on density is less than under cases where the FAR restrictions do not apply – see (3) above.

The model is solved via the population constraint (c.f. (9) in Bertaud and Brueckner, 2005):

$$\int_0^{\hat{x}} \frac{\hat{h}}{H(x)}\theta x dx + \int_{\hat{x}}^{\bar{x}} \frac{h(x)}{H(x)}\theta x dx = N$$

and the condition that $\hat{x}$ satisfies $h\left(\hat{x}\right) = \hat{h}$, such that $\hat{x}$ denotes the distance at which $\hat{h}$ becomes binding.

In practice, however, regulations that affect housing construction typically vary between different zones of a city. To bring the model closer to urban planning in practice, we extend the general framework by permitting different zones across the city disk. Each zone has a different restriction on $h\left(x\right)$. Let $\omega_j\left(x\right) \in \left(0,1\right)$ denote a continuous function in x that describes the proportion of land at distance x that is assigned to residential zone $j = 1, 2, ..., m_z$. Let $\hat{h}_j$ denote the FAR restriction that applies in zone j, such that $h\left(x\right) \leq \hat{h_j}$. The population condition becomes

$$\theta\sum_{j=1}^{m_z}\left(\int_0^{\hat{x}_j} \frac{\hat{h}_j}{H(x)}\omega_j\left(x\right)xdx + \int_{\hat{x}_j}^{\bar{x}} \frac{h(x)}{H(x)}\omega_j\left(x\right)xdx\right) = N \tag{5}$$

where $\hat{x}_j$ satisfies $h\left(\hat{x}_j\right) = \hat{h}_j$, such that $\hat{x}_j$ denotes the distance at which $\hat{h}_j$ becomes binding. The remaining conditions for solving the model are the same as in the standard AMM model.

A simple example of the framework is given by $\omega_j\left(x\right) = \omega_j \in \left(0,1\right)$ for all $j = 1, \ldots, m$. In this case, the city disk spanning θ radians is decomposed into circular sectors, with each sector corresponding to a zone. Such a model may be appropriate for transit-oriented zoning, whereby residential areas close to rapid transit and highway corridors are zoned for greater density. Figure 1 below provides an example where $\omega_j\left(x\right) = \omega_j \in \left(0,1\right)$ for all $j = 1, \ldots, m$. However, in practice, planners often locate high density zones closer to downtown. In such cases we might expect $\omega_j(x)$ to be monotonically decreasing in x for zoning that allows high levels of capital intensity in housing, and increasing for zoning that only allows low levels of capital intensity.

2.21 Character protections

We model character protections as a (re)development restriction that (i) indirectly generates a positive amenity flow for households, i.e. $b_j(x) > 0$ in a certain zone j, and (ii) imposes a (possibly binding) FAR restriction. The parameter $\xi_j = \{0, 1\}$ is used to indicate whether the character protections apply ($\xi_j = 1$) or not ($\xi_j = 0$). Amenity flows are positive if and only if character protections apply, and are zero otherwise, i.e.

$$b_j(x) > 1 \iff \xi_j = 1 \qquad \text{and} \qquad b_j(x) = 1 \iff \xi_j = 0$$

Character protections also imply that there is an FAR restriction, i.e.

$$\exists\ \hat{h}_j < \infty \Leftarrow \xi_j = 1$$

Note, however, that the FAR restriction may or may not be binding, i.e. $h(x) \leq\ \hat{h}_j$, and character protections are not necessary for a FAR restriction to exist.

The parameter ξ_j can be thought of as the rules preventing or allowing redevelopment of the aspects of the dwelling that contribute to the built-form character of the neighbourhood, such as prohibitions on redeveloping the exteriors of the building that can be observed from the road (see section 3.1 for a description of character protection rules in Auckland). These redevelopment restrictions are always binding when $\xi_j = 1$. While character protections do not prohibit development at the rear of the property, they do necessarily impose a maximum FAR, since allowing developers to build up beyond the height of the original building would be viewable from the street, and hence $\xi_j = 1$ implies that there exists an $\hat{h}_j < \infty$. However, the FAR restriction $\hat{h}_j$ may or may not be binding depending on housing demand in the area.[4]

[4]The process of redevelopment without increasing floorspace is not explicitly modelled. But we can infer that the existence of character protections implies that character dwellings would be torn down and replaced with modern houses of a similar size at some background rate in the absence of the protection. Otherwise, the character of the neighbourhood could be preserved by conventional floor-to-area restrictions or minimum lot sizes alone.

We parametrise locational character amenities for some finite $\kappa > 0$ as

$$b_j(x) = 1 + \kappa \iff \xi_j = 1 \tag{6}$$

In what follows, we reserve $j = 1$ to represent the character zone, while $j = 2, 3...$ denote non-character zones without amenity flows. In practice, we will select κ such that the reduction in floorspace per dwellings in character zones relative to non-character areas matches the data, since, as shown under (2), amenities reduce floorspace.

2.22 Discretization into annulus sectors

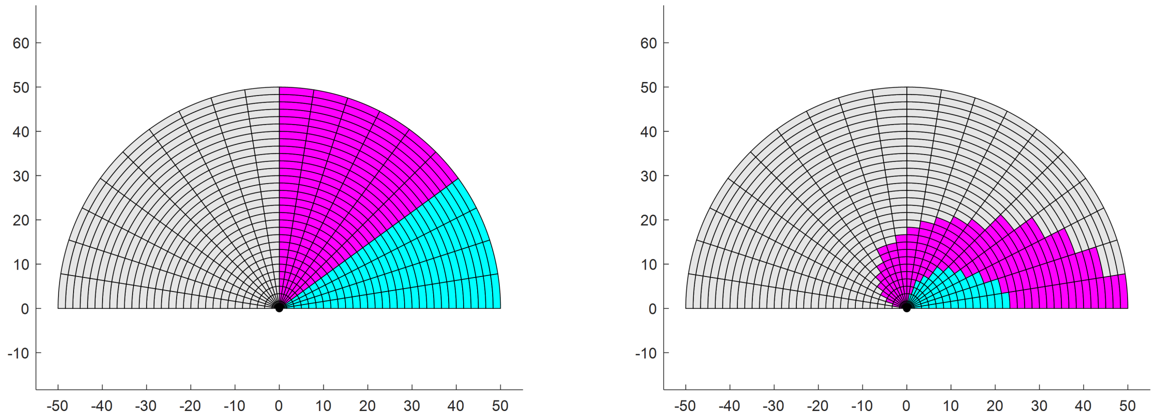
The model can also be solved via numerical integration when the functions $\{\omega_j(x)\}_{j=1}^{m_z}$ are discretized via a step function over x. Discretization may be desirable to match the zoning topography to land use maps.

Discretization involves decomposing the disk into a grid of annulus sectors and assigning a zone to each sector. We assign m_s circular sectors, each of angle θ/m_s. Each annulus has an annulus radius of length l. Let (a, s) index the annulus and sector, such that $s = 1, \ldots, m_s$ indexes the sectors and $a = 1, 2, \ldots$ indexes the countably infinite annuli. We define $\omega_{j,a} \in [0, 1]$ to be the proportion of sectors within the ath annulus that are assigned to zone j.

Figure 1 exhibits two examples of the annulus sectors framework for a case where there are three different zones. Each annulus sector within the disk is assigned a zone and signified by a different colour (magenta, cyan or grey). In the example on the left of figure 1, we have the case where the proportion of land assigned to each zone is constant for all distances x. In the example on the right, the cyan zone is more prevalent close to the CBD, while the grey zone becomes more prevalent towards the outskirts of the city. Because distance to the CBD determines outcomes in the monocentric AMM model, the ordering of the zones within the ath annulus is inconsequential in the disks presented in figure 1.

Under the discretization into annulus sectors, the population condition (5) becomes more complicated. We use x_a^* to denote a discrete measure of distance to the CBD. Specifically, x_a^* is the distance of the outer edge of the ath annulus to the CBD, such that $x_a^* \in \{x_0^*, x_1^*, x_2^*, x_3^*, \ldots\} =$

Figure 1: Example of Annulus Sector Zones in the Alonso-Muth-Mills model



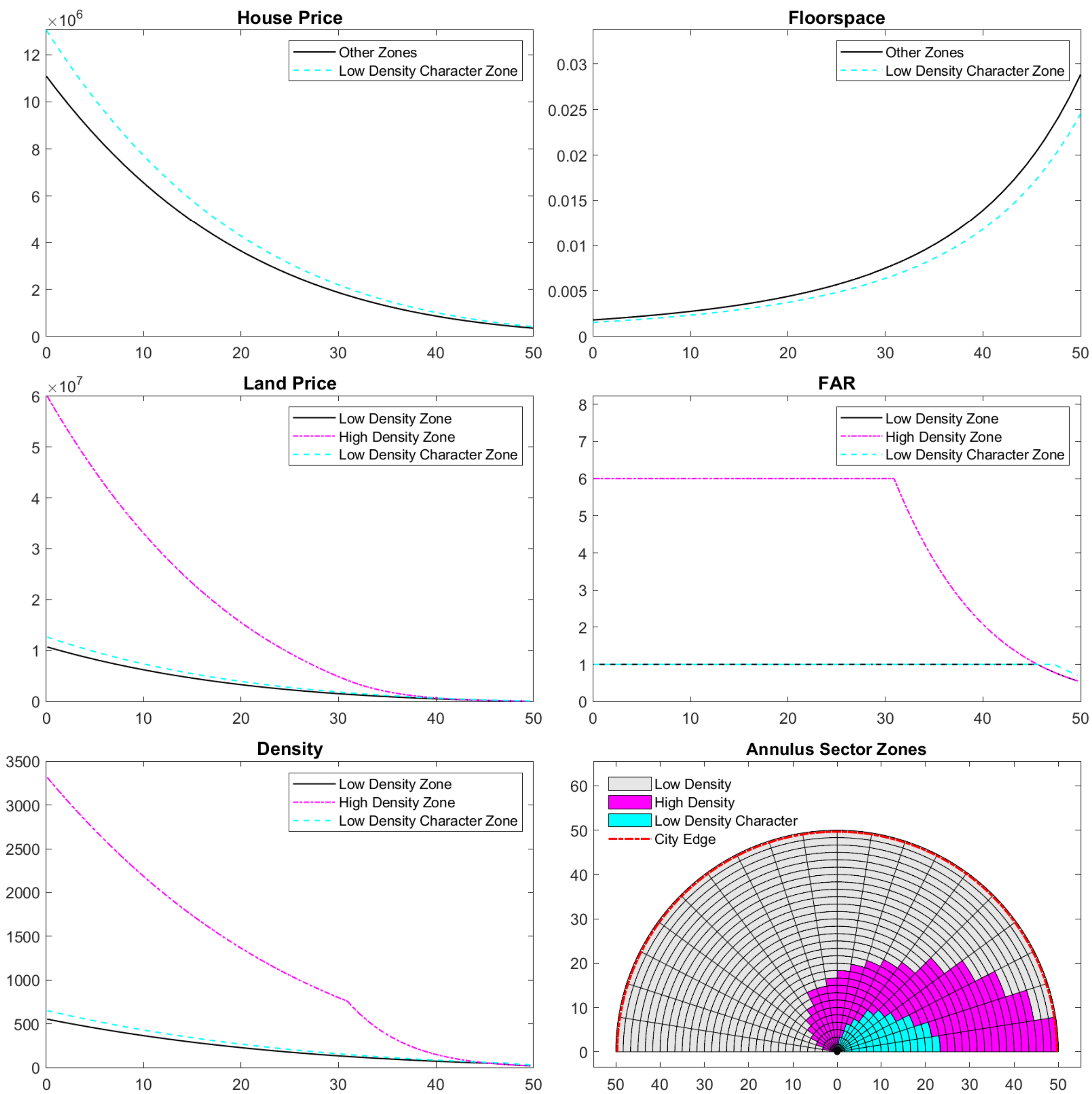
Notes: Disk decomposed into annulus sectors, $\theta = \pi$. Colours represent different zones. In the example on the left, the proportion of sectors in each annuli assigned to each zone is constant. In the example on the right, the proportion of annuli assigned to each zone is dependent on the distance of the annuli to the CBD.

$\{0, l, 2l, 3l, \ldots\}$. Then (5) becomes

$$\theta \sum_{j=1}^{m_z} \left(\begin{array}{c} \sum_{a=1}^{a_j} \int_{x_{a-1}^*}^{x_a^*} \omega_{j,a} \frac{\hat{h}_j}{H(x)} x dx + \int_{x_{a_j}^*}^{\hat{x}_j} \omega_{j,a+1} \frac{\hat{h}_j}{H(x)} x dx + \omega_{j,a_j+1} \int_{\hat{x}_j}^{x_{a+1}^*} \frac{h(x)}{H(x)} x dx + \\ \sum_{a=a_j+2}^{\bar{a}} \omega_{j,a} \int_{x_{a-1}^*}^{x_a^*} \frac{h(x)}{H(x)} x dx + \omega_{j,\bar{a}+1} \int_{x_{\bar{a}}^*}^{\bar{x}} \frac{h(x)}{H(x)} x dx \end{array} \right) = N$$

where $a_j = \lfloor \frac{\hat{x}_j}{l} \rfloor$ and $\bar{a} = \lfloor \frac{\bar{x}}{l} \rfloor$, and where $\lfloor \cdot \rfloor$ denotes the largest integer less than or equal to the argument. Thus the FAR restriction for zone j becomes non-binding in the $(a_j + 1)$th annulus, and the radius of the city lies within the $(\bar{a} + 1)$th annulus.

Figure 2: Modelled impacts of character protections on urban development



Notes: Simulated equilibrium outcomes using the annulus sector zoning depicted in the lower right panel. Cyan denotes the (low density) character zone ($\xi = 1$ and $\hat{h} = 1$); magenta denotes the high density zone ($\xi = 0$ and $\hat{h} = 6$), while black denotes the low density zone without character protections ($\xi = 0$ and $\hat{h} = 1$). Utility is Cobb Douglas with a housing share of 0.2, while floorspace production is Cobb-Douglas with a capital share of 0.6 and TFP of $5e^{-4}$. These parameters are adopted from (Kulish *et al.*, 2012). The remaining parameters are $W = \$100,000$, $t = \$1,000$, $\bar{R} = \$80,000$, $N = 1,000,000$, $\kappa = 0.03305$ and $\theta = \pi$. The various outcome functions exist and are depicted for all $x \geq 0$ (where x is distance from the CBD, measured on the x-axis). Readers should not infer that the depiction of a function for a particular zone over an arbitrary interval of x implies that there is positive land allocated to that zone over the interval. For example, there is no character zone for $x > 24$ of the CBD depicted in the bottom right panel of the figure, but the land price, FAR and density functions for the zone still exist for $x > 24$.

2.23 Numerical simulation

We present an example of urban development outcomes when spatial equilibrium holds under the annulus sectors disk depicted on the right panel of figure 1. For the purposes of this instructive exercise, we impose a FAR restriction of 6 on the magenta annulus sectors in figure 1. We refer to this as the 'high density zone'. The cyan areas have a FAR restriction of 1, but is also subject to character protection, while the grey areas have a FAR restriction of 1 and no amenity benefit. We refer to the former as the 'low density character zone', or just 'character zone' for brevity, and the latter as the 'low density zone'. For this exercise, we set $\kappa = 0.03305$, which results in a 15% reduction in floorspace in character zones. Other parameters of the model are described in the notes to figure 2. For instructive purposes, distance x is measured in km.

Figure 2 depicts outcome variables of interest under spatial equilibrium. It depicts dwelling rents $P(x)$ and floorspaces $H(x)$, which, in the absence of amenities, depend only on x and $\bar{x}$. However, the presence of amenities in the character zone are reflected in the price and quantity of floorspace. Because utility is constant across all locations, but residents of the character zone benefit from amenities, at each distance x the price of housing is higher, and floorspace lower, in the character zone compared to non-character zones. Specifically, it follows straightforwardly from (1) and (6) that

$$P_1(x) = P(x)(1+\kappa)^{\frac{1}{\alpha}} \tag{7}$$

where $P_1(x)$ denotes house prices in the character zone ($j = 1$), and $P(x)$ denotes prices in zones $j = 2, 3, ...$ Similarly we have

$$H_1(x) = H(x)(1+\kappa)^{-\frac{1}{\alpha}} \tag{8}$$

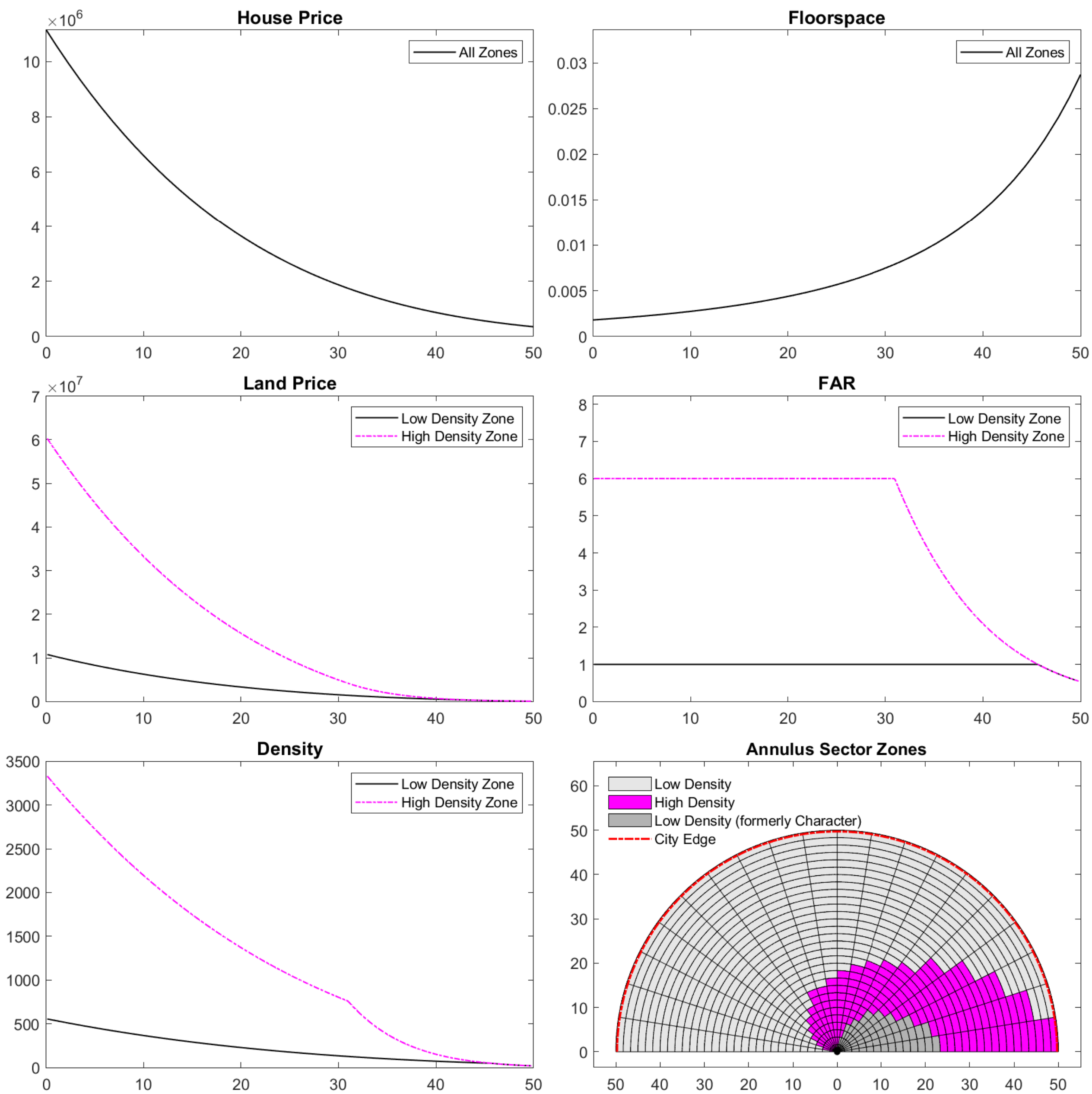
Figure 2 also depicts land rents $R(x)$, FARs $h(x)$, and densities $h(x)/H(x)$, all of which vary according to zone. Character amenities also effect these variables, since prices are higher and floorspaces lower. Density is higher in the character zone, since there is greater demand from households to live there. Land prices are also higher, since land is an input to production of housing in these locations of higher demand.

The plot of FARs illustrates the distance from the CBD at which the FAR restrictions become non-binding. The restriction in the high density zone is non-binding at about 30 km, while that of the low density zone is binding at 44 km from the CBD. The restriction on the character zone is further out (at about 46 km), despite having the same FAR restriction of 1 as the low density zone. This reflects greater demand to live in the character zone due to amenity effects. The radius of the city is about 48km.

Next we use the model to simulate a zoning change by comparing this static equilibrium to that obtained under a different set of zoning rules.[5] First we consider what happens when character protections are removed, but the FAR restriction remains unchanged. This is achieved by setting $\xi_1 = 0$, such that character protections are removed and local amenity flows become zero, $\kappa = 0$. Outcomes are depicted in figure 3. The city expands slightly from 49.67 km to 49.71 km. This entails a welfare loss for the representative household of 0.1% (as illustrated in Bertaud and Brueckner (2005), under Cobb-Douglas utility the welfare cost (gain) is equal to the reduction in radius multiplied by the travel cost per km). In this example, there is no welfare gain from removing the character protections because the attendant FAR restriction has not been removed. Instead, welfare decreases, illustrating that redevelopment restrictions are welfare enhancing when the counterfactual is non-character housing of identical density to the former character zone. See figure 3 for the other outcomes of the model.

[5]This policy evaluation exercise abstracts from transition costs beyond housing construction, such as providing housing for households during teardown and replacement of the housing stock. We thank an anonymous referee for bringing this to our attention.

Figure 3: Modelled impacts of removing character protections and retaining low density zoning

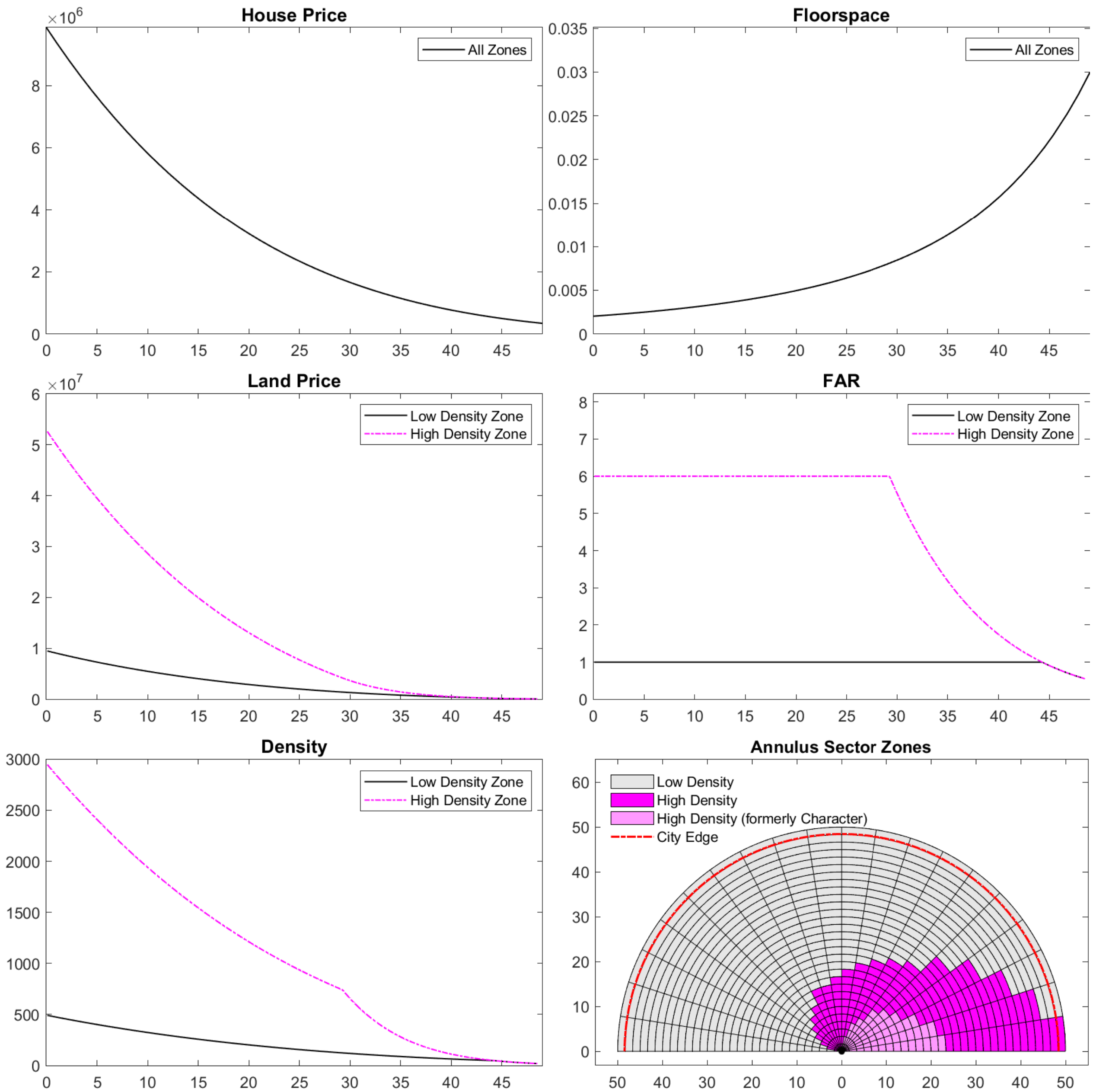


Notes: Simulated equilibrium outcomes using the annulus sector zoning depicted in the lower right panel. Areas that were zoned as low density character in figure 2 are now zoned as low density. Magenta denotes the high density zone ($\xi = 0$ and $\hat{h} = 6$), while grey denotes the low density zone without character protections ($\xi = 0$ and $\hat{h} = 1$). Utility is Cobb Douglas with a housing share of 0.2, while floorspace production is Cobb-Douglas with a capital share of 0.6 and TFP of 5e^{-4}. These parameters are adopted from (Kulish *et al.*, 2012). The remaining parameters are $W = \$100,000$, $t = \$1,000$, $\bar{R} = \$80,000$, $N = 1,000,000$ and $\theta = \pi$.

Finally we consider the welfare effects from removing the special character protection and increasing the FAR restriction to that of the high density zone. Outcomes are depicted in figure 4.The low density, non-character zone is retained. The city shrinks to 48.5km. This entails a welfare gain for local residents of 2.4%. In this example, the welfare gain from the amenities indirectly generated by the character protections are outweighed by the welfare losses from the restrictions on floorspace. See figure 4 for the other outcomes of the model.

The examples pursued herein have floorspace restrictions that are tightly binding and consequently generate a significant amount of sprawl. In such situations, character protections are likely to be welfare decreasing compared to medium- or high- density alternatives. When floorspace constraints are not as tightly binding, as may occur in less populous cities, or in cities where the character zone FARs are set at higher levels (to allow medium or high density), there can be welfare gains from character protections.

Figure 4: Modelled impacts of removing character protections and allowing high density in the former character zone



Notes: Simulated equilibrium outcomes using the annulus sector zoning depicted in the lower right panel. Areas that were zoned as low density character in figure 2 are now zoned as high density. Magenta denotes the high density zone ($\xi = 0$ and $\hat{h} = 6$), while grey denotes the low density zone without character protections ($\xi = 0$ and $\hat{h} = 1$). Utility is Cobb Douglas with a housing share of 0.2, while floorspace production is Cobb-Douglas with a capital share of 0.6 and TFP of 5e^{-4}. These parameters are adopted from Kulish *et al.* (2012). The remaining parameters are $W = \$100,000$,$t = \$1,000$, $\bar{R} = \$80,000$, $N = 1,000,000$ and $\theta = \pi$.

3.0 Estimated welfare effects of character protections in Auckland

The previous section provides a simulation in order to gain insight into the trade off in household welfare when cities enact character protection provisions. In this section we calibrate the model to a real-world city where such restrictions are in place. AMM models are frequently employed for such applications (Bertaud and Brueckner, 2005; Kulish *et al.*, 2012; Larson *et al.*, 2012; Larson and Yezer, 2015; Larson and Zhao, 2017), and are frequently used as the basis for evaluating zoning reforms on urban development outcomes commissioned by government agencies (Ge *et al.*, 2021; Lynch and Lees, 2021). However, a major limitation of calibrated AMM modelling has been the unrealistic modelling of zoning restrictions and amenity protections. Our model brings the calibration exercise closer to urban planning in practice.

We follow the approach laid out in Bertaud and Brueckner (2005), carefully choosing the parameters of the model so that the simulated city with character provisions matches data from the existing city. Then, in order to measure the welfare gain or loss from the character provisions, the spatial equilibrium in the absence of both the FAR restriction and amenities is computed, holding all else constant. The change in the welfare of the representative household can then be computed, either directly, or indirectly based on the change in the radius of the city.

We calibrate the model to Auckland, New Zealand, to assess the net welfare effects of character preservations currently in place in the city. We begin by discussing the institutional background underlying Auckland's current district plan. Section 3.2 then presents evidence of Auckland's monocentricity (and thus the appropriateness of the AMM structure) by illustrating empirical patterns in commuting direction and wages by employment location. Findings from the latter inform our approach to calibrating the model, which is presented in section 3.3. Finally, section 3.4 presents our results, including welfare effects across plausible parametrisations of the model.

3.1 Institutional background

Auckland is the largest city in New Zealand with a population of approximately 1.57 million within the greater metropolitan region (as of 2018 census). It is centred on an isthmus between two harbours and extends over 4,894 km^2 of land area, including several large inhabited islands, and falls under the jurisdiction of a single local government, Auckland Council.

In November 2016, Auckland Council released the Auckland Unitary Plan (AUP) which relaxed land use regulation (LURs) in most of the city in order to enable residential intensification and greater population density, including allowing multi-family housing such as terraced housing and apartments in residential areas. However, many areas of low density, detached family homes were preserved. A significant amount of low density zoning was retained within 5km of the CBD. These areas were also frequently subject to a 'special character area overlay' (SCO), which aims to preserve the current built form and character of these neighbourhoods.

In 2021, the central government announced the Medium Density Residential Standard (MDRS), which requires Auckland and other large cities to have a medium density default for residential zoning. Specifically, it requires three dwellings and three storeys per parcel, much like the existing Mixed Housing Urban (MHU) zone in the AUP. The MDRS allows character provisions to be retained, although it makes the conditions for retaining these more stringent. Auckland Council's proposed re-zoning in accordance with the MDRS (known as 'Plan Change 78') retained approximately 71% of the houses covered by the AUP SCOs.[6]

Table 1 exhibits the LURs that apply in each of the zones retained under the proposed AUP that is compliant with the MDRS.

[6]See Auckland Council Planning Committee Meeting 4 August 2022 Addendum, paragraph 21, p.8. Available from: https://infocouncil.aucklandcouncil.govt.nz/Open/2022/08/PLA_20220804_ATT_10162_PLANS.PDF [accessed 20 October 2022].

Table 1: Summary of land use regulation by residential zone under Plan Change 78 to the Unitary Plan

Regulation	Terrace Housing and Apartments	Mixed Housing Urban	Mixed Housing Suburban	Low Density	Single House	Large Lot
Max. height	16 to 21m (five to six 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	4m up + 60° recession plane	4m up + 60° recession plane	2.5m up + 45° recession plane	4m up + 60° recession plane	2.5m up + 45° recession plane	does not apply*
Setback (side and rear)	0m	1m	1m	1m	1m	6m
Setback (front)	1.5m	1.5m	3m	3m	3m	10m
Max. site coverage (%)	50%	50%	40%	35%	35%	lesser of 20% or 400m^2
Max. impervious area (%)	70%	60%	60%	60%	60%	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	3	3	3	1	1	1

Notes: Tabulated 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. Maximum dwellings per site are the number permitted as of right in the Unitary Plan. Minimum lot sizes do not apply to extant residential parcels. Mixed housing suburban zoning does not apply within the 'metropolitan' and 'large' urban areas of the Auckland region under PC78. Translations of height limits into storeys are taken from PC78 documentation. The 21m height limit in Terrace Housing and Apartments applies within walkable catchments of city and town centres and rapid transit stations, otherwise the 16m height limit applies.

*Planners have discretion in setting height in relation to boundary and setbacks in the large lot zone. The regulations '[r]require 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'.

SCOs apply to properties that are almost exclusively located in the low density or single house zones. SCOs impose additional controls to housing in these zones. Planning consents must be sought in order to: demolish or change more than 30% of the building's area, make any minor exterior alterations that are not at the rear of a property, or construct a new building or ancillary unit. Theses activities are 'restricted discretionary', meaning consent may be granted or denied at the discretion of Auckland Council. Factors that are considered in the decision include: whether all practical steps have been taken to retain and restore the original fabric and facade of the building;

whether construction materials, styles, and building proportions are in keeping with the original building; and how the proposed development fits with the existing area, in terms of character, style, and scale of other buildings. This means that redevelopment can occur, typically at the back of the parcel, where it is less visibly apparent from the road.

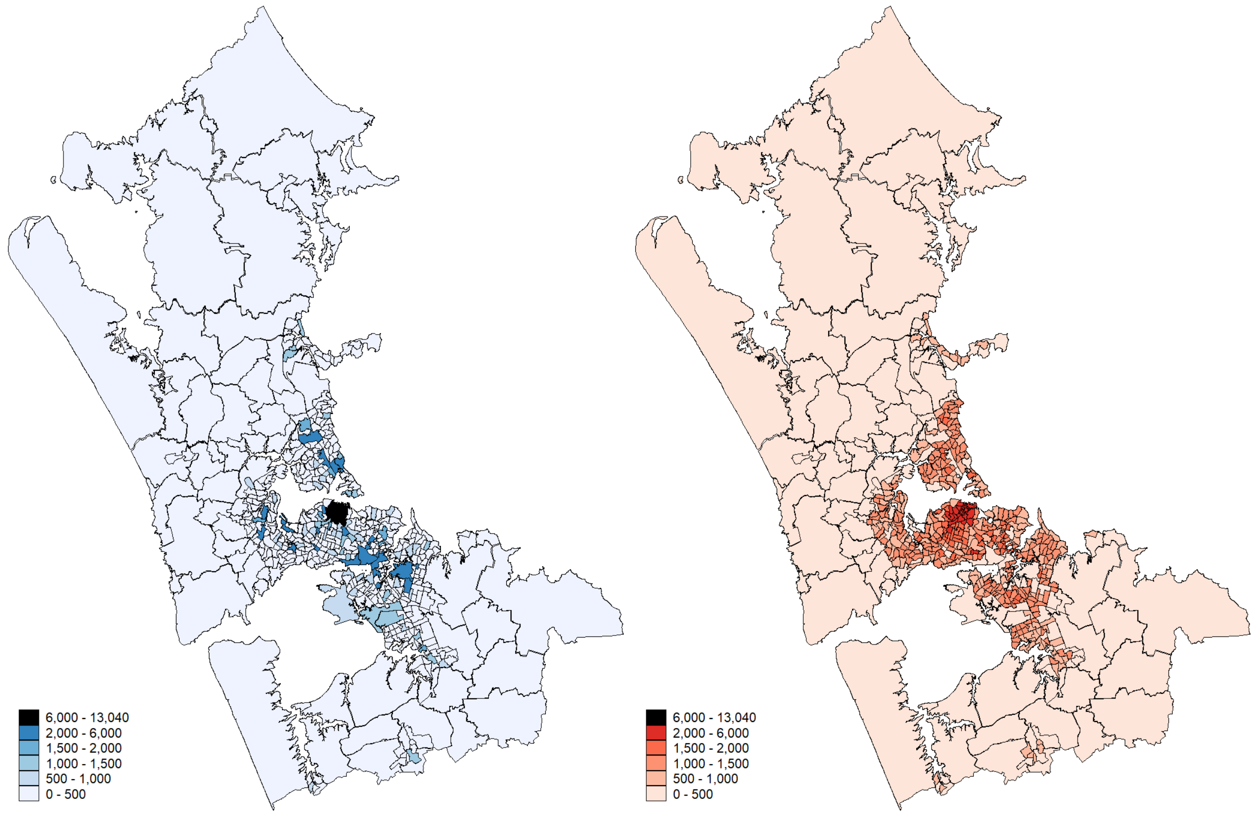
Although SCOs apply predominantly to low density residential areas, a small number do apply to higher density residential, business, and mixed-use zones. For example, SCOs exist to preserve the character of historic town centres. For ease of exposition, we will refer to single house or low density zoned areas that are also subject to an SCO as 'Special Character Areas' (SCAs). Our calibration exercise measures the welfare effects of the SCAs as proposed under Plan Change 78.

3.2 Monocentricity of Auckland

Planning policy documents frequently characterise Auckland as not monocentric because there are locations of concentrated employment outside the CBD, as is the case in every large metropolitan area.[7] However, such observations do not negate monocentricity as required in the AMM model. As outlined in Glaeser (2008), the monocentric model is observationally equivalent to a set of models in which employment is dispersed across the city and wages decrease linearly as the distance between place of work and the CBD increases. In this subsection we provide evidence of monocentricity in Auckland, in the sense that (a) workers generally commute towards the CBD, rather than away from it, and (b) wages by place of work generally decrease with distance to the CBD, so that, holding household location fixed, commuters are compensated for longer commutes with higher wages, which accords with the AMM (Glaeser, 2008).

[7] This is evident in recent discussions regarding Plan Change 78. For example, paragraph 82 of Auckland Council's initial submission to the independent hearing panel (IHP) states that ''... Auckland has a polycentric form, with a range of centres of varying sizes. [...] Auckland does not have a monocentric form''. A similar logic underlies repeated assertions that Auckland is polycentric or ''multi-nodal'' on pp. 9, 10, 39, 41, 64, and 66 of the supporting economic evaluation report commissioned by Auckland Council. Meanwhile, in a follow up submission from Auckland Council to the IHP made in rebuttal of submissions made by, amount others, the Ministry of Housing and Urban Development, the council witness rejects the suitably of the AMM model to apply to Auckland, stating in section 3.16 that "[t]he AMM model assumes [...] all business activity is located in the City Centre, and all residential activity is assumed to be distributed around that one centre". See `https://bit.ly/3W83Qum`, `https://bit.ly/4cLCGPp`, and `https://bit.ly/3zpLUCm` respectively [accessed 5 July 2024, see appendix for full URLs].

Figure 5: Population density by location of work and location of residence



Notes: This shows the total number of full and part time employed individuals per square kilometre by workplace location on the left and by home location on the right. Note that the colour scales used in each figure are identical. The scales are not linear.

3.21 Commuting direction

Our first task is to measure commuting direction patterns to see whether workers generally commute towards the CBD. We define the CBD as the set of Statistical Areas (SAs)[8] that lie within and adjacent to a ring of highways around the centre of the CBD.[9] First, we examine the degree to which jobs and homes are concentrated in various regions of Auckland. Figure 5 exhibits the population density (persons per km^2) of employees by place of work and by place of residence. The left hand panel exhibits job density. Jobs are heavily concentrated in the CBD. Around the CBD there

[8]We use 2018 Statistical Area 2 units, which are refereed to as 'SAs' throughout the paper. SAs contain 2000–4000 residents in cities such as Auckland. SA geographic units are designed for the purpose of collecting household information through the census.

[9]This definition of the Auckland CBD is similar to that used in Maré (2008). See figure 10 in the appendix for the geographical location of the CBD and a list of its constituent SAs.

are several locations with moderate density.[10] The right hand panel exhibits employee population density by location of residence. Worker home locations are substantially more diffuse, indicating that travel costs are an important component to understanding urban development.

Next, we measure commuting direction using census data on commuter flows.[11] We measure commuting direction relative to the CBD by calculating the angular displacement between actual commutes and a commute to the CBD.[12]

For each home location SA i, we calculate the bearing between the centroid of SA i and the centroid of every other SA j. For each bearing, we calculate the absolute angle of displacement between this bearing and the bearing of a commute from the centroid of SA i to the CBD. The CBD coordinate is the centroid of the 'Hobson Ridge North' SA, which contains the iconic 'Sky Tower', a central Auckland landmark and major piece of communications infrastructure. If j is a CBD SA, then we define the displacement angle to be 0 by default. Second, we assign the calculated displacement angle to all commuters travelling between SA i and j in the commuter flow census data.

Table 2 and figure 6 display the results. The majority of commuters travel towards the CBD. Over 35% of commuters have a displacement angle between the direction of their commute and the direction of the CBD of less than 5 degrees. Of these, approximately 26% work in the CBD. 56% of commuters have a displacement angle of less than 30 degrees, and only 19% have a displacement angle of greater than 90 degrees, indicating that they travel away from the CBD. These patterns are strong evidence of monocentricity.

[10] For readers familiar with Auckland geography, these are located in the suburbs of Penrose, Mt Wellington, East Tamaki, Takapuna, Albany, Wairau Park, Te Atutu, New Lynn and Henderson.

[11] We use the '2018 census main means of travel to work by statistical area' dataset of commuter flows of employed individuals between usual residence and workplace. This dataset excludes respondents that do not supply sufficient information to identify their workplace address, respondents without a fixed workplace address, and home-work statistical area unit pairs with less than 6 commuters, which are suppressed for confidentiality. We also omit people that work from home or that live and work in the same statistical area, and the Hauraki gulf islands. We also exclude the Glenbrook SA due to the presence of a large, high wage steel mill that causes the SA to be an outlier and unrepresentative of employment and wage gradients in the wider Auckland region. This mill produces approximately 90% of New Zealand's steel requirements and accounts for around three quarters of employment in the Glenbrook SA. It is 62km from the Auckland CBD by road, but the mill's location is determined by proximity to an ironsand mine and the largest thermal power station in New Zealand.

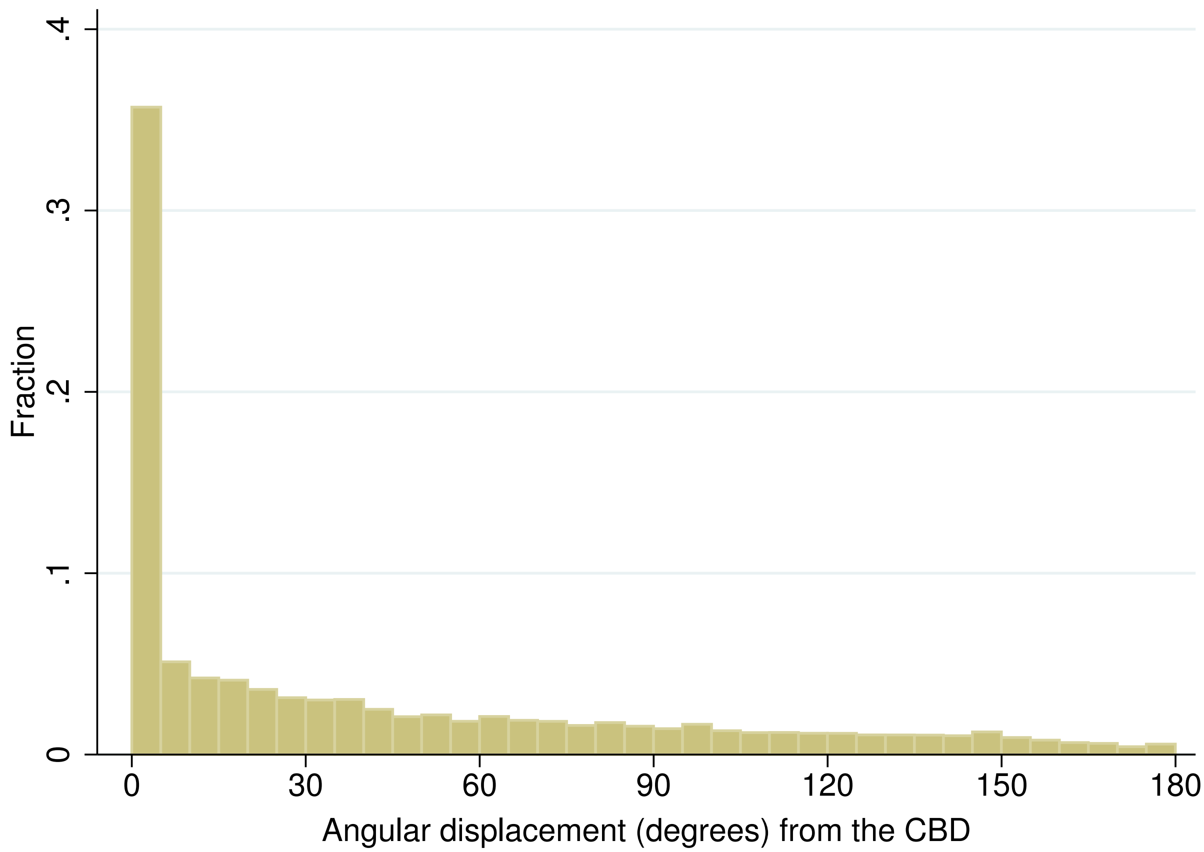
[12] We use commuter flows in private vehicles to ensure consistency with the dataset used to estimate the wage gradient regressions in section 3.22. Given that public transport in Auckland is predominantly to- and from- the CBD, private vehicle commutes likely understates monocentricity.

Table 2: Commuting direction in Auckland

Angular displacement from CBD (degrees)	Proportion of commuters	Cumulative proportion
0 to 30	0.56	0.56
30 to 60	0.14	0.70
60 to 90	0.11	0.81
90 to 120	0.08	0.89
120 to 150	0.07	0.96
150 to 180	0.04	1.00

Notes: A displacement angle of 0 means the commute is directly towards the CBD, while an angle of 180 is directly away from the CBD. Data source: 2018 census data on private vehicle commuter flows.

Figure 6: Commuting direction in Auckland



Notes: Histogram of the angular displacement between (i) the direction from place of residence to place of work and (ii) the direction between place of residence and the CBD. Each bin spans five degrees. People that work in the CBD are assigned an angular displacement of 0 degrees.

3.22 Wage gradient

Our next task is to examine whether wages fall with distance between place of work and the CBD (note this is not distance between place of work and place of residence). The underlying intuition behind this posited relationship is that employers must compensate employees for longer commutes (Glaeser, 2008).

To do this, we calculate average wages by location, and plot this as a function of a measure of distance to the CBD. We refer to this function as the 'wage gradient'. For average wages by location, we use 2018 census data on median income for employees by SA. We use the median to reduce the impact of outliers on the measure of average wages.

We use estimated commuting time between the centroid of the SA and the CBD as the measure of distance. We use commuting time for two reasons. First, transportation corridors, such as highways, have a significant impact of commuting times. Second, commuting times take into account of traffic congestion.

Travel time is derived from google direction requests for the estimated travel time in traffic by private vehicle between the centroid of each SA and the centroid of Hobson Ridge North.[13] Direction requests are made for a midweek commute in to the CBD, arriving at 9:00am, and a commute out on the same day, departing at 5:00pm. We then average duration of the two journeys.[14]

We calculate the wage gradient by regressing the median wage by SA on the travel time between the SA and the CBD. In order to account for the significant discrepancies in employment density between SAs, the regression function is weighted by the (square root of the) number of jobs in the SA. Consequently the regression function is weighted towards SAs with more jobs.

Figure 7 plots median wages against travel time in minutes from the CBD. The size of the markers corresponds to the relative number of jobs in the SA. The gradient shows that wages decrease (on average) as distant between workplace location and the CBD increases. The largest circle in the top left of the figure corresponds to the CBD. Because the CBD comprises several SAs, we aggregate the contiguous SAs in the CBD into one observation.

Table 3 displays the regression output. Column (1) shows the regression with travel time as the

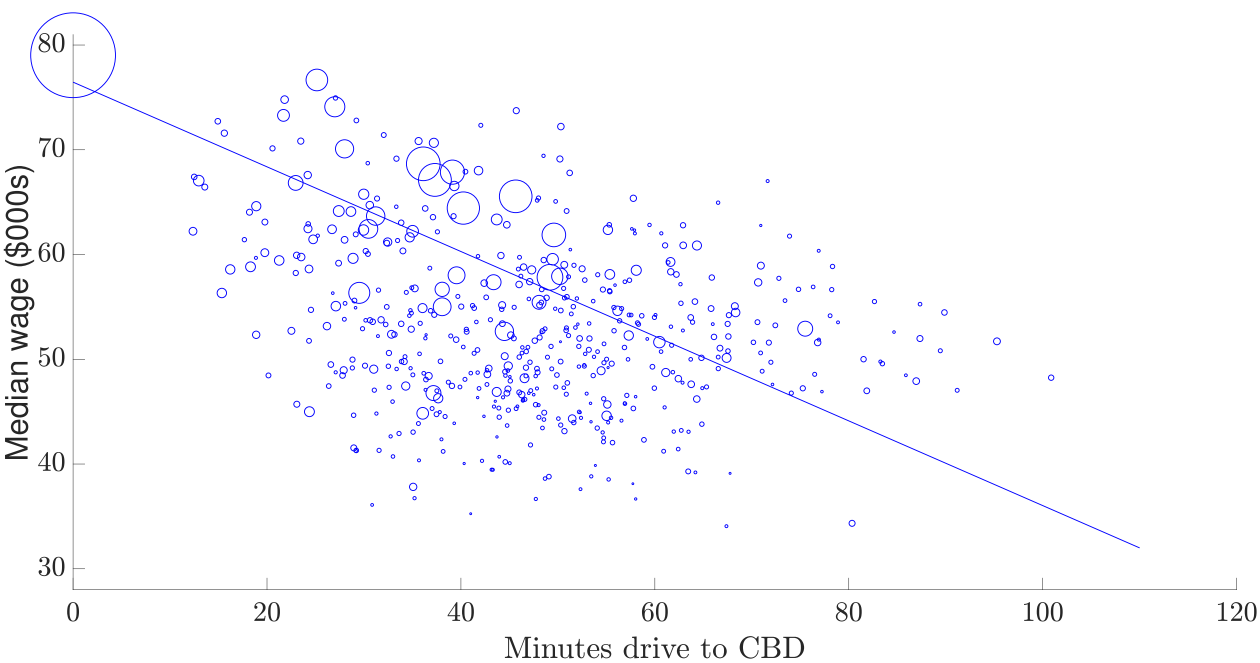
[13]Travel times via public transport are not considered for three reasons. First, and most importantly, for many SAs there is no public transport option for travel to the CBD. Second, the majority of commutes in Auckland are by private motor vehicle. Third, the travel times by private vehicle are typically faster than public transport for most commuting routes.

[14]Direction request were made using automated Google API calls for travel on 04 August 2021.

explanatory variable. For completeness, we also include an alternative specification in column (2) which uses distance by road in kilometres instead of travel time. The second specification displays poorer model fit, with a substantially lower R-squared. This is likely because distance does not take account of variation in travel speeds to the CBD between locations that are equidistant form the CBD.

To compare the wage gradient implied by the two models, we convert the \$/minute coefficient from column (1) into a \$/km figure. This is achieved using the estimated average peak-hour road commute speed of 25km/h in our commuting data. The estimated reduction in wages paid by workplaces located an additional kilometre away from the CBD is presented in the final row of the table. This is substantially larger in magnitude than the figure estimated by the regression of road distance on median wage, suggesting that relying on measures of distance that ignore commute times will significantly understate the costs associated with commuting.

Figure 7: Annual wages and travel time from the CBD



Notes: The size of the circular markers corresponds to the number of people employed in each SA. Line of best fit is given by weighted OLS. Coefficients are tabulated in table 3. Drive time is time in rush hour traffic.

Table 3: Regression of median wages on drive time from the CBD

Variable	Median Wage (1)	Median Wage (2)
Constant	76,457***	70,831***
	(1,979)	(4,184)
Minutes drive from the CBD	-404.2***	
	(43.02)	
Distance by road from the CBD (km)		-492.9***
		(152.9)
Observations	521	521
R-squared	0.592	0.360
Implied $ per km distance from the CBD	-$970.08	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The regressions are weighted by total employment in each SA. The average CBD wage is given by the constant in columns (1) and (2). The final row shows a conversion of the $/minute coefficient on minutes drive from the CBD from column (1) into a $/km figure using the average commute speed of 25km/h.

3.3 Calibration

In this subsection, we calibrate the model to Auckland in order to quantify the welfare effects of the character provisions. We begin by discussing how we select model parameters.

3.31 Parameters

We take a data-driven approach to selecting θ, the radians of the city disk. Auckland lies on an isthmus between two harbours. Consequently much of the area surrounding its downtown is not available for development. We estimate θ by calculating the land area within a carefully defined radius of the CBD. First, we aggregate the land area of all SAs with a centroid within 55km of the CBD. This radius is selected as it extends to the south eastern edge of the Auckland jurisdiction. Second, we remove the proportion of land devoted to roads, transportation and infrastructure corridors. The proportion of land relative to the area of a circle of 55km radius then yields our estimate of θ. This yields an estimate of 2.25 radians.

We perform a sensitivity analysis across a range of values for the parameters α (housing share in utility) and γ (capital share in housing production). The ranges adopted are informed by the related literature. Lees (2014) uses $\alpha = 0.175$ based on the average share of income spent on housing services in New Zealand. In order to guard against the possibility that this share is low, we also consider $\alpha = 0.25$ and $\alpha = 0.325$, which correspond to one-quarter and almost one-third of income. Bertaud and Brueckner (2005), Kulish *et al.* (2012) and Lees (2014) use $\gamma = 0.6$. However, Combes *et al.* (2019) estimate $\gamma = 0.8$ for housing construction in France. We therefore consider values of $\gamma = 0.4, 0.6, 0.8$. Finally, following Kulish *et al.* (2012) we set $A = 5e^{-4}$ (total factor productivity (TFP) in housing production).

Amenity parameter. We next consider the amenity parameter, κ. A key outcome of the model is that there is a one-to-one mapping of floorspace differentials between dwellings in character protected areas and non-protected areas, and the magnitude of the amenity effect of the character provisions. This observation enables us to use a hedonic regression to obtain an estimate of κ, because a direct implication of the model is that homeowners are willing to accept a smaller house to live in a character neighbourhood. Hedonic methods that accurately price elasticities of special character areas and floorspace can be used to calculate the 'floor area equivalent' of the amenity value of living in a special character area as follows:

$$F_{SC} = \frac{E_{SC}}{E_F\,(1 - E_{SC})}$$

where F_{SC} is the floor area equivalent (in percentage terms), E_{SC} and E_F are the price elasticities with respect to character protections and floor space respectively. Nunns (2015) uses a similar hedonic approach to estimate the relative trade-off between preserving a character building and allowing redevelopment. We then set $\kappa = (1 + F_{SC})^{\alpha} - 1$ so that the amenity value in character areas results in a F_{SC} percent reduction in floorspace in character areas under (8).

In order to estimate E_{SC} and E_F we fit a linear hedonic regression to individual log house prices using an array of individual attributes as explanatory variables. House prices are obtained from the June 2021 Auckland Council ratings valuations (RVs). These are used to calculate property taxes and are estimated every three years based on property characteristics and local sales information. RVs also contain additional information on housing attributes that are used as explanatory variables in the regression. Our set of explanatory variables include: an indicator for whether the property is in a special character area; the (log) floorspace of the dwelling; an indicator for whether the individual property is subject to additional heritage building development restrictions; and the log of the total land area. In order to distinguish between the SCA and whether there is a premium or discount associated with owning a house from the early 20th century, in some specifications we include an indicator for whether the house was built prior to 1940. We also consider a larger set of regressions that also include: an indicator for if the property has a deck; the combined number of off-street and garaged parking spaces; an indicator for whether the walls and roof are in ‘good’ condition as opposed to ‘average’, ‘poor’ or ‘mixed’; an indicator for whether the land parcel is ‘level’ as opposed to having a ‘medium’ or a ‘steep’ gradient; an indicator for whether the property has an ‘appreciable view’; and the total number of secondary school zones covering the property. We follow Ahlfeldt and Maennig (2010), Heintzelman and Altieri (2013), and Bade *et al.* (2020) and include local area fixed effects (based on SAs). Fixed effects control unobserved locational or neighbourhood confounders, including the general attractiveness of the area, thereby accounting for selection into protection that would otherwise bias estimates upwards (Noonan and Krupka, 2011; Heintzelman and Altieri, 2013). We also account for spatial dependence by adopting Conley (1999) standard errors.

We define SCAs as areas zoned for single housing covered by special character overlays. Our sample is comprised exclusively of houses located in single house or low density zoning in order to ensure that the estimated coefficient on the SCA indicator is based on a comparison of houses in SCA areas to houses that otherwise share equivalent development rights. Housing in higher density zones – such as MHU or THA – are a less plausible counterfactual because properties in these zones have substantially enhanced development rights. We also exclude any property with zero land area recorded. These properties are generally cross-leased properties or unit titles, such as apartments. We also exclude vacant land, any property not recorded as being used for residential purposes, and any property valued at greater than \$10 million. The latter generally represents residential institutions such as nursing homes or communal housing. We exclude properties that have missing explanatory variables. Many are missing the decade of construction.[15] Refer to table 6 in the Appendix for the regression results.

We find that the SCA elasticity E_{SC} ranges between 0.037 and 0.006, and depends, in particular, on how the model controls for the epoch of the house.

[15]This represents approximately 13,000 property records out of 80,000 properties that meet all the other criteria listed.

The specification which does not include an indicator for whether the property is built prior to the 1940s has an SCA elasticity of 0.037 in the smaller model and 0.033 in a larger model. This suggests that a house located in an SCA sells for approximately 3.3 to 3.7% more, on average, than an identical house not located in an SCA. Together with an elasticity on floorspace between between 0.418 and 0.397, these imply that $F_{SC} = 0.09$ (2 d.p.). This suggests that a typical property owner in a special character area with 140m^2 of floorspace would be willing to forgo their special character protection if it allows them to gain at least 12.6m^2 of additional floor area.

However, once a pre-1940 indicator is included in the regression, the SCA elasticity falls to 0.022 in the smaller model and 0.017 in the larger model, while the coefficient on the pre-1940 indicator is 0.058 and 0.065 in the small and large model, respectively. The latter coefficients are highly significant, while the SCA coefficients lose significance. Thus it appears that houses built before 1940 command a premium.[16] Since many houses in SCA areas were built prior to 1940, it is important to control for the epoch of construction.

Finally, we allow for interactive effects between SCA designation and pre-1940s era housing. This reveals that character protections yield a significantly higher premium when applied to pre-war built forms, with a premium of 3.5% and 2.7% for properties built before 1940 (for the small and big models respectively) and 0.8% and 0.6% for properties built after 1940. Together with the floor area elasticities, this yields $F_{SC} = 0.09$ and 0.07 (2 d.p.) for the small and large model for pre-1940s houses under SCA protection. If we instead consider houses built after 1940 with SCA designation, we obtain $F_{SC} = 0.02$ for both the small and large models.

In the calibration exercise we use a range of values for F_{SC} between 0.02 and 0.09. The lower end represents a scenario where there are no historic properties (built prior to 1940s) in the character areas. The upper end represents a scenario where all properties are historic. An intermediate value reflects a mixture of historic and non-historic properties in the character area. Approximately 78% of properties were built prior to 1940 in our sample.

Unlike existing work on character premia in Auckland, we identify important interactive effects between building age and SCA designation. Our specifications that omit interactive effects result in character premia that are similar to those obtained by Fernandez and Martin (2020) and Bade

[16] These estimates are are similar in magnitude to premia on pre-1940s properties estimated by Nunns (2015) based on earlier property values for Auckland.

et al. (2020). For example, Fernandez and Martin (2020) estimate an SCA premium of 4.3% for 2016 sales data, while Bade *et al.* (2020) estimate the premium to be 3.7% for sales over the 2006 to 2016 period. However, once we condition on building age, we find that character premia are driven primarily by SCA designations on pre-1940s houses. Houses built after 1940 that fall under SCA designation command much smaller premia. Nunns (2015) estimates a rather large premium of 9.8% for pre-1940s houses regardless of SCA designation. Our findings suggest that while pre-1940s houses command a premium, this premium is nearly doubled under SCA designation. We caution that these estimates cannot readily be generalised to other cities, as the character premia are likely to be dependent on the relative scarcity of character protections, the precise nature of the protections, the quality of the dwelling stock, among other idiosyncratic factors that are likely to vary between locations.

3.32 Data

We obtain household income for commuters that work in the CBD from the wage regressions presented in subsection 3.22. The intercept tells us the average income in the CBD. We use $76,500 for this figure. We multiply this by 1.35, which is the average number of workers per household in Auckland (Lees, 2014).

We obtain a figure from the rental price of agricultural land using REINZ data on farm sales between January 2011 to December 2016. We take the average sales price per hectare over this period from the two regions surrounding Auckland – Northland and Waikato. This yields an average price per hectare of $20,000. This equates to a rental price of $80,000 per km^2 under a capitalization rate of 4%.

We obtain an annual per km commuting cost of $970/km from the wage regressions described in subsection 3.22 and presented in table 3.

3.33 FARs and annulus sectors

Finally, we also require a method to assign annulus sectors to different zones. We then assign FAR restrictions to each zone as implied by the LURs in table 1.

To assign annulus sectors to different zones, we calculate the proportion of residential land assigned to each zone at distances from the CBD spanning 0 to 70km. We then fit a smoothed function to these proportions that serves as the basis for assigning zones to annulus sectors. We merge 'single house' with 'low density' since these two zones have the same height and coverage restrictions.

We use 2018 SAs as the geographic unit of analysis for calculating these proportions. For each SA we calculate total area of land assigned to each zone, and the distance from the centroid of the SA to the CBD using road networks. We then calculate the proportion of land assigned to each zone within 5km of the CBD, 5 to 10km of the CBD, 10 to 15km of the CBD, and so forth. We then fit a smoothing spline to the proportions, with the smoothing parameter set to the commonly used value of $1/(1 + (5^3)/6)$, using the mid points of the 5km bins as the explanatory variable.

We expand the set of zones from the three zones discussed thus far to include two additional zones: *Large Lot* and *Rural*. Large Lot (LL) is a residential zone used at suburban fringes of the city. Its LURs are also tabulated in table 1, and demonstrate that it is a very low density residential zone.[17] For the purposes of this exercise, we include rural zones within residential land because commuters can live in dwellings on rural land, albeit in dwellings with significantly lower capital intensities than those built in residential areas due to even more restrictive LURs. Allowing residents to commute in from rural zones is important because urban growth boundaries have been found to constrain urban growth in Auckland (Grimes and Liang, 2009). Excluding these zones from the analysis would significantly bias the increase in floorspace capacity upwards.[18]

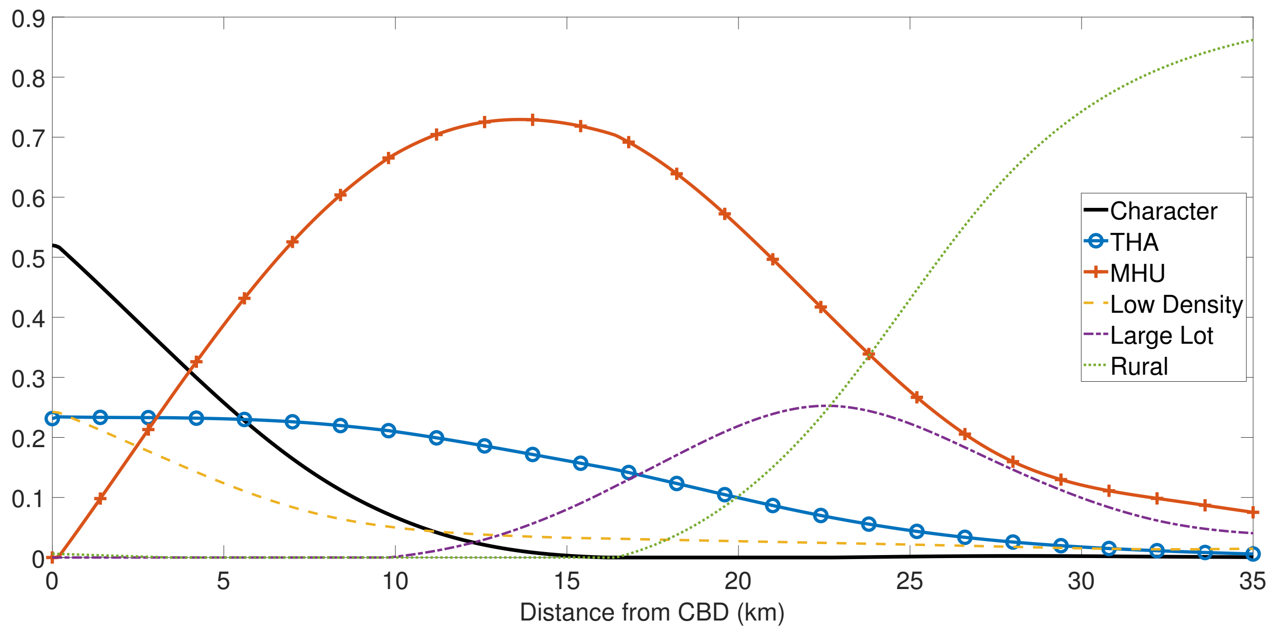
The results shown in figure 8 demonstrate how a large proportion of Auckland's real estate falls under special character protections. According to the smoothed function, over 50% of residential land very near the CBD falls under a SCO. In contrast, less than 25% of the area is zoned for maximum intensity as terrace houses and apartments (THA). The remaining land is zoned mixed housing urban, which permits greater density than SCO following the MDRS. The proportion of SCO decreases with distance to the CBD while the MHU category increases to almost 70% of all land at 10km from the CBD. THA remains at a relative constant proportion of all land. From 10km, the proportion of rural and large lot zones begins to increase, and the MHU proportion decreases, along with THA.[19]

[17]We also include the 'Residential - Rural and Coastal Settlement' and 'Waitākere Ranges' zones in large lot, as they have very low density zoning similar to large lot.

[18]We include the 'Future Urban' zone in *Rural* and the 'Hauraki Gulf Islands' zone in *Large Lot*.

[19]The mixed housing suburban (MHS) zone does not apply within the more central 'metropolitan' and 'large' urban areas within Auckland, and accounts for less than 1% of all residential land in the Auckland region. We include MHS zoned land under MHU for ease of calibration.

Figure 8: Proportion of residential and rural land assigned to different zones



Notes: Smoothed proportions of each zone by distance to the CBD. 'THA' (Terrace Housing and Apartments) is a high density urban zone and 'MHU' (Mixed Housing Urban) is a medium density zone . 'Low Density' refers to zones designed for detached single family dwellings (FAR = 0.7). 'Large Lot' is a peri-urban zone with very low density.

Using these functions we can assign each annulus sector in a gridded disc to a zone. We use 100 sectors and set increments in the annuli to 100 metres.

FAR restrictions in each zone are taken as the site coverage ratio multiplied by the number of storeys permitted under the maximum height provision. Two storeys are permitted under character and low density zones, three under MHU, and six in THA.[20] Taken with the site coverage ratios tabulated in table 1 above, this means that $\hat{h}_j$ is 0.7 in character areas, 1.5 in MHU, and 3 in THA. For large lot, we use the maximum site coverage ratio of 0.2 and a single story, yielding an $\hat{h}_j$ of 0.2. The rural zones lack binding site coverage ratios, so we cannot use this approach to model FARs in these areas. We instead use the empirical FAR for rural areas given in Greenaway-McGrevy (2024), which yields an $\hat{h}_j$ of 0.02 for rural.

3.4 Results

In this section we present results from the calibration exercise. Following Bertaud and Brueckner (2005) our primary measure of representative household welfare is the change in income for a household that is located at the edge of the city. Their change in income is straightforwardly given by the change in city radius multiplied by t (travel cost per km).

Bertaud and Brueckner (2005) explain the intuition behind this result. At the edge of the city, housing costs depend on the exogenous agricultural price of land and capital, and thus the housing costs paid by the edge resident is unchanged as the FAR restriction pushes the edge outward. FAR restrictions reduce the welfare of the edge resident via an increase in their commuting cost. Under the iso-utility assumption, this is also the welfare loss for all residents.[21]

We express the change in income of the edge resident as a percentage of average household income. Table 4 exhibits the results across a range of values of α, γ and F_{SC}.

The welfare effects from removing character restrictions and upzoning are positive across all parameterisations considered. However, there is substantial variation around the size of the positive effect, ranging from 1.331% down to 0.377%. Given the (average) household wage of \$103,275 =

[20] We use the six storey height limit for THA that applies within walkable catchments (rather than the 5 storey limit) because much of the THA zoning is adjacent to rapid transit stations and town and city centres See table 1 for further details. Using the higher height limit also ensures that estimated welfare losses are conservative.

[21] This insight also allows us to characterise the optimal size of a character area conditional on a given zoning alternative. The size of the character area is optimised when the population density within the character area is equal to what would be enabled under the alternative zoning regime, since the alternative would yield no reduction in city radius. The size will depend on the distance of the character area to the CBD, amoung other factors.

\$76,500 × 1.35 for workers in the CBD, this equates to between \$391 and \$1,375 per year.

Welfare gains are increasing in α since representative household welfare depends more on the quantity of housing services as α grows larger. Welfare is also decreasing in F_{SC}, since larger values of F_{SC} imply greater amenity benefits from protections. Finally, note that welfare gains are increasing in γ. As γ increases, the land becomes more productive (in terms of floorspace capacity), and thus restraints on productivity entail larger welfare losses.

Jenner and Tulip (2020) (p.10) and Combes *et al.* (2021) (p. 27) suggest that a higher value for the capital share parameter γ is appropriate, suggesting that the welfare effects are closer to the top end of the estimates. For example, when $\gamma = 0.8$, the welfare gains are between 1.059 and 1.331%.

Table 4: Welfare improvements from removing character protections and allowing medium density in the former character neighbourhoods

	$F_{SC} = 0.02$			$F_{SC} = 0.055$			$F_{SC} = 0.09$		
γ	α			α			α		
	0.175	0.25	0.325	0.175	0.25	0.325	0.175	0.25	0.325
0.4	0.437	0.601	0.736	0.407	0.509	0.713	0.377	0.483	0.690
0.6	0.839	1.004	1.144	0.831	0.997	1.138	0.822	0.99	1.132
0.8	1.069	1.233	1.331	1.064	1.229	1.329	1.059	1.225	1.326

Notes: Table entries are percent increases in average household income for households living at the boundary of the city. α denotes housing share in utility. γ denotes capital share in housing production. F_{SC} denotes floorspace elasticity with respect to character area. Amenities from living in character areas are increasing in F_{SC}.

3.41 Illustrative calibration

We present calibrated outcomes in figure 9 in order to compare housing market outcomes under the baseline and counterfactual zoning scenarios. In the interests of brevity, we present outcomes for two of the parameterizations of the model. 'Character' and 'Medium Density' labels (the solid black and pink lines, respectively) depict outcomes in each zone when character neighbourhoods are protected under the proposed planning regime. 'Uniform Medium Density' (the black dashed lines) depicts outcomes when character protections are removed and upzoned to medium density, i.e. the policy counterfactual. Axes on the left and right panels are the same. Given the sensitivity of the results to alternative parameters, we wish to focus on qualitative results and so do not show axis labels.

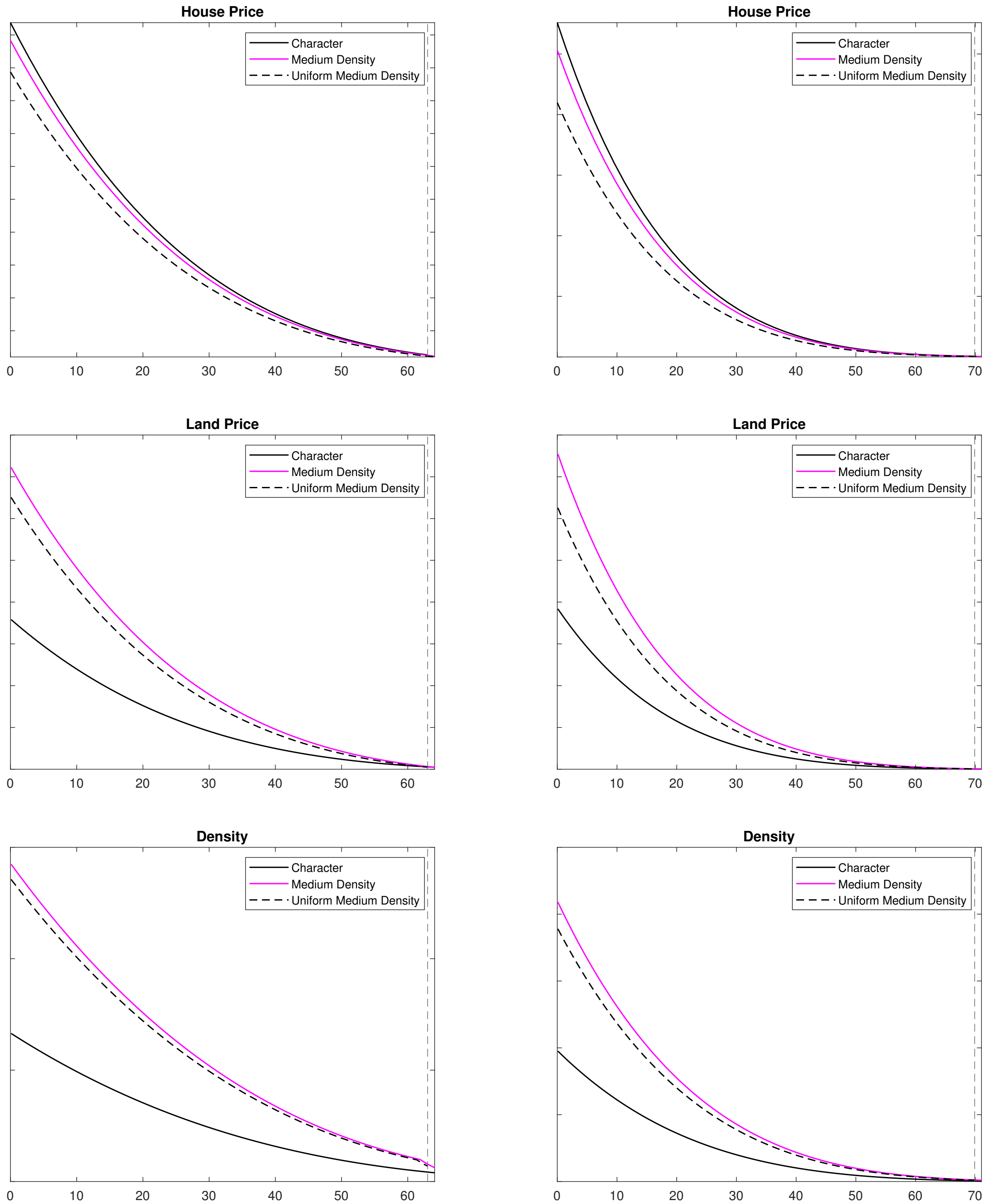
House prices in both character and pre-existing medium density areas fall when character areas are upzoned to medium density since the supply of floorspace increases in the former character areas. Land prices and density increase in character areas, and fall in the medium density zone. The latter result is due to the increase in supply of land zoned for medium density once character protections are lifted. The radius of the city contracts as the population can fit within a smaller area after upzoning.

Comparing outcomes from the two parameterisations also provide insights into how variation in parameters can affect outcomes. Density is (i) decreasing in housing share (α), since demand for floorspace is increasing in α, and (ii) increasing in the capital share in floorspace production (γ), since less land is required per unit of flooring as γ increases. Density in the character area is also increasing in the amenity flow parameter, since households are willing to accept less floorspace to live in the character zone. This effect is, however, moderated by exogenous FAR restrictions, which impede density in the character zone. Land prices are similar between the two calibration exercises. This is because land prices are (i) increasing in housing share (α), since households require more floorspace, and there are decreasing returns to building 'up', and (ii) decreasing in capital share (γ), since less land is required per unit of flooring. The two effects offset one-another in the two parametrisations of the model presented, since the model on the left of the figure has a lower housing share (α) but a higher capital share (γ). Future research could examine selecting model parameters based on empirical density, house price, or land price gradients, thereby enabling researchers to use to the model to make more concrete counterfactual predictions for these and other observable outcomes from the model.

3.42 Effects on landowners

The absentee landlord AMM model measures welfare based on consumption flows of the (renting) representative household. However, many households also own (part of) the house the occupy, and thus their wealth will be affected by land use policies. By considering effects on land values, we can also gain insight into how the policy affects the wealth of existing owner-occupiers, providing a framework for understanding differential welfare effects for renters and first-time homebuyers on the one hand, and owner-occupiers that own their property outright on the other.

Figure 9: Modelled impacts of removing character protections and allowing medium density in the former character neighbourhoods



Notes: Outcomes under the proposed planning regime are given by the solid black and pink lines. The x-axis denotes distance from the CBD in kilometres. 'Character' (black line) and 'Medium Density' (pink line) depict outcomes in each zone when character neighbourhoods are protected and other residential areas are zoned for medium density. The character zone has $\xi = 1$ and $\hat{h} = 0.7$, while medium density has $\xi = 0$ and $\hat{h} = 1.5$. The x-axis spans the radius of the city when character protections are in place. Outcomes under the policy counterfactual of medium density in all residential areas are given be a dashed black lines, labelled 'Uniform Medium Density'. Under this regime, character protections are removed and the neighbourhoods are re-zoned for medium density, so that all residential areas are zoned for medium density ($\xi = 0$ and $\hat{h} = 1.5$). The vertical dashed line denotes the edge of the city after this change. The left column exhibits outcomes for $\alpha = 0.175, \gamma = 0.8$ and $F_{SC} = 0.09$; the right column exhibits outcomes for $\alpha = 0.25, \gamma = 0.6$ and $F_{SC} = 0.055$.

Land prices increase for parcels upzoned from character to medium density (see figure 9). Non-upzoned land parcels fall in value, including land already zoned for medium density housing, as this category of land becomes more abundant after character neighbourhoods are upzoned. Thus the impact on landowners is heterogeneous, and depends on where their land is located. We can, however, calculate the total value of land as $\sum_{j=1}^{m_z} \sum_{a=1}^{\bar{a}} \omega_{j,a} \frac{\theta}{2} R_j(x) \left(x_a^{*2} - x_{a-1}^{*2}\right)$. Table 5 provides the percentage change in aggregate land value, showing that it falls, and varies significantly between model specifications (ranging from 6 to 28%). Thus, if we assume diffuse landownership, most landowners experience a decrease in wealth under upzoning.

Table 5: Impact on aggregate land values from removing character protections and upzoning to medium density

	$F_{SC} = 0.02$			$F_{SC} = 0.055$			$F_{SC} = 0.09$		
γ	α			α			α		
	0.175	0.25	0.325	0.175	0.25	0.325	0.175	0.25	0.325
0.4	-7.04	-7.98	-8.96	-7.06	-7.17	-8.96	-7.07	-7.16	-8.97
0.6	-6.36	-7.84	-9.84	-6.37	-7.85	-9.85	-6.38	-7.86	-9.85
0.8	-14.58	-20.10	-27.91	-14.58	-20.11	-27.91	-14.59	-20.11	-27.91

Notes: Table entries are percent changes in aggregate land values. α denotes housing share in utility. γ denotes capital share in housing production. F_{SC} denotes floorspace elasticity with respect to character area. Amenities from living in character areas are increasing in F_{SC}.

This net wealth decrease represents a transfer from current homeowners to future homeowners, the desirability of which is an ethical issue on which views differ. Households that occupy and bequeath the residence experience no change in welfare, as their consumption is unaffected by the change in land value. Meanwhile households that consume the home in retirement will have their lifetime consumption reduced. Under such circumstances, an intergenerational approach to measuring the redistribution of housing services is appropriate.

4.0 Discussion

This paper presents a version of the monocentric AMM model to study the welfare impacts of character protections. Within our framework, character protections present a trade-off between welfare-increasing amenities and welfare-decreasing restrictions on floorspace. The overall effect of protections is therefore ambiguous. Welfare effects become negative when their attendant FAR restrictions are sufficiently binding. This is likely to be the case when character provisions are applied to neighbourhoods that have high demand due to their proximity to other (non-character) amenities or employment locations. The framework is a first step towards quantifying these trade-offs in policy evaluation exercises, such as cost benefit analysis.

The trade-off makes it difficult to accurately assess the welfare effects of character protections in practice. In order to get some idea of the direction of these welfare effects in the case of Auckland, we calibrate the model using a plausible range of parameter values, finding that character protections have negative welfare effects that are equivalent to a reduction in average household income of between $391 and $1,375 per year.

The absentee landlord AMM model measures welfare based on income flows, so that localised amenities affect representative household utility via an increase in population density in the affected suburbs. If increases in density are prevented via regulation, then there are no positive ongoing welfare effects from locational amenities: Although the residents gain utility from living in suburbs with amenities, in equilibrium this is exactly offset by a utility loss from higher housing rents, and the amenity benefits are captured exclusively by the landlord. By the same token, landlords also bear some of the costs of development restrictions via lower land rents.

In practice many residents own the property they occupy. The model could also be used to make predictions about the welfare effects of locational amenities for landowners by focussing on wealth rather than income. Under the plausible assumption that housing rents are capitalised into house prices, policies that generate positive local amenities will be reflected in higher house prices. Thus it is resident property owners at the time the policy is announced or implemented that experience an increase in wealth via a capital gain. Residents that purchased their property after the amenity was created are made no better off by the policy because the value of the amenities are capitalised into house prices. In the case of character protections, a reduction in the wealth of incumbent households due to lower land prices under redevelopment restrictions would also have to be considered when assessing the total wealth effects of the policy.

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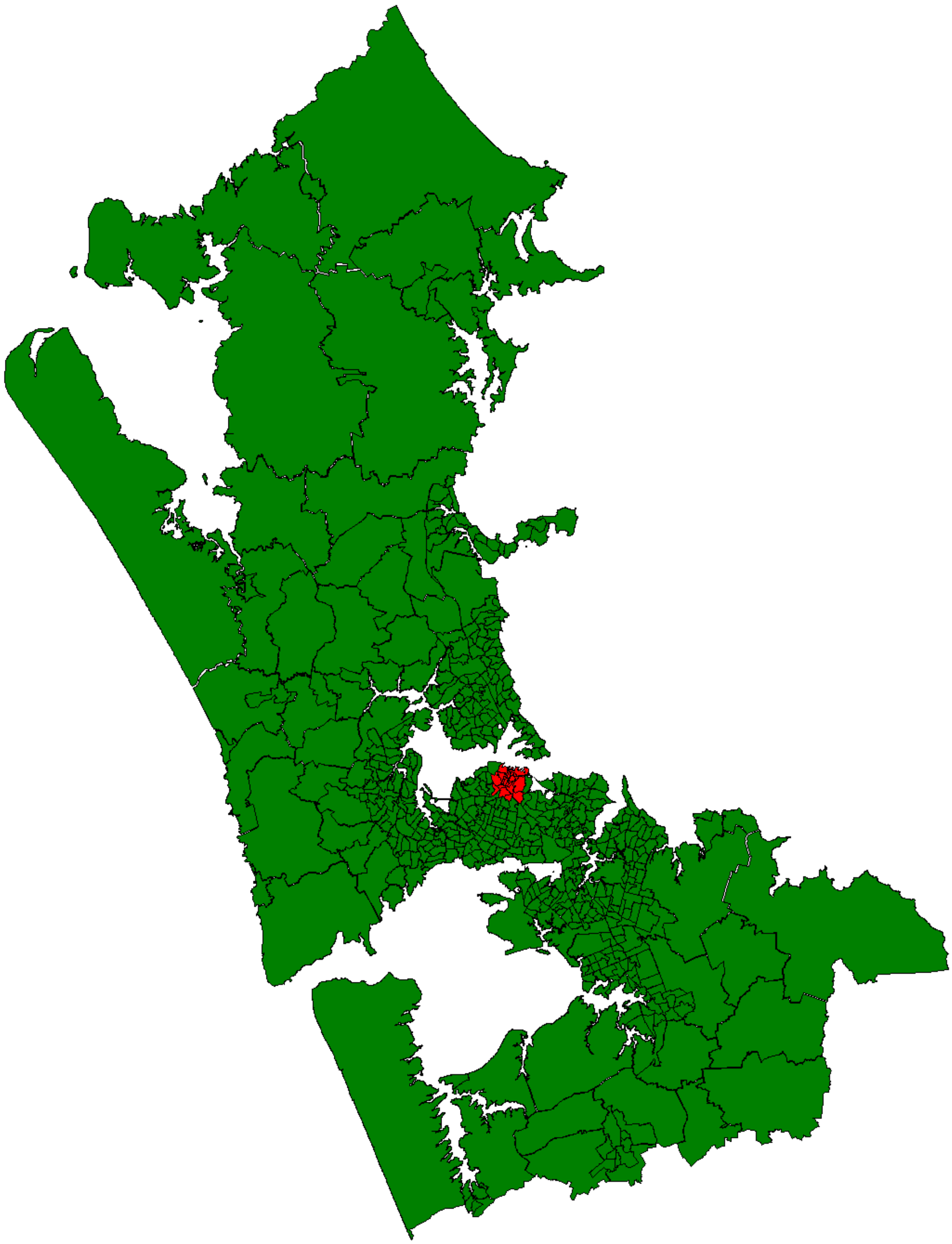
A Appendix

Figure 10: Auckland region and central business district



Notes: Central business district (red) and other areas of the Auckland region (green), excluding islands. The CBD is comprised of the following SAs: Anzac Avenue, Auckland-University, Eden Terrace, Freemans Bay, Grafton, Grey Lynn East, Hobson Ridge Central, Hobson Ridge North, Hobson Ridge South, Karangahape, Mount Eden North East, Newmarket, Parnell West, Quay Street-Customs Street, Queen Street, Queen Street South West, Shortland Street, Symonds Street East, Symonds Street North West, Symonds Street West, The Strand, Victoria Park, and Wynyard-Viaduct.

Table 6: Hedonic regression

Variable	(1)	(2)	(3)	(4)	(5)	(6)
SCA (=1)	0.037	0.022	0.008	0.033	0.017	0.006
	[0.006]	[0.006]	[0.007]	[0.006]	[0.006]	[0.007]
	(0.024)	(0.022)	(0.024)	(0.024)	(0.022)	(0.023)
Pre-1940 (=1)		0.058	0.038		0.065	0.050
		[0.003]	[0.005]		[0.003]	[0.005]
		(0.007)	(0.011)		(0.006)	(0.010)
SCA×Pre-1940 (=1)			0.027			0.021
			[0.006]			[0.006]
			(0.014)			(0.013)
HHE (=1)	0.113	0.103	0.104	0.107	0.096	0.097
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
	(0.030)	(0.031)	(0.030)	(0.029)	(0.030)	(0.029)
log(Floor Area)	0.418	0.422	0.422	0.397	0.398	0.398
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
log(Land Area)	0.218	0.215	0.216	0.224	0.221	0.221
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
	(0.012)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)
Appreciable view (=1)				0.037	0.037	0.037
				[0.002]	[0.002]	[0.002]
				(0.007)	(0.007)	(0.007)
Deck (=1)				0.010	0.009	0.009
				[0.002]	[0.002]	[0.002]
				(0.002)	(0.002)	(0.002)
Walls and roof in good condition (=1)				0.039	0.043	0.043
				[0.002]	[0.002]	[0.002]
				(0.004)	(0.004)	(0.004)
Level site (=1)				0.049	0.048	0.048
				[0.002]	[0.002]	[0.002]
				(0.008)	(0.008)	(0.008)
Off-street and garage parking spaces				0.005	0.007	0.007
				[0.001]	[0.001]	[0.001]
				(0.002)	(0.002)	(0.002)
Number of school zones				0.041	0.042	0.042
				[0.004]	[0.004]	[0.004]
				(0.019)	(0.020)	(0.020)
Observations	66,663	66,663	66,663	66,663	66,663	66,663
R-squared / Adj. R-squared	0.88 / 0.88	0.88 / 0.88	0.88 / 0.88	0.89 / 0.89	0.89 / 0.89	0.89 / 0.89
AIC	-47,744	-48,122	-48,138	-49,644	-50,135	-50,144
BIC	-45,631	-46,000	-46,007	-47,476	-47,958	-47,958

Notes: All specifications include SA fixed effects. 'SCA', 'Pre-1940' and 'HHE' are indicators for: houses located in special character areas; houses built prior to 1940; and houses that are protected by heritage restrictions on demolitions and alterations, respectively. The reference group is a house not in an SCA built in 1940 or later. The dependent variable is log of the council valuation of house price. Classical standard errors are in [] brackets. Conley (1999) HAC robust standard errors are in parentheses.

1.1 Shortened URLs within the document

Shortened URL	Full URL	Created and accessed
https://bit.ly/3W83Qum	https://infocouncil.aucklandcouncil.govt.nz/Open/2023/03/20230302_PEPCC_AGN_11303_files/20230302_PEPCC_AGN_11303_Attachment_92129_5.PDF	5/07/2024
https://bit.ly/4cLCGPp	https://www.aucklandcouncil.govt.nz/UnitaryPlanDocuments/03-pc-78-section-32-economy-matters.pdf	5/07/2024
https://bit.ly/3zpLUCm	https://hearing.aucklandcouncil.govt.nz/h724/Evidence/Auckland%20Council%2C%20016A%20010F%20010G%20020B%20020C%20020F%2C%20Ecomonics%20Rebuttal%2C%20D%20Fairgray.pdf	5/07/2024