THE CAUSES AND ECONOMIC CONSEQUENCES OF RISING REGIONAL HOUSING PRICES IN NEW ZEALAND

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The causes and economic consequences of rising regional housing prices in New Zealand

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Abstract

Over the last generation, house prices and rents have risen more rapidly than incomes in New Zealand. Regional house prices have also diverged significantly, with Auckland and Queenstown in particular rising above the rest. This paper explores the causes and economic consequences of recent increases in regional house prices in New Zealand.

I demonstrate that recent house price increases in New Zealand are due in large part to rising house price distortions, which reflect 'wedges' between house prices and underlying costs of supply. These distortions are largest in Auckland, Queenstown, Tauranga, Hamilton, and Wellington. They arise due to the collision of rising demand for housing, due to factors such as population growth, availability of mortgage credit, and tax policies that incentivise property investment, with housing supply constraints, such as zoning rules that limit new subdivision, limit redevelopment of existing sites, or require large lot sizes and costly features such as on-site carparking. Regions with larger house price distortions, indicating the presence of binding supply constraints, appear to have experienced larger increases in house prices and rents in response to migration shocks.

Rising house price distortions have large economic impacts due to misallocation of labour away from high-productivity regions in New Zealand, in particular Auckland and Wellington, and increased net migration of New Zealanders to Australia. To quantify these economic costs, I calibrate a spatial equilibrium model using regional economic data for the 2000-2016 period and use it to investigate the effect of counterfactual scenarios in which house price distortions had not increased in recent decades.

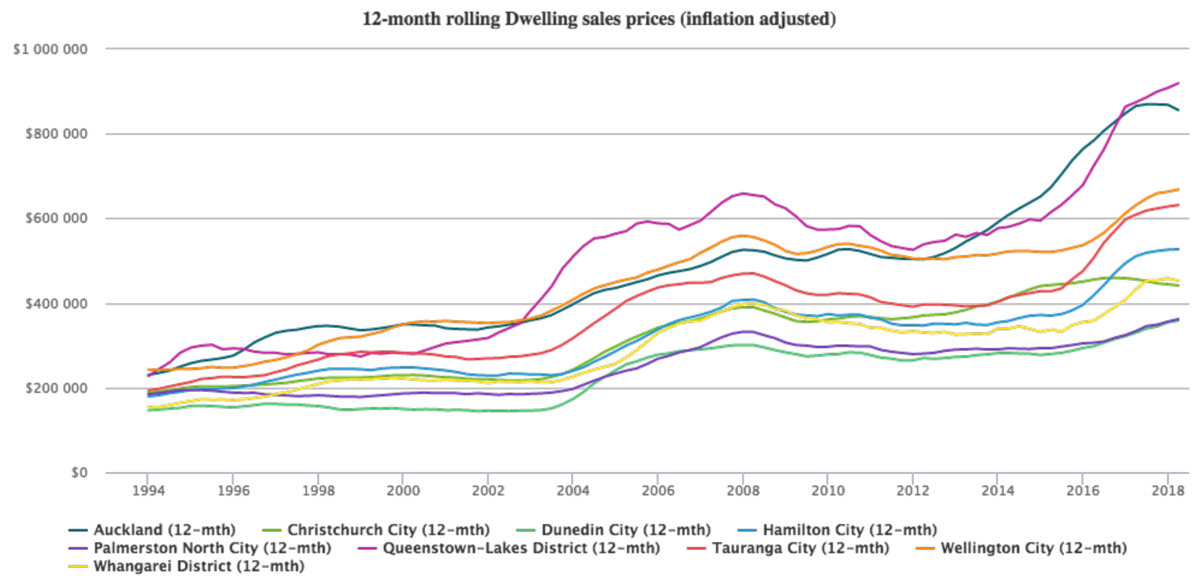
My 'upper bound' estimate is that comprehensively removing constraints to housing supply would have increased New Zealand's total economic output by up to 7.7%, increased per-worker output by 0.9%, and eliminated recent net migration outflows to Australia. More plausible counterfactual scenarios would result in smaller, but still economically meaningful, gains on the order of one to five percent of gross domestic product.

Keywords: Housing prices, Zoning, Housing supply, Migration, Urban growth

1. Introduction

Over the last generation, house prices and rents have risen more rapidly than incomes in New Zealand. Since 1990, average house prices have risen by over 430%, rents have risen by over 180%, but average hourly wages have only risen by 125% (source: author's calculations based on RBNZ, 2018a; MBIE 2018a; SNZ, 2018a). Furthermore, as shown in Figure 1, regional house prices have diverged significantly, with Auckland and Queenstown in particular rising above the rest.

Figure 1: House prices in selected New Zealand cities (MBIE, 2018)



Anecdotally, high housing prices in Auckland are encouraging some people to move to other New Zealand cities with more affordable housing. For instance, a May 2018 article in *The Wireless* interviewed people moving to the Hawkes Bay and other places (Sumner, 2018):

> *Lucy says she would never go back. "We hated living in Auckland, we couldn't get our heads above water, we were in the grossest flat. Just cold, damp, not somewhere you want to raise a child. We knew we couldn't afford to buy there; it just wasn't an option for us. I still have friends in Auckland but most of the people I know who live there don't have kids, so they still flat or they can buy a really small home and not worry about kids clawing at the walls. Here the kids can run around. I would never choose another lifestyle anymore."*

Notwithstanding the anecdotes, the most expensive places in New Zealand have grown rapidly in spite of high house prices. For instance, from 2012 to 2017, Auckland's population grew by

12.2% and Queenstown's population rose 28.8% (SNZ, 2017a). Only Selwyn and Waimakariri Districts grew faster, and that was due the impact of the 2011 Canterbury Earthquakes on the distribution of population around Greater Christchurch.

Would Auckland have grown more rapidly if house prices had risen less rapidly? Have differences in house prices between regions 'distorted' people's choice of locations within New Zealand, or do they simply reflect differences in the attractiveness of living in different places? And, if house prices have affected location decisions, does this have any macroeconomic consequences for New Zealand?

I explore these questions in this paper. I begin with a brief literature review to situate this research and identify methods that can be used to investigate this question. Following that, I set out a simple theoretical model of how people make location decisions, considering house prices, local productivity levels, and local amenities. In the two subsequent sections I use this theoretical model to examine the causes and economic consequences of high house prices in New Zealand regions.

In Section 4, I analyse how distortions in house prices in New Zealand regions, which reflect regulatory constraints on housing supply, have changed since the 1990s. I find that house price distortions differ significantly between regions and that increasing price distortions are a key cause of increasing and diverging regional house prices.

I then analyse whether differing housing supply constraints have caused regional housing markets to respond in different ways to housing demand shocks from migration over the 2000-2016 period. If housing supply is constrained, we would expect demand shocks to have a larger impact on prices, and vice versa. Empirically, this appears to be the case, which creates the potential for some people to be 'rationed out' of supply-constrained regions due to rising house prices.

In Section 5, I use data on regional wages, employment, and house prices to calibrate a spatial equilibrium model of location choice in New Zealand regions over the 2000-2016 period. I use my estimates of changes in house price distortions over this period to define several counterfactual scenarios for what might have happened if New Zealand regions had fewer constraints to housing supply and hence smaller distortions in house prices.

I find that rising house price distortions in recent decades have had large economic impacts. These arise due to misallocation of labour away from high-productivity regions in New

Zealand (in particular Auckland and Wellington) and increased net migration of New Zealanders to Australia. My ‘upper bound’ estimate is that comprehensively removing constraints to housing supply may increase New Zealand’s total economic output by 7.7%, increase per-worker output by 0.9%, and eliminate net migration outflows to Australia. More plausible counterfactual scenarios would result in smaller, but still economically meaningful, gains on the order of one to five percent of gross domestic product.

2. Literature review

To set the scene, I review several strands in the urban economics literature. These relate to the determinants of house prices, including in New Zealand, the drivers of housing supply responsiveness, the determinants of households' location decisions in the context of varying productivity levels, amenity levels, and constraints on housing supply, and the responses of local housing markets to demand shocks from migration.

A theme emerging from this literature is that differences in house prices between locations can be due to differences in productivity levels or amenity levels, or differing constraints to housing supply that interact with rising demand for housing. High house prices do not necessarily indicate that there is a problem – they may simply reflect differences in the desirability of different places. However, where house prices are distorted, it can generate both local and macro-economic costs.

2.1. House price distortions

Various research papers have attempted to measure distortions in house prices. These papers rely upon the microeconomic principle that, in a competitive market, prices for goods (including houses and residential land) should be set equal to the marginal cost of production (Cheshire and Hilber, 2008). Where there is a large deviation between prices and marginal costs, it indicates the presence of a distorting factor.

New Zealand research has focused on 'discontinuities' in land values across zoning boundaries, eg Grimes and Liang (2009), Productivity Commission (2015). More recently, MBIE (2017) has published estimates of land price discontinuities across rural-urban zoning boundaries and industrial zone boundaries for a number of New Zealand cities. In the US, Grout, Jaeger, and Plantiga (2011) consider the potential endogeneity of zoning boundaries and estimate their effects in Portland using a regression discontinuity method.

Several papers also use land price discontinuities around zoning boundaries in welfare analysis of the positive and negative effects of zoning. Cheshire and Sheppard (2002) analyse property sales and survey data on buyers to estimate the costs and benefits of local zoning controls in Reading, UK. Rouwendal and van der Straaten (2008) estimate the costs and benefits of open space provision in three Dutch cities. Turner, Haughwout, and van der Klaauw (2014) decompose differences in land prices at boundaries to account for the potential positive and negative impacts on land prices.

In the US and the UK, several papers measure the difference between prices for high-rise apartments / offices and high-rise construction costs (Glaeser, Gyourko and Saks, 2005; Cheshire and Hilber, 2008). Denne, Nunns, Wright, and Donovan (2016) construct a similar measure for apartments in the Auckland and Wellington city centres. Several papers adapt this method to standalone homes, using an estimate of the value of residential sections in a competitive land market (Glaeser and Gyourko, 2018; MBIE, 2017; Lees, 2018).

Glaeser and Gyourko (2002) and Glaeser and Ward (2009) estimate land price distortions using residential property sales data. I discuss this approach further in Section 4 and implement it for New Zealand regions over the 1990-2016 period.

2.2. Housing supply responsiveness

A number of papers also investigate the determinants and impacts of housing supply responsiveness in various countries, including New Zealand. Caldera and Johannson (2013) estimate long-run housing supply elasticities at the national level for 21 OECD countries, including New Zealand, over the mid-1980s to mid/late-2000s period. They find that housing supply is highly responsive to increased demand in the US, Canada, Sweden, and Denmark, while New Zealand exhibits intermediate levels of supply responsiveness.

Mayer and Somerville (2000a) estimate the responsiveness of housing supply for US metropolitan areas over the 1985-1999 period in a panel regression framework that models new housing construction as a function of changes in house prices in the current and recent quarters. Mayer and Somerville (2000b) extend this model to show that growth controls and delay in obtaining consent result in lower housing supply responses in US cities. Several papers apply the same approach to estimate housing supply responsiveness in Australian regions (McLaughlin, 2011; Ong *et al*, 2017).

Grimes and Aitken (2010) estimate the responsiveness of supply to house price increases in New Zealand regions over the 1991-2004 period by modelling new dwelling consents as a function of the level of house prices, construction costs, and land prices using a panel instrumental variables approach. They also demonstrate that regions with lower supply responsiveness tend to experience larger spikes in prices in response to demand shocks. Nunns (2018) uses a similar approach to show that New Zealand regions with tighter geographic constraints or greater incidence of delays in processing resource consents had lower housing supply responsiveness over the 2001-2016 period.

Saiz (2010) and Paciorek (2013) find that both restrictive land use regulations and a shortage of developable land reduce housing supply responsiveness in US cities. Paciorek further finds that delays in obtaining consent have a larger negative impact on supply than other types of land use regulations. Mayo and Sheppard (1996) and Jackson (2016) provide further evidence of the causal impact of land use regulations. They show that the rate of new construction fell after Malaysia and Californian regions, respectively, adopted of tighter land use regulations.

2.3. Determinants of location choices

Inter-regional variations in housing supply responsiveness mean that different places will build different amounts of housing in response to demand shocks. This raises the question of whether there are also effects on the long-run inter-regional distribution of population.

A number of recent papers have investigated these effects in the US and other jurisdictions, generally using spatial equilibrium models originated by Rosen (1979) and Roback (1982). This model, which I outline in Section 3, posits that the utility from choosing different locations must be equalised, at least for the marginal individual that might move between locations. As a result, persistent differences in the ratio of house prices to wages between locations must be 'compensated' by differences in the level of un-priced amenities (Glaeser, 2008).

The impact of housing supply on location choices has received recent attention in the United States, following the divergence of regional house prices since the 1970s and the associated slow-down in inter-regional migration. Glaeser, Gyourko, and Saks (2006) describe a spatial equilibrium model and use this to motivate an analysis of the impact of productivity shocks on population changes and house price changes over the 1980-2000 period. They find that cities with higher levels of land use regulations grow more slowly in response to shocks and experience more rapid increases in house prices. Saks (2008) uses a vector autoregression model to estimate how the impact of labour demand shocks on employment growth, wages, and house prices varies in US cities with different levels of land use regulation. She finds that cities with stricter land use regulation experienced less growth in employment and more growth in wages and house prices following labour demand shocks over the 1980-2002 period.

Vermeulen and van Ommeren (2009) analyse housing supply, internal migration, and employment growth in Dutch regions over the 1973-2002 period. They find that housing supply has been insensitive to changes in employment or migration, while net internal migration was primarily determined by housing supply, rather than employment growth. They interpret this as evidence that regional land use planning decisions shape the distribution of economic activity in the Netherlands.

More recent research has focused on estimating the impacts of housing supply constraints on welfare or economic output by calibrating spatial equilibrium models of location choice and using them to identify counterfactual scenarios for urban growth.

Hsieh and Moretti (2015) estimate a spatial equilibrium model for US cities using data on employment, wages, and house prices for 220 metropolitan areas over the 1964-2009 period. They use Saiz's (2010) estimates of housing supply elasticities for US cities to estimate a counterfactual scenario in which San Francisco, San Jose, and New York had more permissive land use regulations. They estimate that this would have raised US gross domestic product by 8.9% in 2009, if workers were assumed to be perfectly mobile, or 3.7% if idiosyncratic preferences for certain locations were taken into account.

Parkhomenko (2017) develops a similar model with extensions for heterogeneous workers with idiosyncratic preferences for certain locations and endogenous regulatory strictness. He calibrates this model using data on US cities over the 1980-2007 period, estimating that the rise in regulation over this period reduced economic output by around 2%. Glaeser and Gyourko (2018) also estimate that tighter regulations imposed a cost of around 2% of economic, based on the assumption of perfectly mobile workers but a different specification for the city production function.

Whereas the above papers focus on the long-run effect of housing supply constraints, Ganong and Shoag (2017) and Herkenhoff, Ohanian, and Prescott (2018) investigate the impact of changing land use regulations over time. Herkenhoff *et al* employ a spatial growth model to identify changes in and use regulations, amenities, and productivity over the 1950-2014 period. They also undertake a counterfactual analysis that obtains qualitatively similar results as the above papers.

Ganong and Shoag (2017) find that rising house prices in high-income states have deterred low-skilled workers from migrating to those states since the 1970s, thereby slowing income convergence between states. They construct a state-level panel of changes in the stringency of land use regulations to demonstrate that increased land use regulation is a cause of falling income convergence.

Finally, de Groot, Marlet, Teulings, and Vermuelen (2015) calibrate a simple spatial equilibrium model for seven cities in the Netherland's Randstad area. They use this to estimate the welfare gains from the creation of new towns or the expansion of existing cities. Their model uses data on land price distortions at zoning boundaries to identify the restrictiveness of land use controls.

Several papers investigate the the drivers of population location and house prices in New Zealand regions. These papers employ a similar spatial equilibrium framework but do not pay specific attention to housing supply constraints. In general, previous New Zealand research does not provide clear-cut evidence that differences in house prices have distorted location choices between cities, at least not prior to 2006.

Sinning and Stillman (2012) use matched Australian and NZ Census data over the 1996-2006 period to identify drivers of movements between regions and between countries. They find that workers are attracted to higher wages but not dissuaded by higher house prices. Grimes et al (2016) investigate drivers of long-run population growth in NZ cities. They find that sunshine hours, higher starting human capital levels, and proximity to Auckland have a positive effect over the 1926-2006 period.

2.4. The impact of migration shocks on house prices

Lastly, I briefly review the literature on the economic impacts of migration. Inward migration may result in shocks to local housing markets that may be accommodated in different ways depending upon the degree to which local housing supply is constrained. I re-examine the impact of housing demand shocks on New Zealand regions in Section 4.5.

A significant body of research assesses the economic impacts of migration. In the US, the National Academy of Sciences (2017) recently published a comprehensive review of the economic and fiscal impacts of migration, while Hodgson and Poot (2011) review the findings of mid-2000s research on the economic impacts of migration in New Zealand. These reviews suggest that immigration has a negligible impact on wages and employment rates for most existing residents (see also Longhi, Nijkamp, and Poot, 2009).[1]

[1] There is, however, a lively debate about the existence and magnitude of impacts on specific categories of workers, in particularly lower-skilled workers.

The impact of migration on housing markets has received less attention, although several studies suggest that house price impacts may be larger than labour market impacts.

In the US, Saiz (2003) uses a natural experiment, the 1980 Mariel Boatlift, which resulted in a large inflow of Cuban refugees to Miami, to estimate the impact of migration shocks on local rents. He estimates that this event increased Miami's population by 4% in one year, and caused rents to increase 8% more in Miami relative to comparator cities. Saiz (2007) undertakes a broader analysis of the impacts of migration inflows on rents and house prices on 306 US cities over the 1983-1997 period. He uses a panel regression model, instrumenting for migration inflows using Bartik-style shift-share measures, to estimate that an immigration inflow equal to one percent of a city's population leads to a 1-2% increase in average rents and house prices.

Several papers have investigated the impact of migration or other population shocks on New Zealand house prices at a national and regional level. Coleman and Landon-Lane (2007) use a structural vector autoregression model to estimate the relationship between migration flows, new home building, and house prices over the 1962-2006 period. They find that a net immigration inflow equal to one percent of the population is associated with an 8-12% increase in real house prices after a year. McDonald (2013) updates this analysis using data for the 1990-2012 period, finding that a net inflow of migrants equal to one percent of the population is followed by a 7% increase in real house prices, and an additional 1 home consented for every six migrants.

Stillman and Maré (2008) use data from the 1986-2006 Censuses to examine how population changes from international and internal migration affect regional rents and house prices. They conclude that a one percent increase in an area's population is likely to lead to a 0.2 to 0.5 percent increase in local housing prices and a smaller impact on rents. They found no evidence that inflows of foreign-born immigrants to an area are positively related to local house prices. In a related paper, they find little evidence that migrant inflows displace either the New Zealand born or earlier migrants with similar skills in the areas in which migrants are settling (Maré and Stillman, 2009).

Similarly, Maré, Grimes, and Morten (2009) find that regional employment shocks result in strong in-migration but not movements in relative house prices. Surprisingly, this differs from their estimates from national-level data, which suggest that a one percent employment shock raises house prices by around 6%.

This research poses a conundrum. There is evidence that migration inflows have a strong impact on house prices at a national level, but less evidence of impacts at the regional level in New Zealand, although Saiz (2007) documents such effects in US cities. On the face of it, this seems like evidence against the hypothesis that local housing supply constraints have made it difficult for New Zealand regions to adjust to housing demand shocks.

3. Theoretical model

As a basis for subsequent analysis, I sketch out a spatial equilibrium model of household location choice based on the Rosen-Roback framework. This model involves three agents:

- A production sector modelled as consisting of one representative firm per region that aims to maximise profit, with non-land capital inputs flexible between regions;
- Workers, who supply labour to the production sector and consume housing, choosing a location to maximise utility; and
- Housing developers, who are assumed to be perfectly competitive but who face differing levels of land use regulations that result in city-specific 'wedges' between house prices and the underlying cost of supply.

This modelling approach has been widely used in the urban economics literature since its development by Rosen (1979) and Roback (1982). Glaeser (2008) describes the three key elements of this model. Glaeser, Gyourko and Saks (2006), Saks (2008), and Ganong and Shoag (2017) adapt this model to motivate empirical analysis of urban growth and house prices in US cities, while de Groot et al (2015) and Hsieh and Moretti (2015) calibrate models for use in policy analysis. As a minor variant to the model, I use Glaeser and Gyourko's (2002) specification for housing development as this allows me to introduce housing price distortions into the model, as suggested by de Groot, Marlet, Teulings, and Vermeulen (2015).

Model equilibrium describes the distribution of workers between different locations, and the overall level of utility and economic outcome that results from this outcome. This model involves several simplifying assumptions around firm production functions and worker preferences. Hsieh and Moretti (2015) investigate the consequences of relaxing these assumptions, finding that the most consequential assumption is around whether workers are perfectly mobile between locations or whether they are imperfectly mobile due to idiosyncratic preferences for specific places. I consider two alternative model specifications that make different assumptions about workers' location preferences.

3.1. Production

In the model, each location *i* is assumed to have a representative firm that produces a homogenous tradeable good Y_i with a Cobb-Douglas technology:

Equation 1: Production function

$$Y_i = A_i L_i^{\alpha} K_i^{\eta} T_i^{1-\alpha-\eta}$$

where A_i is total factor productivity (TFP); L_i is local employment; K_i is capital stock; T_i is land available for business use, which is assumed to be exogenous; and α and η are production elasticities that are assumed to be constant across all locations. Business land is assumed to be fixed and exogenously determined, and hence this production function exhibits decreasing returns to scale in labour and capital.[2] This specific specification follows Hsieh and Moretti (2015), but a similar Cobb-Douglas form with diminishing returns to labour inputs is also used by Glaeser (2008), Ganong and Shoag (2017), and others.

Representative firms are assumed to maximise profits by choosing L_i and K_i. This results in the following first-order conditions for local wages W_i and the cost of capital R:

Equation 2: First order conditions for local labour demand and capital demand

$$W_i = \frac{\partial Y_i}{\partial L_i}$$

$$R = \frac{\partial Y_i}{\partial K_i}$$

Solving the first-order conditions for profit maximisation results in a local (inverse) labour demand function that is increasing in local TFP (ie the combination of A_i and T_i) and decreasing in W_i:

Equation 3: Local labour demand function

$$L_i = \left(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}}\right)^{1/(1-\alpha-\eta)} * \left(\frac{1}{W_i}\right)^{\frac{1-\eta}{1-\alpha-\eta}} * A_i^{1/(1-\alpha-\eta)} * T_i$$

Local house prices P_i do not enter into the local labour demand function. As output is assumed to be tradeable, the marginal product of labour (measured based on the ‘national’ price of exported goods) must be set equal to local nominal wages (ie not adjusted for differences in local house prices). This assumption allows local TFP levels to be identified based on

[2] In New Zealand, cities with constraints on housing supply often have abundant business land. For instance, MBIE (2017) finds that industrially-zoned land is often valued at a discount from nearby residential land. A 2015 study also found that one-quarter of the industrially-zoned land in New Zealand’s upper North Island, which includes housing-constrained cities like Auckland and Tauranga, was vacant in 2011, implying significant ‘slack’ in business land markets (Sanderson et al, 2015).

(observed) local wages and labour shares, while local amenities can be identified based on (observed) local wages and house prices.

3.2. Housing development

Housing development is modelled based on the assumption that housing units are homogenous and supplied by a perfectly competitive development sector that sells housing for a price that covers the cost of developing it. Following Glaeser and Gyourko (2002), housing development costs are defined as a linear function of:

- The cost of construction inputs C, which are produced and traded competitively and hence which are similar in all locations;
- The ‘free-market’ price of land ρ_i, which is set by the opportunity cost of converting rural land to residential use and which may vary by city;[3] and
- Local constraints on housing supply that introduce a city-specific ‘wedge’ δ_i between the above costs and house prices.

In this setting, the sale price of a typical home in location i is given by:

Equation 4: Housing development costs

$$P_i = C + \rho_i + \delta_i$$

This specification has been widely used in the literature on house price distortions, including by Glaeser and Gyourko (2002), Cheshire and Hilber (2008), and Grimes and Liang (2009). De Groot, Marlet, Teulings, and Vermeulen (2015) incorporate a similar specification into their spatial equilibrium model of housing demand in the Netherlands. This enables me to use empirical estimates of land price distortions (estimated in Section 4) to define counterfactual scenarios for house prices, but it represents a minor departure from the approach used by Ganong and Shoag (2017) and Hsieh and Moretti (2015), who model house prices using an inverse elasticity of supply parameter.

3.3. Workers

I consider two alternative specifications for worker utility and hence workers’ willingness to supply labour in each location. In the simplest formulation of the model, workers are assumed

[3] For example, a city surrounded by avocado and kiwifruit orchards will have a higher opportunity cost to convert rural land than a city surrounded by sheep farms, as orchards are a higher-value rural use.

to have homogenous preferences to live in different places. While they derive utility (or disutility) from wages, housing costs, and local amenities, which vary between locations, they are not assumed to have specific preferences for any particular location, eg due to family ties or cultural connections to place. As a result, they are perfectly mobile between locations.

Alternatively, workers may have idiosyncratic preferences to live in certain places. That is, in addition to deriving utility (or disutility) from wages, housing costs, and local amenities, they also derive utility from living in their preferred location. This may be due to family or cultural ties, individual preferences for certain climates or lifestyles, or the social and financial costs of moving between locations. As a result, workers are *not* perfectly mobile between locations, creating 'stickiness' in the regional distribution of employment.

As it happens, perfectly mobile workers can be modelled as a special case of imperfectly mobile workers. To illustrate, I define alternative specifications for worker utility, building upon a specification for worker utility that is widely used in the urban economics literature (see eg Glaeser, 2008; Hsieh and Moretti, 2015).

Under perfect mobility, workers are assumed to derive indirect utility V_i from living in location i. Due to the assumption of free mobility and utility maximisation, utility is equalised across all locations:

Equation 5: Worker utility under perfect mobility

$$V = V_i = \frac{W_i Z_i}{P_i^{\beta}}$$

where W_i is the local wage, P_i is the local price for one unit of housing, β is the expenditure share on housing, and Z_i is the value of local amenities, which cannot be directly measured. This specification assumes that the price of output good is the same in all cities, and that housing and business land are owned by an absentee landlord, rather than workers.

Under imperfect mobility, worker j is assumed to derive indirect utility V_{ij} from living in location i:

Equation 6: Worker utility under imperfect mobility

$$V_{ij} = \epsilon_{ij} \frac{W_i Z_i}{P_i^{\beta}}$$

where ϵ_{ij} is a random variable that measures their preference to be in location i. A larger value means that worker j is willing to accept a lower wage or pay higher prices to live there. Each individual worker chooses a location that maximises their utility. In equilibrium, *marginal* workers are indifferent between locations, ie $V_{ij} = V_{kj}$ for marginal worker j and all locations i and k. However, most workers derive higher utility from their chosen location than they would from other locations.

If $\epsilon_{ij} = \epsilon_{kj}$ for all workers j and all locations i and k, or if $\epsilon_{ij} = \epsilon_{im}$ for all locations i and for all workers j and m, then this expression simplifies into indirect utility under perfect mobility.

Following Hsieh and Moretti (2015), I assume that ϵ_{ij} are identically and independently distributed and drawn from a multivariate extreme value distribution $[F_g(\epsilon_1, \dots, \epsilon_N) = \exp(\sum_i^N \epsilon_i^{-\theta})]$, where $1/\theta$ determines the strength of idiosyncratic preferences for location. The labour supply equation under imperfect mobility is therefore:

Equation 7: Local labour supply function under imperfect mobility

$$W_i = V * \frac{P_i^{\beta} L_i^{1/\theta}}{Z_i}$$

where V denotes *average* worker utility in all cities, and the elasticity of the local labour supply curve depends upon the strength of idiosyncratic location preferences. When $1/\theta$ is large, few workers are willing to relocate in response to wage or amenity differences, and when it is small, many workers are willing to relocate.

If $1/\theta = 0$, then it implies that labour supply is perfectly elastic in each location, and hence any increase in amenities or reduction in house prices must be fully counterbalanced by an equal reduction in wages. However, in the imperfect mobility case, the wage response will be dampened.

3.4. Model equilibrium

The above equations enable identification of equilibrium outcomes for the distribution of labour between cities, output per worker in each location, and national output per worker:

- local TFP levels are identified as a function of observed differences in wages and employment shares between locations, based on the assumption that output is tradeable between locations.

- Local (relative) amenity levels are identified as a function of observed differences in wages, house prices, and employment levels between locations, based on the assumption that higher amenity is required to 'compensate' workers for living in places where housing prices are high relative to wages.
- The economic impacts of counterfactual scenarios for regional house price distortions (ie different levels of δ_i) can be calculated by modelling the resulting spatial distribution of workers and levels of output per worker.

The endogenous variables in this model are L_i, W_i, Y_i, and Y, while the exogenous variables are the model parameters, local TFP, local amenities, and local house price distortions arising from supply constraints.

Equilibrium employment levels can be calculated by substituting the labour supply function derived from workers' equilibrium utility condition into the labour demand equation arising from the production function. After some algebra, this provides the following expression for equilibrium employment.

Equation 8: Equilibrium employment in an individual region

$$L_i = \left[\frac{\eta^\eta \alpha^{1-\eta}}{R^\eta V^{1-\eta}} * \left(\frac{Z_i}{P_i^\beta}\right)^{1-\eta} * A_i * T_i^{1-\alpha-\eta}\right]^{\frac{1}{(1-\eta)\left(1+\frac{1}{\theta}\right)-\alpha}}$$

The model implies that differences in equilibrium employment between locations are driven by differences in local TFP and availability of business land (which has a positive impact on employment), differences in amenities (positive impact), and the local price of housing (negative impact). Heterogeneity in preferences 'dampens' the employment response to amenities, house prices, and local TFP, as shown by the exponent term. If $1/\theta = 0$, then this model predicts a larger change in equilibrium employment in response to changes in house prices, local amenities, or local TFP.

Equilibrium employment is then substituted back into the production function to obtain an expression for equilibrium output in each location i. Imposing the condition that economy-wide labour supply equals labour demand, and normalising L_i as the share of total employment in location i, this implies that economy-wide output per worker Y is:

Equation 9: Equilibrium output per worker

$$Y = \sum_i L_i Y_i = \left(\frac{\eta}{R}\right)^{\frac{\eta}{1-\eta}} * \left[\sum_i \left(A_i * T_i^{1-\alpha-\eta} * \left(\frac{\bar{Q}}{Q_i}\right)^{1-\eta}\right)^{\frac{1}{(1-\eta)\left(1+\frac{1}{\theta}\right)-\alpha}}\right]^{\frac{(1-\eta)\left(1+\frac{1}{\theta}\right)-\alpha}{1-\eta}}$$

where $Q_i = P_i^{\beta}/Z_i$ is the 'local price' of amenity in different locations, and $\bar{Q} = \sum_i L_i^{1+1/\theta} Q_i$ is the employment-weighted average of the local price. As a result, $\bar{Q}/Q_i$ is also equal to a measure of wage dispersion between locations.

This implies that national output per worker is a power mean of local TFP weighted by the degree of price dispersion (or wage dispersion) between different cities.[4] As $(1-\eta)/((1-\eta)\left(1+\frac{1}{\theta}\right)-\alpha) > 1$, an increase in the dispersion of prices or wages between cities will lower aggregate output. In other words, rising house price distortions between locations will result in a loss of economic output. However, this effect will be dampened by the degree to which workers have idiosyncratic preferences to live in specific locations, which will result in a higher value for $1/\theta$.

To use this model to conduct counterfactual analysis of the impact of relaxing or tightening housing supply constraints, I estimate the exogenous variables (local TFP and local amenities) from observed data on house prices, wages, and worker location. The labour supply equation can be restated as follows to calculate local TFP (ie TFP plus business land availability) as a function of observed local employment and wages.

Equation 10: Estimating local TFP levels

$$A_i * T_i^{1-\alpha-\eta} = \left(\frac{R^{\eta}}{\alpha^{1-\eta}\eta^{\eta}}\right)^{1-\alpha-\eta} * L_i^{1-\alpha-\eta} * W_i^{1-\eta}$$

Similarly, the spatial equilibrium condition for workers can be restated to obtain an estimate of amenity levels in each location as a function of wages, house prices, the share of workers in that location, and the overall level of wellbeing. The level of V is unknown, but this still allows us to calculate relative amenity levels, which is all that is required for calculations.

[4] For a definition of this term, see http://mathworld.wolfram.com/PowerMean.html.

Equation 11: Estimating local amenity levels

$$Z_i = V * \frac{P_i^{\beta} * L_i^{1/\theta}}{W_i}$$

4. Measuring house price distortions in New Zealand regions

I begin by measuring how house price distortions vary between regions and how they have changed over time. These estimates are based on the theoretical model of housing development set out above, which suggests that house prices are an additive function of construction costs, 'free market' land prices, and a location-specific 'wedge' that arises when housing supply constraints collide with rising demand for housing. I use Glaeser and Gyourko's (2002) approach to 'decompose' house prices into these three components using residential property sales microdata for New Zealand regions over the 1990-2016 period.

To check whether this approach provides a meaningful indicator of local housing supply constraints, I investigate whether regional housing markets respond differently to demand shocks in regions with higher or lower price distortions. I find suggestive, although not conclusive, evidence that regions with larger price distortions experience larger increases in house prices and rents in response to housing demand shocks from international migration, which is what we would expect to see if they indicated the presence of supply constraints. Supplementary analysis reported in the technical appendix also shows that regional house price distortions are associated with the presence of several quantifiable constraints on housing supply.

This suggests that, where housing supply is constrained, prices must rise faster in response to demand shocks to 'ration' the limited stock of housing. Price-driven rationing may in turn cause some people to exit from local housing markets, eg by moving to different regions. Conversely, in regions where housing supply is unconstrained, then we would expect shocks to housing demand to be followed by larger supply increases and smaller price increases, allowing these regions to accommodate demand shocks without displacing residents.

4.1. Estimating house price distortions

Grimes and Liang (2009), the Productivity Commission (2015), MBIE (2017), and Lees (2018) have previously demonstrated that housing prices in New Zealand are 'distorted', ie that prices have diverged from marginal costs of production. This analysis is based on previous research by Cheshire and Sheppard (2002), Glaeser and Gyourko (2002), Glaeser, Gyourko, and Saks (2005), and Cheshire and Hilber (2008).

I use Glaeser and Gyourko's (2002) model of housing development, which is set out in Section 3.2, to quantify how these distortions vary across all New Zealand regions and over time.

Glaeser and Gyourko applied this method to 22 US cities, while Lees (2018) and Kendall and Tulip (2018) recently extended this approach to selected New Zealand and Australian cities. Previous research on US and New Zealand house price distortions has focused on cross-sectional differences, rather than changes over time. I therefore extend Glaeser and Gyourko's methodology to all New Zealand regions over the 1990-2016 period and use it to 'decompose' changes in house prices over this period.

In this model, I assume that a city has a given supply of land, house construction cost C, and a 'tax' δ_i on new construction, which can arise due either to supply constraints or requirements that impose cost on developers. The 'free market' price of land, defined as buyers' marginal willingness to pay for land, is ρ_i. The sale price of a home with L units of land is given by:

Equation 12: Decomposition of house prices

$$P_i(L) = C + \rho_i L + \delta_i$$

Glaeser and Gyourko (2002) and Gyourko and Molloy (2015) argue that δ_i reflects the presence of housing supply constraints or 'taxes' on new development. These may include development contributions / growth charges for new dwellings, regulatory requirement to provide dwelling or site features that residents do not value, such as excessive on-site carparking or high minimum lot sizes, and policies that constrain the number of homes that can be produced, either due to limits on new subdivision at the edge of the city or limits to redeveloping and intensifying existing sites.

Glaeser and Gyourko (2002) demonstrate that it is possible to separate the contribution of δ_i and ρ_iL to the price of housing using a two-step process. In the first step, the average value of land at the 'extensive' margin is calculated by subtracting each property's improvement value (ie an estimate of the depreciated construction cost of buildings on the site) from its sale price, and dividing by land area. In this equation, individual property sales are denoted as j and location subscripts have been dropped for convenience:

Equation 13: The average value of land on the extensive margin

$$p_{ext} = \frac{\sum P_j - IV_j}{\sum L_j} = \frac{\delta}{L} + \rho$$

In the second step, the value of land at the 'intensive' margin is calculated by using hedonic analysis of property sales to calculate the marginal impact of an additional unit of land on house sale price.[5] I follow Glaeser and Gyourko (2002) and recent research on the determinants of property values in Auckland (eg Greenaway-McGrevy, Pacheco and Sorensen, 2018) and use ordinary least squares (OLS) regression to estimate the following two regression models. In these equations, j indexes individual sales records with a given city:

Equation 14: Hedonic model 1

$$\ln P_j = \rho \ln L_j + \beta X_j + \gamma I_j + \varepsilon_j$$

Equation 15: Hedonic model 2

$$\ln P_j = \rho \ln L_j + \beta X_j + \varepsilon_j$$

The outcome variable is the natural logarithm of house sale price ($\ln P_j$), and the explanatory variables include the natural logarithm of land area ($\ln L_j$) plus a vector of dwelling characteristics (X_j).[6] The first model also includes the ratio of improvement value to total house price (I_j), which is a measure of the degree to which a site is 'built out' and hence likely to have little redevelopment potential.[7] ε_j is a residual term.

Finally, the intensive value of land at the mean and the estimated distortion in land prices on a per-square metre basis is calculated using the following equations.

Equation 16: The average value of land on the intensive margin

$$p_{int} = \rho * \frac{\sum P_j}{\sum L_j}$$

Equation 17: Estimating the 'wedge' between prices and costs

$$\frac{\delta}{L} = p_{ext} - p_{int}$$

[5] This is calculated at the mean, but it could in principle be calculated at different points in the distribution of dwellings, as in Cutter and Franco's (2012) analysis of the impact of minimum parking requirements in Los Angeles.

[6] I included the following variables: natural log of building floor area ($\ln F_i$); indicator variables for decade of construction (A_i); indicator variables for Census area unit (CAU_i), which act as proxies for localised amenities/disamenities and accessibility to productive jobs; indicators for sale year (Y_i); indicators for building construction, building condition, roof construction, and roof condition; and indicator variables for whether the property has a view of water or a view of land (V_i).

[7] In Auckland, Greenaway-McGrevy, Pacheco and Sorensen (2018) find that properties with different intensity ratios have followed different price paths in recent years, which they interpret as evidence of a changing redevelopment premium for low-intensity sites. Hence including this variable should control (to an extent) for the degree to which property prices reflect expected future redevelopment profits.

To undertake this analysis, I used CoreLogic microdata on residential property sales for all New Zealand territorial authorities (TAs) over the 1990-2016 period.[8] University of Auckland has licensed this data for use in research.

Computational constraints meant that it was not possible to estimate a single hedonic model for all TAs or all years. Consequently, I split the data by territorial authority. To deal with 'noise' in the data arising from a small number of annual sales in smaller TAs, I estimated models using a rolling three-year window, eg for the 2014-2016 period.

I imposed the following data cleaning rules:

- Excluded all properties not matching the description "Single Unit excluding Bach", properties with missing sales data or rating valuations, properties with zero land area (predominantly cross-lease sites or misclassified apartments – see Nunns, Allpress, and Balderston, 2016 for a discussion of this issue), properties with land area over 1 hectare (likely to be large lifestyle blocks or misclassified farm properties), properties with building coverage larger than site area or building floor area more than five times building coverage (likely to be misclassified apartment buildings or data entry errors), and properties with building floor area under 50m^2 or over 500m^2.
- For properties that were missing data on views, building or roof construction or condition, I created an indicator variable for missing values.
  For all properties, I restated sale prices and improvement values in real 2017 Q1 New Zealand dollars using Statistics New Zealand's (2018b) Consumer Price Index.

After cleaning the data, I estimated both hedonic models for each territorial authority in New Zealand, and for 22 aggregated labour market areas. As I have 72 TAs (based on the 2006 Census classification) and 25 three-year time periods, this resulted in a total of up to 1800 hedonic models.

4.2. Extensive and intensive land values in New Zealand regions

Table 6 in the technical appendix summarises results for the 2014-2016 period. Land prices on the extensive margin vary significantly – between \$14/m^2 in Westland District and \$1,548/m^2 in the former Auckland City. There is also variation in the elasticity of sale prices with respect

[8] Territorial authorities were based on 2006 boundaries, ie they split out the Auckland region into seven territorial authorities rather than grouping it into one region. There were a total of 72 TAs.

to land area. It is highest in Auckland’s urban TAs and lowest many small rural TAs and, interestingly, Wellington City.

Model 1, which includes the intensity ratio variable, often results in lower coefficients and a slightly lower estimated intensive land value than Model 2. Estimates from the two models are strongly positively correlated (correlation coefficient of 0.997 in the 2014-2016 period), and the differences are generally not economically significant. This suggests that these results are not greatly affected by including or excluding controls for the redevelopment potential of sites, and hence I focus on results from Model 1 in the subsequent analysis.

My estimates cover the 1990-2016 period (divided into 25 three-year rolling windows) and thus I can investigate how land price distortions have changed over time. The following charts decompose the growth in land values on the intensive and extensive margins in Auckland City and Whangārei District, which is affected by housing demand spillover from Auckland but which has a more abundant supply of developable land and more responsive housing supply (Nunns, 2018).

In Auckland City, the intensive value of land has risen significantly over this period, from around $113/m^2 to $533/m^2, reflecting rising demand for centrally located land in Auckland. However, in spite of this significant increase, extensive land values have risen even faster, meaning that land price distortions have risen from $105/m^2 to $1,015/m^2.

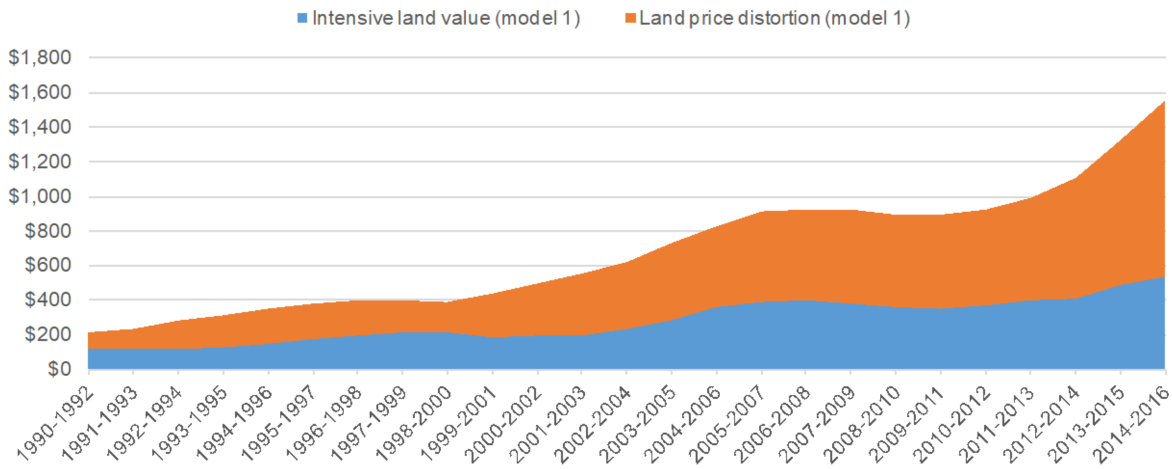
In Whangārei, the intensive value of land has scarcely moved over this period – going from $22/m^2 to $28/m^2. Consequently, most of the increase in the extensive value of land appears to reflect a rise in price distortions from around $40/m^2 to $165/m^2. However, this is a significantly slower rate of increase than in Auckland, and land price distortions remain comparatively low.

Land price distortions appear to be positively correlated over time: there is a correlation coefficient of 0.813 between this measure in the 1990-1992 and in 2014-2016 periods.[9] This in turn suggests that price distortions may reflect some persistent features that cause housing supply to be constrained or ‘taxed’ more in some locations than others. In the technical appendix, I show that larger price distortions coincide with the presence of several measurable factors that are likely to constrain housing supply constraints.

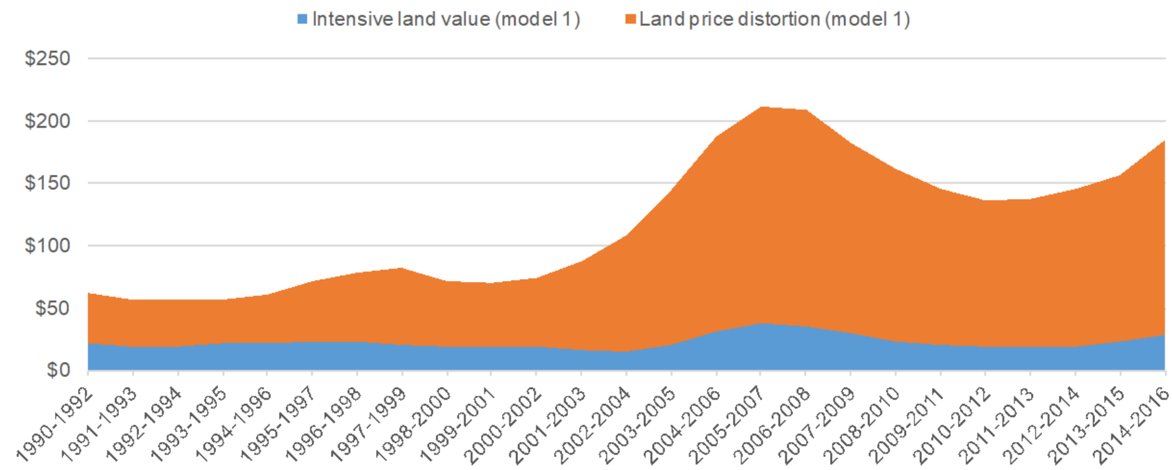
[9] This correlation coefficient is based on model 1 results; model 2 results show a similar degree of correlation.

Figure 2: Changes in land price distortions over time

Panel 1: Auckland City



Panel 2: Whangārei District



4.3. Decomposing changes in average house prices over time

Equation 12 can be used to decompose real increases in regional house prices into three components:

- The change in the value of buildings, eg due to renovations or construction of larger houses: I estimate this based on the change in average improvement values over this period.

- The change in the value of land on the intensive margin: I estimate this by multiplying average lot size by the hedonic value of land and calculating the change between the two periods.[10]
- Changing land price distortions: this is the remaining 'unexplained' change in prices.

As these estimates are used in counterfactual analysis of the impact of housing supply constraints on the regional distribution of employment in Section 5, I present them for 22 areas that correspond to distinct labour markets in New Zealand, over the period from 1999/2000 to 2015/2016.

Auckland, Queenstown-Central Otago, and Greater Tauranga have experienced the largest increases in land price distortions over this period. These areas enjoy relatively high amenity, strong labour markets, and, historically, constraints on new housing supply arising from both regulation and geography. On the other hand, the Whanganui and Central North Island Rural regions have had negligible increases in house price distortions.

This table provides an indication of the degree to which recent house price increases are due to constrained housing supply versus improvements to buildings or changes in the underlying demand for land.

[10] This captures both changing demands for land and changing lot sizes.

Table 1: Decomposing real changes in regional house prices over the 2000-2016 period

Labour market area	Average house price 1999/2000	Average house price 2015/2016	Change in value of buildings	Change in intensive land value	Change in land price distortion
Northland	$234,092	$405,032	$55,806	$16,990	$98,144
Auckland	$390,034	$998,955	$91,319	$153,179	$364,423
Thames-Coromandel	$250,682	$446,769	$47,247	$14,264	$134,576
Greater Hamilton	$252,868	$490,485	$55,829	$36,909	$144,879
Taranaki Rural	$122,870	$210,415	$38,844	$10,465	$38,236
North central NI	$217,284	$316,086	$25,082	$15,779	$57,940
Greater Tauranga	$306,110	$579,549	$64,313	$29,186	$179,941
Gisborne-Opotiki-Wairoa	$164,117	$257,957	$38,354	$21,943	$33,543
Napier-Hastings	$222,356	$401,542	$58,132	$27,539	$93,515
Central NI rural	$108,357	$171,872	$27,224	$16,170	$20,122
New Plymouth	$176,875	$412,724	$95,954	$16,372	$123,524
Whanganui	$133,633	$215,368	$42,606	$21,229	$17,900
Greater Palmy	$197,137	$342,498	$56,311	$25,001	$64,049
Horowhenua-Wairarapa	$143,727	$281,619	$63,399	$21,035	$53,458
Greater Wellington	$317,091	$539,933	$83,445	$27,966	$111,431
Nelson-Tasman-West Coast	$229,418	$456,765	$98,098	$39,361	$89,888
Marlborough-North Canterbury	$205,939	$398,047	$75,159	$18,280	$98,669
Rural Canterbury-Westland	$132,806	$314,874	$79,336	$28,531	$74,200
Greater Christchurch	$259,588	$540,359	$159,917	$63,752	$57,102
Queenstown-Central Otago	$271,487	$704,327	$180,338	$62,229	$190,273
Dunedin	$163,511	$341,472	$94,966	$17,079	$65,916
Southland	$105,371	$225,257	$55,463	$13,515	$50,908

4.4. House price distortions and regional adjustment to housing demand shocks

If housing supply is constrained, then we would expect shocks to housing demand, such as increases in migration to a specific location, to be followed by a smaller increase in supply. In this context, prices would have to rise faster to 'ration' the limited stock of housing. Price-driven rationing may in turn cause some people to exit from local housing markets, eg by moving to different regions. Conversely, in regions where housing supply is unconstrained, then we would expect shocks to housing demand to be followed by larger supply increases and smaller price increases. Intuitively, we would expect these regions to accommodate demand shocks without displacing residents.

To check whether price distortions indicate the presence of housing supply constraints, I investigate whether this is the case in practice by applying the methodology outlined by Saiz (2007) to a quarterly panel of New Zealand territorial authorities over the 2001-2016 period.[11] This approach is similar to the model used by Stillman and Maré (2008), but it differs from the VAR approach used by several previous New Zealand papers.

Saiz (2007) posits that changes in regional house prices or rents are a function of population growth, which is driven by immigration in the short run, changes in incomes, local unemployment, local geographic factors (eg climate amenities and city size), and persistent features such as skill levels. The following equation presents this basic model.

Equation 18: A basic model of regional house price changes

$$\Delta \ln P_{kt} = \beta \frac{Imm_{kt-1}}{Pop_{kt-2}} + \alpha X_k + \gamma U_{kt-1} + \rho \Delta Inc_{kt-1} + F_t + \varepsilon_{kt}$$

The dependent variable is the change in the natural logarithm of housing prices or rents (which I denote as P_{kt}) in region k at time period t. The explanatory variables include the (lagged) change in population from immigration (Imm_{kt}) divided by population in the previous period (Pop_{kt}), a vector of time-invariant regional characteristics (X_k),[12] (lagged) regional unemployment rates (U_{kt}), (lagged) changes to average incomes for employed people (ΔInc_{kt}), and a time fixed effect (F_t). ε_{kt} is a residual term, and the Greek letters are parameters to be

[11] Unlike in the previous section, this analysis takes place at the level of the territorial authorities defined at the 2013 Census, of which there are 66. In 2010, seven Auckland TAs were aggregated into a single Auckland Council. Unfortunately, several key data series were only available for the newly aggregated Auckland Council area.

[12] Following Saiz (2007) and Glaeser, Kolko and Saiz (2001), I included the 2001 share of the population aged 15+ that had a bachelor's degree or postgraduate degree, reasoning that places with a higher educational attainment may be more likely to benefit from broad structural economic changes ('knowledge economy'), and also the 1972-2013 average annual sunshine hours, reasoning that places with a better climate may be more attractive in general. Grimes et al (2016) find that higher human capital and a better climate positively affected regional growth over the 1926-2006 period. Unlike Saiz, I did not include regional crime rates as I did not have access to good historical data on crime.

estimated. (Note that the final model specification was slightly different for the house price and rent models, as a result of testing of different lag structures.)

I extend this basic model by adding a time-invariant variable measuring TA-level housing supply constraints (C_k), and interacting it with the immigration variable. Following the analysis in the previous section, I measure housing supply constraints using the ratio of the intensive price of land to the extensive price of land (p_{int}/p_{ext}) in the early 1990s. This measure ranges from 0 to 1, with higher values indicating house prices that are less distorted.

Equation 19: An extended model of regional house price changes with varying housing supply constraints

$$\Delta \ln P_{kt} = \beta \frac{Imm_{kt-1}}{Pop_{kt-2}} + \delta \frac{Imm_{kt-1}}{Pop_{kt-2}} * C_k + \alpha X_k + \gamma U_{kt-1} + \rho \Delta Inc_{kt-1} + F_t + \varepsilon_{kt}$$

To select a functional form for the model, I tested the house price, rent and immigration variables for unit roots using the LLC and IPS tests, with and without a trend. Based on this analysis, which is summarised in the technical appendix, I concluded that house prices and rents are non-stationary in levels but stationary in first differences, and that immigration levels relative to population are stationary. I then used the Akaike Information Criterion to select the number of lags of the explanatory variables to include.

I estimate these models in two steps. First, I estimate the model using a random effects panel model, including dummy variables for time periods. A Hausman test failed to reject the null hypothesis of a difference between coefficients from area fixed effects and random effects models, and hence I used random effects. If migrant arrivals are exogenous to local housing prices, then this will lead to consistent estimates of the effect of migration on local housing markets.

Second, to address potential endogeneity between migration and housing prices, I estimate each model using instrumental variables panel regression, again using random effects and time dummy variables. Endogeneity may arise due to the presence of omitted variables that cause some locations to attract more migrants while simultaneously increasing overall housing prices in those areas. This could include, for instance, amenities or economic advantages that I have not captured in the above variables.

I construct an exogenous 'shift-share' instrument for regional migration levels following the approach outlined by Saiz (2007) and Paciorek (2013). This instrument exploits chain migration patterns in which new migrants tend to settle in the same places that previous migrants from the same origin had settled. Mare, Morten, and Stillman (2007) find that this pattern holds true in New Zealand: the presence of previous migrants in a region is a strong attractor for new migrants.

As shown in Equation 20, I multiply the share of immigrants from country j who arrived in each region over the 1990-1995 period by the total number of immigrants from country j in period t. This provides an estimate of the number of immigrants that are expected to arrive in region k in time period t that reflects (a) time series variation in the total amount of immigration to New Zealand and (b) the effect of prior immigration trends that influence chain migration.

Equation 20: Construction of an instrument for immigrant arrivals at a regional level

$$\widehat{Imm}_{k,t} = \sum_j \phi_{j,k,90-95} * Imm_{j,NZ,t}$$

The validity of this instrument rests on two identifying assumptions. First, I assume that migrants' destinations during the 1990-1995 period are not driven by omitted variables that will also affect future housing prices. This seems reasonable, as this period pre-dates recent divergences in the level of house prices between regions. It is also soon after the Immigration Act 1987, which opened up migration from a wider range of source countries (Beaglehole, 2005). The second identifying assumption is that quarterly changes in national immigration inflows are exogenous to economic conditions in any particular region. This also seems reasonable, as variations in immigration are driven by New Zealand-wide economic conditions, conditions in source countries, and migration policy decisions.

While I am unable to test instrument validity directly, in earlier work I tested three instrumental variables for house prices, including Bartik-style labour demand and income shock measures and a similar shift-share measure of migrant arrivals, and found that this combination of instruments was valid (Nunns, 2018).

I estimate these models using quarterly data over the 1999 Q1 – 2016 Q2 period for 66 territorial authorities, with the seven former Auckland TAs merged into a single Auckland Council. This data is explained in the technical appendix.

4.5. Regional house price adjustment

The following two tables summarise the key results of this analysis, with coefficients of interest highlighted in bold. Interestingly, the coefficients on controls for local amenities, incomes and unemployment rates are not statistically significant in most model specifications, and at times have counterintuitive signs (eg the negative sign on sunshine hours). However, the coefficients of interest have the expected sign and are often statistically significant. They imply that:

- A migration shock equal to one percent of regional population leads to a 1.6% to 2.7% increase in local house prices, based on models 1 and 3.[13] The lower estimate is based on the non-instrumented model (1). These estimates are statistically significant at the 5% and 10% level, respectively.
- A similarly-sized migration shock leads to a 1.5% to 2.1% increase in local rents, based on models 5 and 7. The lower estimate is based on the IV model (7). The estimate from the non-instrumented model is statistically significant at the 1% level.

The sign on the interaction term between migrations shocks and land price distortions is negative in three of four models (ie models 2, 4, and 8, but not 6). This indicates that areas with a higher ratio of intensive land values to extensive land values (indicating smaller house price distortions) in the early 1990s experience *smaller* housing price increases in response to migration shocks. This is consistent with the hypothesis that areas with fewer constraints to housing supply, or more slack in their housing market due to previously low levels of demand, can accommodate demand increases without price increases.

The magnitude of these effects is intuitively plausible. For instance, coefficients from models 4 and 8 suggest that a 1% migration shock in the Auckland region, which had an intensive/extensive land value ratio of 0.24 in the early 1990s, will cause a 3.3% increase in house prices and a 2.3% increase in rents. By contrast, Palmerston North, with an intensive/extensive ratio of 0.38 in the early 1990s, is predicted to only experience a 1.4% increase in house prices and no increase in rents as a result of a similarly-sized shock.

That being said, these effects are not precisely estimated. Coefficients on the interaction term are only statistically significant (at the 5% level) in model 8. I therefore interpret these findings as providing suggestive, but not definitive, evidence that housing supply constraints affect how regional housing markets respond to demand shocks from migration. This tentative finding in turn informs my analysis in the next section.

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[13] Strictly speaking, not all of this effect is due to migrant arrivals. At the national level, increased migrant arrivals tend to coincide with reduced departures of New Zealanders, which will also affect local housing demand. Hence these estimates may capture the effect of both outcomes.

Table 2: Econometric models of regional house prices and migration

Model	**1**			**2**			**3**			**4**		
Dependent variable	**Δln(HP$_{i,t}$)**			**Δln(HP$_{i,t}$)**			**Δln(HP$_{i,t}$)**			**Δln(HP$_{i,t}$)**		
Model type	**Random effects**			**Random effects**			**Random effects IV**			**Random effects IV**		
Explanatory variables	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**
$\frac{Imm_{kt-1}}{Pop_{kt-2}}$ (1)	1.633	0.796	*	3.279	1.137	**	2.675	1.489	.	6.597	3.131	*
$\frac{Imm_{kt-1}}{Pop_{kt-2}} * C_k$ (1)				-5.124	3.706					-13.774	12.542	
DegreeShare$_k$	-0.030	0.020		-0.039	0.022	.	-0.056	0.038		-0.077	0.047	
ln(Sunshine$_k$)	-0.004	0.004		-0.004	0.004		-0.006	0.005		-0.006	0.006	
C_k				0.014	0.008	.				0.033	0.024	
ΔInc_{kt}	0.080	0.057		0.082	0.058		0.082	0.057		0.086	0.058	
ΔInc_{kt-1}	0.008	0.105		0.008	0.105		0.009	0.105		0.008	0.107	
U_{kt-1}	-0.0006	0.0005		-0.0007	0.0006		-0.0005	0.0006		-0.0007	0.0008	
Quarter fixed effects?	Yes			Yes			Yes			Yes		

Notes:

(1) These variables are instrumented in the IV models

(2) Significance levels: . $p<0.1$ * $p<0.05$ ** $p<0.01$ *** $p<0.001$

(3) Standard errors are clustered on territorial authority

Table 3: Econometric models of regional rents and migration

Model	**5**			**6**			**7**			**8**		
Dependent variable	**$\Delta \ln(R_{i,t})$**			**$\Delta \ln(R_{i,t})$**			**$\Delta \ln(R_{i,t})$**			**$\Delta \ln(R_{i,t})$**		
Model type	**Random effects**			**Random effects**			**Random effects IV**			**Random effects IV**		
Explanatory variables	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**	**Coeff**	**Std err**	**p-value**
$\frac{Imm_{kt}}{Pop_{kt-1}}$ (1)	2.088	0.659	**	1.654	1.008		1.536	1.219		6.174	2.297	**
$\frac{Imm_{kt}}{Pop_{kt-1}} * C_k$ (1)				1.590	3.469					-16.255	6.969	*
DegreeShare$_k$	-0.056	0.017	***	-0.049	0.015	***	-0.042	0.031		-0.075	0.048	
ln(Sunshine$_k$)	-0.008	0.004	*	-0.007	0.004	.	-0.007	0.004		-0.009	0.006	
C_k				-0.001	0.007					0.036	0.014	*
ΔInc_{kt}	-0.129	0.065	*	-0.128	0.065	.	-0.129	0.065	*	-0.135	0.066	*
ΔInc_{kt-1}	0.034	0.030		0.035	0.030		0.034	0.030		0.032	0.030	
U_{kt-1}	0.0001	0.0005		0.0001	0.0005		0.0000	0.0004		-0.0002	0.0005	
Quarter fixed effects?	Yes			Yes			Yes			Yes		

Notes:

(1) These variables are instrumented in the IV models

(2) Significance levels: . p<0.1 * p<0.05 ** p<0.01 *** p<0.001

(3) Standard errors are clustered on territorial authority

5. The impact of house price distortions on the regional distribution of employment

The previous section establishes that house price distortions vary significantly between regions, that they have increased more in some locations than in others, and that regions with larger price distortions in the early 1990s may have subsequently experienced larger increases in house prices following migration shocks. The latter finding means that housing may be 'rationed' in supply-constrained regions, requiring some existing residents to move in response to demand shocks.

I now estimate the economic impacts of recent increases in regional house price distortions on New Zealand's economic output (gross domestic product, or GDP) and the distribution of workers between New Zealand regions. To do so, I calibrate the spatial equilibrium model described in Section 3 using data from the 2000-2016 period, and then apply it to several counterfactual scenarios for changes to house price distortions over this period. My analysis follows the approach laid out in Hsieh and Moretti (2015).

5.1. Data used in model calibration

As set out in the theory section, the endogenous variables in the spatial equilibrium model are the share of workers in each location (L_i), local wages (W_i), and output per worker (Y), while the exogenous variables are the model parameters, local total factor productivity (TFP), and local amenities. I define counterfactual scenarios for house price increases over the 2000-2016 period based on my analysis of rising house price distortions (see Table 1).

I group New Zealand's territorial authorities into 22 labour market areas, as defined in the technical appendix. The following data sources are used to identify the observed distribution of workers, regional wages, and regional house prices in New Zealand during the 2000-2016 period:

- Number of workers in each region: I estimate this using Statistics New Zealand's (2018c) *Linked Employer-Employee Data* (LEED), which provides quarterly data on total filled jobs at a TA level over the 1999-2016 period.[14] I group this data to years ended in the March quarter.
- Average wages in each region: I estimate this using LEED data by dividing total wage and salary earnings in each region by total filled jobs. As a robustness check, I construct

[14] Available online at: http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7037

a measure of 'residual' wages controlling for worker characteristics in each region and apply this to estimate regional average wages. An explanation of my residual wage estimates is provided in the technical appendix. I adjust wages to 2017 Q1 New Zealand dollars using SNZ's (2018b) *Consumer Price Index*.

- Average house prices in each region: I estimate this using the sales price dataset described in Section 4, which excludes dwellings other than standalone houses. I group this data over a two-year window, eg using data from 1999/2000 to estimate average house prices in the year ended March 2000. I use the related estimates of changes in land price distortions over time to construct counterfactual scenarios for house prices. I adjust house prices to 2017 Q1 New Zealand dollars using SNZ's *Consumer Price Index*.

As around one in seven employed New Zealanders actually lives in Australia, I extend the model to include Australia as an exogenous 'reservation' location for New Zealand workers. Data from the 2013 New Zealand Census suggests that are few Australian-born people living in New Zealand – equal to less than 0.3% of Australia's population. Hence I assume, conservatively, that most of the people who might be persuaded to migrate back to New Zealand in response to local economic conditions are likely to be New Zealanders. Sensitivity testing reported in the technical appendix suggests that this assumption results in a conservative estimate of the economic impacts of high regional house prices.

I use Australian Bureau of Statistics (2016) Census data to estimate the number of people working in Australia who were born in New Zealand, and estimate the wages and house prices that they face using ABS (2018) data on average weekly wages/salaries and a Bank of International Settlement (2018) house price index for Australia.[15] I convert these figures to real 2017 Q1 New Zealand dollars using an exchange rate series published by the Reserve Bank of New Zealand (2018b) and SNZ's *Consumer Price Index*. I hold Australian wages and house prices constant in the counterfactual scenarios, as New Zealand workers make up a small part of Australian labour and housing markets and thus are unlikely to significantly affect prices.

Lastly, Table 9 in the technical appendix summarises other model parameters and provides a sensitivity range that I use for robustness checks. The main model calibration assumes that the

[15] New Zealanders do not necessarily earn the national average wage, or buy the average house, as they may cluster in certain industries or cities. However, as Australian wages and prices are treated as exogenous, choosing different values will not affect the model results.

labour share of output is 0.6, that the non-land capital share is 0.25, and that workers have a housing expenditure share of 0.25.

5.2. Estimated level of local TFP and amenities

Table 10 in the technical appendix summarises the observed data and estimated levels of the exogenous variables, local TFP and local amenities (net of a constant). This data suggests that Auckland and Greater Wellington are the most productive locations in New Zealand, and that both are roughly comparable in productivity to Australia. All regions are estimated to have increased in productivity over this period, albeit to different degrees. Productivity differentials follow wage differentials between regions.

The model estimates that GDP per worker has risen by around 19.1% over this period, while total GDP has increased by 63.1% due to an increase in the size of the labour force.[16]

Local amenities are estimated to be highest in Queenstown-Central Otago and in Greater Tauranga. They are lower in Australia than almost all New Zealand regions, suggesting that New Zealanders have a preference for living in New Zealand. Auckland and Queenstown are estimated to have experienced relative increases in amenities over this period, although this effect is dampened considerably if we assume imperfect labour mobility.

Lastly, the share of New Zealanders working in Australia appears to have declined slightly over this period, while the share of New Zealand-based workers located in Auckland has risen from just over 33% to almost 35%. Although Auckland has experienced a rapid increase in house prices over this period, in part due to supply constraints, increasing amenities appear to have offset this to a degree, allowing the city to keep growing.

Next, I use estimated levels of local TFP and local amenities as inputs to a counterfactual analysis of what would have happened if house price distortions had *not* increased so rapidly over this period.

5.3. Defining counterfactual scenarios for house price increases

I define three counterfactual scenarios for house price increases over the 2000-2016 period to investigate the impact that reducing constraints on housing supply would have had on the regional distribution of employment and hence on economic output. These scenarios are based

[16] By comparison, Statistics New Zealand data suggests that labour productivity in the measured sector rose by 23% over this period, while real GDP (production measure) rose by 53%.

on the results of the decomposition of regional house price changes in Section 4. Under these scenarios, I assume that regional house prices would rise over the 2000-2016 period due to increased building value and increased hedonic value of land, but that removal of constraints to housing supply would prevent some or all of the increase in land price distortions that occurred over that period:

- **Scenario 1: Reduce housing supply constraints in Auckland**. This scenario is assumed to halve the growth in land price distortions in that location. As a result, average Auckland house prices would have risen to around $816,700, rather than the observed level of $999,000. Other regions would be unaffected.
- **Scenario 2: Reduce housing supply constraints nationally**. This scenario is assumed to prevent any further increase in house price distortions over the 2000-2016 period. Average house prices would still increase due to increases in the value of buildings and increases in the hedonic value of land, but increases would be considerably lower.
- **Scenario 3: Reduce house price distortions to zero**. In this scenario, comprehensively eliminating constraints to housing supply in all New Zealand regions is assumed to reduce price distortions to zero in all locations. This would entail a further reduction in price distortions over and above Scenario 2, although prices would still rise slightly relative to 2000 levels due to building improvements and the rising hedonic price of land. This is an ‘aspirational’ scenario that provides an upper bound on the economic gains that could be achieved by reducing house prices.

5.4. Overview of results

The following table summarises my counterfactual analysis of these three scenarios, highlighting the impact that each scenario would have on output per worker (ie labour productivity), total economic output (ie GDP), and the distribution of New Zealand workers between New Zealand and Australia and between Auckland and other New Zealand regions. These outputs are based on central assumptions about model parameters. In the technical appendix, I demonstrate that these results are robust to changes in parameters.

I present results for two alternative model specifications. The top panel shows results from a model specification that assumes perfect labour mobility, with workers that do not have any idiosyncratic preferences to live in specific places. In this specification, the regional labour supply curve is perfectly elastic. The bottom panel shows results from a model specification that assumes imperfect labour mobility as individual workers prefer some locations to others. In this specification, the regional labour supply curve is upward-sloping, as some workers require higher wages to encourage them to switch between regions.[17]

The third scenario has the largest impact on economic output. As it results in the largest decreases in house prices, especially in Auckland, it redistributes more workers from Australia and towards New Zealand's higher-productivity regions. In the perfect labour mobility case, reducing land price distortions to zero would increase New Zealand's GDP by around 7.7%. However, output per worker would only increase by 0.9%, as the shift of New Zealand workers back across the Tasman would 'arbitrage' away some of the growth in productivity and wages.

In the imperfect labour mobility case, the third scenario would increase total output by 4.5%, as fewer New Zealanders would return from Australia, but output per worker would rise by 1.4%. Under either specification, this scenario would have a large impact on trans-Tasman migration flows. It would lead to a cessation of net migration from New Zealand to Australia in the perfect mobility case, or a roughly 50% reduction in net migration in the imperfect mobility case.

In the second scenario, preventing further increases in land price distortions over the 2000-2016 period, but not unwinding distortions that arose prior to 2000, would deliver approximately two-thirds of the economic benefits of the third scenario. This suggests that most of the economic costs of housing supply constraints in New Zealand have arisen since 2000.

The first scenario, which would reduce the growth in house prices in Auckland but not in other regions, is estimated to result in smaller but still significant economic impacts. Results from this scenario suggest that would have been possible to achieve roughly one-third to half of the total gains for output per worker simply by slowing the rapid increase in house price distortions in Auckland over the 2000 to 2016 period. This highlights the macro-economic importance of the Auckland housing market.

[17] Both specifications assume full employment, with no labour supply response from people entering the labour force.

Table 4: Outcomes from counterfactual scenarios for house price distortions

Outcome	Scenario 1: Reduce supply constraints in Auckland	Scenario 2: Reduce supply constraints nationally	Scenario 3: Reduce house price distortions to zero
Panel 1: Perfect labour mobility ($1/\theta = 0$)			
Increase in output per worker relative to observed outcome	0.5%	0.6%	0.9%
Increase in total output relative to observed outcome	1.8%	5.3%	7.7%
Share of NZers working in New Zealand	87.4%	90.4%	92.2%
Share of NZ workers located in Auckland	40.8%	41.3%	42.5%
Panel 2: Imperfect labour mobility ($1/\theta = 0.3$)			
Increase in output per worker relative to observed outcome	0.4%	0.9%	1.4%
Increase in total output relative to observed outcome	0.9%	3.0%	4.5%
Share of NZers working in New Zealand	86.8%	88.1%	89.0%
Share of NZ workers located in Auckland	37.2%	37.4%	37.9%

In Table 11 in the technical appendix, I present results for a variant of this model that excludes trans-Tasman migration and focuses only on redistribution of workers between New Zealand regions. Under this model variant, Scenario 3 would lift total economic output and per-worker output by 0.8% in the perfect labour mobility case and 0.4% in the imperfect labour mobility case. A comparison with the above results suggests that most of the estimated economic impacts arise from a reduction in net migration of workers from New Zealand to Australia, rather than reallocation of labour from low-productivity regions to high-productivity regions within New Zealand.

6. Conclusion and discussion

This paper explores the causes and economic consequences of recent increases in regional house prices in New Zealand.

I demonstrate that recent house price increases in New Zealand are due in large part to distortions in house prices, which in turn reflect housing supply constraints colliding with rising housing demand. While I have not identified specific supply constraints or demand factors, the literature suggests that zoning rules that limit new subdivision, limit redevelopment of existing sites, or require large lot sizes and costly features such as on-site carparking can constrain supply, while population growth, availability of mortgage credit, and tax policies that incentivise property investment can push up demand (Gyourko and Molloy, 2015; Andrews, Sanchez, and Johansson, 2011). Regions with larger house price distortions appear to have experienced larger increases in house prices and rents in response to migration shocks.

Rising house price distortions in recent decades have had large economic impacts. These arise due to misallocation of labour away from high-productivity regions in New Zealand (ie Auckland and Wellington) and increased net migration of New Zealanders to Australia. My ‘upper bound’ estimate is that comprehensively removing constraints to housing supply may increase New Zealand’s total economic output by 7.7%, increase per-worker output by 0.9%, and eliminate net migration outflows to Australia. However, more plausible counterfactual scenarios would result in smaller, but still economically meaningful, gains on the order of one to five percent of GDP.

To put these results in context, modelling of the Trans-Pacific Partnership, a major international trade and investment agreement that originally involved twelve countries, indicated that it may increase New Zealand’s GDP by up to 1.4% (Strutt, Minor, and Rae, 2015).[18] In other words, the economic gains from overcoming constraints to housing supply and reducing house price distortions appear to outweigh the benefits of further trade liberalisation.

[18] Coates, Oram, Bertram, and Hazledine (2016) critique the modelling assumptions underpinning this estimate and argue that the true economic gains may be significantly lower. Their critique reinforces my point that the gains from improving housing supply are likely to outweigh the gains from further trade liberalisation.

6.1. Comparison with previous studies

My results provide an interesting contrast with Hsieh and Moretti's (2015) findings for the United States. Using a similar spatial equilibrium model, they estimate that labour reallocation between US cities may increase output per worker by up to 8.9%. Likewise, de Groot, Marlet, Teulings, and Vermeulen (2015) estimate that relaxing planning constraints in the Dutch Randstad region could increase economic welfare by up to 10%. By comparison, my analysis suggests that labour reallocation between New Zealand regions may increase output per worker by up to 0.9%.

The gains from reallocation of labour between low-productivity and high-productivity regions in New Zealand are smaller because wage and productivity differentials between regions are much smaller than in the US or the Netherlands. For instance, Hsieh and Moretti estimate that San Francisco, San Jose, and New York enjoy a wage premium of nearly 50%, whereas wages in Auckland and Wellington are only around 10% higher than the national average.

However, the *total* economic gains from reducing housing supply constraints in New Zealand are still large – up to 7.7% of GDP – because high house prices also affect trans-Tasman migration and hence the total size of the New Zealand labour force.

My findings also reflect on previous New Zealand research on the impacts of migration on regional housing markets. Previous research, based on data from the 1980s to mid-2000s, indicates that demand shocks from immigration or industry growth have small impacts on regional house prices (Stillman and Maré, 2008; Maré, Grimes and Morten, 2009). By contrast, I find evidence that migration inflows have had larger effects on regional house prices over the 2000-2016 period, and some evidence of stronger effects in regions that previously had larger house price distortions.

The analysis reported in Table 4 suggests that around two-thirds of the economic impacts of rising house price distortions have arisen since 2000. This is consistent with the idea that housing demand shocks have had larger impacts on regional house prices since 2000 than in earlier decades.

It also suggests that the past may be a poor guide to the future. Supply constraints that were not initially binding can become increasingly restrictive as housing demand increases. Housing demand is likely to continue increasing: SNZ's medium population projection implies that New Zealand's population will rise by 25% over the next three decades, and faster increases are possible if strong net migration continues (Statistics New Zealand, 2017b). This highlights the ongoing importance of policy measures to increase the responsiveness of housing supply and reduce distortions in house prices.

6.2. Areas for further research

To conclude, I discuss some areas for further research.

First, the analysis in Section 4.5 demonstrates that house price distortions provide a useful indicator of housing supply constraints that may cause regional housing markets to respond differently to demand shocks from migration. Measured house price distortions could therefore be used in further analysis of how regional housing markets and labour markets adjust to demand shocks. This could include, for instance, re-examining the impacts of employment shocks on house prices (Maré, Graham, and Morten, 2009), further investigating housing supply responses to demand shocks (Grimes and Aitken, 2010; Nunns, 2018), or investigating the drivers of regional employment growth (Saks, 2008; Vermuelen and van Ommeren, 2009).

Second, further research is needed to identify specific policy, geographic, or economic factors that cause regional house price distortions. In the technical appendix I present supplementary analysis showing that current price distortions are associated with several measurable factors that may constrain housing supply. This analysis is limited by the lack of quantitative indicators of supply constraints, a la the Wharton Land Use Regulation Index (WRI) that is commonly used in US research (Gyourko and Molloy, 2015). However, Hilber and Vermeulen (2016) demonstrate that it is possible to analyse these relationships without WRI-style indicators.

Third, future work could extend the spatial equilibrium model described in Section 3 to consider alternative specifications for the regional production function. Sensitivity testing reported in the technical appendix suggests that my results are robust to changes in labour and capital factor shares and other model parameters. However, it may be useful to relax other assumptions, such as the assumption that all regions produce a homogeneous tradeable good or the assumption that labour, capital, and land factor shares are similar in all regions.

Urban areas in New Zealand tend to specialise in producing non-tradeable goods and intermediate inputs for export production, while rural areas specialise in production of agricultural goods for export (Conway and Zheng, 2014). Hsieh and Moretti (2015) suggest that these differences could be captured through variations to the core model. For instance, regional specialisation could be captured by allowing regions to produce differentiated goods that can be traded with other regions (incurring shipping costs) or consumed locally, a la Krugman's (1991) model of regional agglomeration.

Fourth, the spatial equilibrium model used in this analysis addresses the possibility that workers have idiosyncratic preferences to live in specific regions, but it could be extended further to explore the impacts of heterogeneity between workers arising from skill levels, age, or home ownership. For instance, Ganong and Shoag (2017) develop a similar spatial equilibrium model that includes high-skilled and low-skilled workers, while Sinning and Stillman (2012) analyse trans-Tasman migration patterns for workers of different ages and occupations. It is possible that different types of workers 'sort' into different locations depending upon their personal characteristics.

Finally, it would be worthwhile to investigate whether the economic impacts of housing supply constraints are as large in other countries as they appear to be in New Zealand and the United States. The spatial equilibrium model outlined in this paper is straightforward to apply in other contexts given data on wages, employment, and house prices. In light of previous research that suggests that house price increases 'spill over' Australian and New Zealand cities (Greenaway-McGrevy, Grimes and Holmes, 2018), a useful first step would be to extend this model to include Australian regions.

Moving beyond the Tasman Sea, this model could be used to benchmark the economic impacts of regional house price differences in a range of countries with different housing market policies. This could assist in identifying policy settings and economic arrangements that are successful in minimising the negative economic impacts of regional housing supply constraints.

7. Technical appendix

7.1. Definition of labour market areas used in analysis

Conway and Zheng (2014) use Census commuting data to divide New Zealand into labour market areas that reflected commuting patterns across administrative boundaries. I adapt their definitions slightly to align with territorial authority boundaries. The following table summarises the resulting classification of territorial authorities into labour market areas.

Table 5: Labour market areas used in analysis

Labour market area	**Territorial authority (2006)**	**Labour market area**	**Territorial authority (2006)**
Northland	Far North District	Taranaki Rural	Stratford District
	Whangarei District		South Taranaki District
	Kaipara District	Greater Palmy	Manawatu District
Auckland	Rodney District		Palmerston North City
	North Shore City	Horowhenua-Wairarapa	Horowhenua District
	Waitakere City		Masterton District
	Auckland City		Carterton District
	Manukau City		South Wairarapa District
	Papakura District	Greater Wellington	Kapiti Coast District
	Franklin District		Porirua City
Thames-Coromandel	Thames-Coromandel District		Upper Hutt City
	Hauraki District		Lower Hutt City
	Matamata-Piako District		Wellington City
Greater Hamilton	Waikato District	Nelson-Tasman-West Coast	Tasman District
	Hamilton City		Nelson City
	Waipa District		Buller District
Taranaki Rural	Otorohanga District		Grey District
	Waitomo District	Marlborough-North Canterbury	Marlborough District
North central NI	South Waikato District		Kaikoura District
	Taupo District		Hurunui District
	Rotorua District	Rural Canterbury-Westland	Westland District
	Whakatane District		Ashburton District
	Kawerau District		Timaru District
Greater Tauranga	Western Bay of Plenty District		Mackenzie District
	Tauranga City		Waimate District
Gisborne-Opotiki-Wairoa	Opotiki District		Waitaki District
	Gisborne District	Greater Christchurch	Waimakariri District

	Wairoa District		Christchurch City
Napier-Hastings	Hastings District		Selwyn District
	Napier City	Queenstown-Central Otago	Central Otago District
Central NI rural	Central Hawke's Bay District		Queenstown-Lakes District
	Ruapehu District	Dunedin	Dunedin City
	Rangitikei District	Southland	Clutha District
	Tararua District		Southland District
New Plymouth	New Plymouth District		Gore District
Whanganui	Wanganui District		Invercargill City

7.2. Summary of land price distortions during the 2014-2016 period

The following table summarises estimated land price distortions for New Zealand's territorial authorities in the 2014-2016 period, based on the results of two alternative hedonic models.

Table 6: Estimated land price distortions at the territorial authority level, 2014-2016

TA	Number of sales	p_{ext}	Model 1 results				Model 2 results			
			ρ	Robust se	p_{int}	p_{ext}-p_{int}	ρ	Robust se	p_{int}	p_{ext}-p_{int}
Christchurch City	16519	$389	0.173	0.006	$142	$247	0.153	0.006	$126	$263
Manukau City	14836	$811	0.245	0.008	$292	$519	0.259	0.007	$309	$502
Waitakere City	9693	$630	0.185	0.007	$176	$454	0.195	0.006	$186	$444
Auckland City	9476	$1,548	0.255	0.014	$533	$1,015	0.287	0.012	$601	$947
North Shore City	9100	$1,061	0.232	0.009	$354	$707	0.234	0.008	$357	$704
Tauranga City	8481	$486	0.141	0.011	$125	$360	0.185	0.013	$165	$321
Hamilton City	8175	$373	0.167	0.009	$117	$256	0.165	0.009	$115	$258
Dunedin City	7249	$181	0.110	0.008	$49	$131	0.105	0.008	$47	$134
Wellington City	6971	$553	0.091	0.008	$103	$451	0.070	0.007	$79	$475
Rodney District	4779	$449	0.108	0.009	$84	$365	0.122	0.009	$94	$355
Palmerston North City	4685	$215	0.208	0.009	$95	$120	0.172	0.008	$79	$136
Lower Hutt City	4484	$316	0.081	0.009	$50	$267	0.073	0.008	$44	$272
Whangarei District	4220	$185	0.073	0.009	$28	$156	0.079	0.009	$31	$154
New Plymouth District	4051	$221	0.090	0.009	$43	$178	0.094	0.009	$45	$176
Papakura District	3704	$624	0.124	0.014	$128	$496	0.139	0.013	$144	$480
Invercargill City	3664	$98	0.161	0.014	$43	$55	0.143	0.014	$38	$60
Selwyn District	3357	$234	0.196	0.012	$113	$120	0.138	0.010	$80	$154
Thames-Coromandel District	3212	$441	0.079	0.016	$56	$385	0.120	0.016	$84	$356
Napier City	3202	$269	0.159	0.011	$87	$182	0.153	0.011	$84	$185
Hastings District	3168	$179	0.225	0.012	$88	$91	0.196	0.010	$77	$103

Waimakariri District	3020	$239	0.183	0.011	$112	$128	0.160	0.007	$98	$142
Kapiti Coast District	2973	$244	0.151	0.011	$76	$168	0.156	0.010	$79	$165
Marlborough District	2879	$180	0.167	0.012	$62	$117	0.162	0.011	$60	$119
Rotorua District	2834	$190	0.125	0.021	$47	$143	0.157	0.021	$59	$131
Franklin District	2807	$377	0.151	0.011	$103	$275	0.159	0.010	$108	$269
Nelson City	2731	$309	0.103	0.014	$65	$243	0.109	0.012	$70	$239
Timaru District	2703	$157	0.163	0.011	$59	$98	0.150	0.011	$54	$103
Waipa District	2676	$249	0.164	0.013	$83	$166	0.138	0.012	$69	$180
Waikato District	2598	$248	0.154	0.016	$71	$177	0.145	0.015	$66	$181
Tasman District	2533	$226	0.211	0.012	$94	$132	0.197	0.010	$87	$138
Queenstown-Lakes District	2379	$362	0.117	0.013	$83	$279	0.136	0.012	$96	$266
Far North District	2363	$84	0.083	0.009	$16	$68	0.087	0.009	$17	$67
Porirua City	2339	$261	0.079	0.012	$51	$211	0.077	0.011	$49	$212
Whanganui District	2269	$67	0.244	0.017	$55	$12	0.178	0.016	$40	$27
Upper Hutt City	2086	$218	0.106	0.011	$52	$166	0.104	0.010	$51	$167
Horowhenua District	2023	$67	0.174	0.013	$32	$35	0.133	0.012	$25	$43
Taupo District	1981	$240	0.171	0.028	$82	$158	0.212	0.029	$101	$138
Western Bay of Plenty District	1981	$305	0.124	0.041	$71	$235	0.155	0.046	$88	$217
Gisborne District	1794	$121	0.186	0.037	$54	$67	0.159	0.032	$46	$74
Matamata-Piako District	1742	$170	0.165	0.024	$64	$106	0.151	0.024	$59	$112
Ashburton District	1684	$188	0.190	0.020	$77	$111	0.167	0.017	$67	$121
Whakatane District	1520	$229	0.168	0.017	$80	$149	0.188	0.017	$90	$139
Waitaki District	1515	$88	0.125	0.017	$31	$57	0.119	0.016	$29	$59
Central Otago District	1445	$171	0.193	0.023	$73	$98	0.166	0.021	$63	$108
Masterton District	1407	$113	0.144	0.018	$37	$76	0.125	0.021	$32	$81
South Waikato District	1383	$62	0.181	0.034	$32	$30	0.105	0.035	$19	$44
South Taranaki District	1178	$67	0.180	0.022	$38	$28	0.139	0.021	$30	$37
Manawatu District	1163	$72	0.167	0.012	$39	$32	0.148	0.012	$35	$37
Hauraki District	1133	$151	0.154	0.021	$48	$103	0.135	0.019	$42	$109
Kaipara District	1088	$152	0.168	0.019	$53	$100	0.165	0.017	$52	$101
Southland District	1067	$60	0.236	0.027	$47	$13	0.214	0.026	$43	$18
South Wairarapa District	799	$108	0.251	0.026	$67	$42	0.161	0.025	$43	$65
Tararua District	774	$34	0.245	0.031	$33	$2	0.177	0.027	$24	$11
Gore District	736	$67	0.161	0.033	$36	$31	0.131	0.033	$29	$37
Clutha District	708	$46	0.232	0.035	$39	$7	0.192	0.034	$32	$14
Rangitikei District	637	$35	0.238	0.027	$30	$5	0.238	0.028	$30	$5
Central Hawke's Bay District	629	$42	0.195	0.031	$27	$14	0.172	0.026	$24	$17
Ruapehu District	604	$33	0.136	0.042	$18	$15	0.124	0.040	$16	$17

Carterton District	504	$76	0.182	0.029	$40	$35	0.130	0.027	$29	$47
Hurunui District	494	$119	0.093	0.017	$28	$91	0.096	0.016	$29	$90
Kawerau District	493	$72	0.434	0.083	$78	-$6	0.214	0.085	$38	$34
Grey District	467	$69	0.199	0.033	$51	$19	0.132	0.034	$34	$36
Stratford District	401	$83	0.156	0.035	$35	$48	0.152	0.034	$34	$50
Mackenzie District	372	$166	0.102	0.068	$40	$125	0.084	0.064	$33	$132
Waitomo District	340	$50	0.149	0.066	$23	$27	0.141	0.071	$22	$28
Westland District	333	$57	0.078	0.038	$14	$42	0.054	0.032	$10	$47
Waimate District	310	$62	0.205	0.031	$37	$25	0.144	0.030	$26	$36
Buller District	266	$39	0.265	0.047	$52	-$13	0.173	0.049	$34	$5
Opotiki District	265	$90	0.123	0.036	$29	$62	0.173	0.037	$40	$50
Wairoa District	238	$36	0.161	0.052	$21	$15	0.158	0.050	$21	$15
Otorohanga District	209	$104	0.133	0.065	$34	$70	0.105	0.063	$27	$77
Kaikoura District	192	$183	0.141	0.035	$57	$126	0.168	0.035	$68	$115

7.3. House price distortions and measurable housing supply constraints

Previous New Zealand research has assumed that these constraints on housing supply cause distortions in house / land prices, but it has not formally tested this assumption. In part, this is due to the fact that there are few good measures of the degree of regulatory constraints to housing supply in New Zealand regions.

In the US, the Wharton Land Use Regulation Index (WRI) is commonly used to measure the strictness of land use regulations, and the characteristics of land use regulations in different locations. It measures both regulatory policy (eg minimum lot sizes, the presence of caps on new building permits, and 'impact fees' for new developments) and regulatory processes (eg the need to obtain development approval from multiple government bodies, and delays in processing building permits). NZIER (2015) trialled a similar measure for nine territorial authorities in New Zealand but did not scale it up to cover all regions.

Following previous research into factors that constrain housing supply, I calculate several new measures of potential supply constraints:

- Geographical constraints: Saiz (2010) and Paciorek (2013) find that the presence of geographic constraints, defined as a lack of flat, reasonably developable land, reduces the responsiveness of housing supply. Following Paciorek (2013), I calculate the amount of land in each TA that has a slope under 15% and use this to estimate the quantity of flat land per existing dwelling at the 2001 Census. To normalise this, I divide it into 170m^2, which is the gross amount of land per dwelling in the Auckland city centre as at the 2013 Census, to obtain a 'buildout ratio'.[19]

- Delays in processing resource consents: Delays in reviewing / approving building permits or rezoning requests has been shown to influence the responsiveness of housing supply (eg Mayer and Somerville, 2000b). I use data from the Ministry for the Environment's 2000-2008 RMA Survey of Local Authorities to estimate the share of resource consents were delayed beyond statutory timeframes of 20 working days for each territorial authority. I chose this time period as it predates a 2009 reform that tightened requirements to comply with statutory processing timeframes.[20]
- Environment Court cases: Ganong and Shoag (2017) measure how land use regulation has changed over time in US states by counting the number of state court cases involving land use issues. They reason that an increase in regulation is likely to coincide with an increase in litigation related to land use. I constructed a similar measure for New Zealand TAs by calculating the number of Environment Court cases that involved each TA as a primary party to the case over the 1996-2006 period and dividing by the number of dwellings consented over this period (Environment Court, 2018).[21] As the Environment Court also hears cases regarding environmental management and water management, many cases are unrelated to land use or housing development, potentially leading to bias for 'unitary' authorities like Marlborough District that are also responsible for environmental management functions of regional councils.[22]
- Development and financial contributions: Many, although not all, councils levy fees on new dwellings to internalise some of the costs of new infrastructure. These fees are factored into house prices, and may also affect new development activity. I estimated the average development contribution per new dwelling consented using data from

[19] See Nunns (2018) for a further description of this measure. I also interact this measure with a dummy variable for whether the TA in question is a city or district council, as city council boundaries tend to be drawn more tightly around the existing urban area.

[20] In the UK, Hilber and Vermuelen (2016) demonstrate that more stringent requirements to process consents within statutory timeframes has caused councils to reject developments faster to comply with the letter, but not the intent, of the law. Anecdotally, the response to the 2009 law changes in New Zealand has been more benign: councils use requests for further information from applicants in order to 'stop the clock' on processing time.

[21] The Environment Court hears appeals on decisions taken under the Resource Management Act, which is the framework legislation for urban planning in New Zealand. This data is available from the last quarter of 1996 to the end of 2017.

[22] A further issue is that councils tend to receive more appeals in the wake of major district plan reviews. In recent years, plan reviews have often (but not always) resulted in increased options to build new housing, eg via reduced minimum lot sizes or greenfield rezoning. This may create problems for interpreting this measure.

Statistics New Zealand's (2014) *Local Authority Financial Statistics*. For each TA, I calculated total revenue from development and financial contributions over the 2003-2008 period, and divided this by total dwelling consents, noting that some councils did not levy DCs during some of these years.

I used OLS regression to estimate the impact of these variables on estimated land price distortions from model 1 above. To avoid the obvious endogeneity problems, I compare land price distortions during the 2014-2016 period with lagged housing supply constraint measures during the mid-1990s to mid-2000s.

The following table summarises the results of this analysis. First, a higher buildout ratio (indicating lower availability of flat, comparatively developable land) results in a statistically significant increase in land price distortions. A one percentage point increase, which is equivalent to rising from Invercargill to Kapiti Coast density levels, is estimated to increase land price distortions by \$39/m^2.[23]

Second, an increased likelihood of consent processing delays also results in a statistically significant increase in land price distortions. A ten percentage point increase, equivalent to the difference between Whangārei to Tauranga, is estimated to result in a \$24/m^2 increase.

Third, higher development contributions are associated with larger land price distortions. The coefficient estimate suggests that a \$1 increase in development contributions is associated with a \$0.02/m^2 increase in land price, which is highly statistically significant. This equates to a \$10 increase in price for a typical 500m^2 residential section, which is ten times as large as the increase in DCs. This implies that councils that adopt high DCs are also more likely to implement other unobserved constraints on new housing supply, eg due to challenges funding infrastructure for new growth areas.

Lastly, the number of Environment Court cases per 1000 dwelling consents did not have a statistically significant effect on land price distortions. This is likely to be due to the issues with this measure that I identified above.

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[23] Further testing suggests that these impacts did not differ between city and district councils. City council boundaries are typically drawn tightly around urbanised areas, while district councils typically include a larger amount of rural land. This suggests that this measure is unlikely to suffer from endogeneity due to how it has been defined.

This analysis suggests that higher land price distortions may indicate the presence of housing supply constraints, some of which cannot be easily measured.

Table 7: Determinants of land price distortions, 2014-2016

Dependent variable	**Land price distortion ($/m^2, estimated using model 1)**		
	Coefficient	**Robust SE**	**p-value**
Constant	0.4	32.3	0.991
Buildout ratio (2001)	3851.6	810.0	0.000***
Share of consents delayed (2000-2008)	238.2	124.0	0.059 .
Average development contribution (2003-2008)	0.019	0.004	0.000***
Environment Court cases per 1000 dwelling consents (1996-2006)	-0.800	0.682	0.245
Observations	72		
R2	0.693		
F-stat	12.1*** (df = 4; 67)		

Note: . p<0.1; * p<0.05; ** p<0.01; *** p<0.001

7.4. Data used to model the impact of migration on regional house prices

To analyse the impact of migration shocks on regional housing markets, I use the following sources of data, which are available at a quarterly basis for New Zealand territorial authorities over the 1999-2016 period:

- Housing prices: I use the average house prices series published at a TA level by MBIE (2018b), and MBIE (2018a) data on mean rents for three bedroom standalone homes based on tenancy bonds lodgements.
- Share of population with a university degree: I use SNZ (2001) data from the 2001 Census to estimate this at a TA level.
- Annual average sunshine hours: I use geographic estimates of sunshine hours from NIWA (2016) to estimate this at a TA level.
- Unemployment rates: I use data from SNZ's (2018d) *Household Labour Force Survey*, matching regions to territorial authorities.
- Incomes: I use TA-level data from SNZ's (2018c) *Linked Employer-Employee Database* to estimate average quarterly earnings per employee.

- Immigration: I use a custom data request for SNZ's *Permanent and Long Term Migration* data to estimate the number of people who state each TA as their destination in each quarter.[24] To create the migration instrument above, I further disaggregated migrant arrivals by country of origin and whether or not they are a New Zealand citizen.
- Population: I use SNZ's (2018f) *Subnational Population Estimates* to estimate the number of people living in each TA. As this data is annual and published in the June quarter, I linearly interpolate for missing quarters.

7.5. Unit root tests for panel model of regional housing prices and migration

Before estimating models of the impact of migration shocks on regional housing prices, I test model variables for non-stationary behaviour. Mayer and Somerville (2000a) and Grimes and Aitken (2010) find that regional house prices tend to be non-stationary, meaning that their mean, variance, and/or covariance between adjacent terms may change over time. Similarly, other model variables such as incomes or unemployment rates may be non-stationary.

I therefore conduct four alternative panel unit root tests on key model variables to understand whether they are stationary or non-stationary:

- The Levin-Lin-Chu (LLC) test, with and without a time trend. LLC tests whether there is a common unit root for all TLAs in the panel.
- The Im-Pesaran-Shin (IPS) test, again with and without a time trend. IPS tests whether any individual TLAs in the panel exhibit a unit root.

The number of lags was selected with the Schwarz information criterion (SIC). As the null hypothesis for these tests is that the variable contains a unit root, a p-value below a given critical value (say 5%) indicates that the variable is stationary. The following table summarises the results, with tests that did not reject a unit root at either the 1%, 5%, or 10% level highlighted in bold.

As expected, all four tests fail to reject the null hypothesis of a unit root for the natural log of house prices and rents, indicating that these variables are likely to be non-stationary. However,

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[24] A share of migrants leave their destination unstated. This share does not appear to have trended up or down over the 2001-2016 period and hence I disregard it. However, I note that it will mean that my estimates of the effect of migration on housing prices are slightly over-stated.

all three housing price variables are stationary in differences, and this is how I include them in the model.

None of the other variables except the migration instrument show signs of a unit root. The LLC test fails to reject the null hypothesis of a common unit root for the migration instrument. I treat this variable as stationary in the model as this may simply arise due to the way I have constructed the instrument.

Table 8: Unit root tests on model variables

Variable	LLC no trend		LLC trend		IPS no trend		IPS trend	
	statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value
ln_rent	-0.54568	0.2926	0.54008	0.7054	-1.22941	0.1095	0.91501	0.8199
ln_mean_price	-0.9052	0.1827	-0.866	0.1932	-1.2638	0.1032	1.06845	0.8573
ln_spar	-0.35861	0.3599	1.28439	0.9005	-1.15823	0.1234	3.17291	0.9992
d_ln_rent	-85.3182	0	-83.5083	0	-86.5392	0	-86.4404	0
d_ln_mean_price	-87.836	0	-90.9623	0	-84.9889	0	-87.9412	0
d_ln_spar	-35.5272	0	-42.0286	0	-37.4991	0	-41.0078	0
unemployment	-10.8077	0	-14.9014	0	-12.7357	0	-11.9834	0
ln_income	-2.38265	0.0086	-5.98078	0	-2.72354	0.0032	-3.87451	0.0001
d_ln_income	-87.836	0	-90.9623	0	-84.9889	0	-87.9412	0
arrivals_per_population	-8.86555	0	-15.8431	0	-14.6732	0	-17.9506	0
migration_instrument	2.85623	0.9979	8.67557	1	-6.92532	0	-6.8876	0

Note: Unit root tests were conducted in EViews.

7.6. Parameters used to calibrate spatial equilibrium model

The following table summarises parameters I used to calibrate the spatial equilibrium model used to estimate the impact of house price distortions on the regional distribution of employment. As indicated in this table, I sensitivity test alternative parameter values to ensure that my results are robust to changes in assumptions.

I note that there is uncertainty around several model parameters, in particular the capital share parameter and the parameter for workers' degree of location preference.

With regards to the capital share parameter, it is necessary to distinguish between returns to investment capital versus returns to land and natural resources. Hsieh and Moretti (2015) estimate that returns to land and natural resources make up around 10% of US GDP, which is similar to Guerriero's (2012) estimate of 8% of US GDP. Caselli and Feyrer (2007) estimate a considerably higher figure for New Zealand: a land and natural resources share of 21% and an investment capital share of only 12%. I choose a midpoint between these estimates.

No studies have estimated the degree of location preference in New Zealand, although we would expect it to be lower than in many other jurisdictions due to the high share of New Zealanders who have migrated at some point in their lives. My central estimate of this parameter is derived from Hornbeck and Moretti (2018), while I note that Serrato and Zidar (2016) and Diamond (2016) provide estimates for shorter (<10 year) periods. I sensitivity test a wide range of parameters as a robustness check.

Table 9: Spatial equilibrium model parameters

Parameter	**Estimate**	**Sensitivity test**	**Source**
Production function labour share α	0.6	0.5	Guerriero (2012) estimate an average labour share of 0.613 in the 2000s (Appendix H). Observed values range between 0.51 (2002) and 0.76 (1980)
Production function capital share η	0.25	0.1	See discussion above. Some estimates suggest that land and natural resources account for most of the capital share.
Cost of capital R	0.07	N/A	RBNZ (2018c) data suggests that the average business lending rate over 2000-2017 period was 6.8% and the average residential mortgage rate was 6.9%.
Housing expenditure share β	0.25	0.3	SNZ's (2017c) *Household Economic Survey* data suggests that the average household spends around 25% on housing. See also Perry (2017) for a discussion of how this parameter varies by income.
Degree of location preference $1/\theta$	0.3	0.1 – 1.0	The central estimate is derived from Hornbeck and Moretti (2018). Serrato and Zidar (2016) and Diamond (2016) provide estimates for shorter (<10 year) periods.

7.7. Spatial equilibrium model inputs and estimated local TFP and amenities

The following table summarises observed inputs to the spatial equilibrium model, and the resulting estimates of local TFP and amenities for New Zealand regions and Australia, which are used as an input to counterfactual analysis.

Table 10: Summary of observed model variables and implied level of exogenous variables (assuming perfect mobility, ie $1/\theta = 0$)

Labour market area	**2000: Observed data**					**2016: Observed data**				
	Average house price	**Employment**	**Average wage**	**Local TFP (natural log)**	**Local amenities (natural log)**	**Average house price**	**Employment**	**Average wage**	**Local TFP (natural log)**	**Local amenities (natural log)**
Northland	$234,092	38,080	$39,561	7.38	-8.16	$405,032	52,438	$50,384	7.56	-8.26
Auckland	$390,034	475,378	$53,603	7.99	-8.34	$998,955	685,618	$61,811	8.10	-8.24
Thames-Coromandel	$250,682	20,235	$38,424	7.27	-8.11	$446,769	27,238	$49,536	7.45	-8.22
Greater Hamilton	$252,868	71,810	$43,855	7.56	-8.24	$490,485	109,588	$54,935	7.74	-8.30
Taranaki Rural	$122,870	18,300	$41,761	7.31	-8.37	$210,415	21,603	$54,020	7.48	-8.50
North central NI	$217,284	54,600	$43,812	7.51	-8.28	$316,086	64,775	$51,170	7.61	-8.34
Greater Tauranga	$306,110	41,613	$39,619	7.40	-8.09	$579,549	69,268	$49,080	7.59	-8.15
Gisborne-Opotiki-Wairoa	$164,117	20,450	$36,762	7.24	-8.17	$257,957	24,070	$45,009	7.36	-8.26
Napier-Hastings	$222,356	44,920	$39,987	7.42	-8.18	$401,542	57,925	$48,846	7.56	-8.24
Central NI rural	$108,357	19,430	$37,030	7.23	-8.29	$171,872	20,048	$45,304	7.34	-8.37
New Plymouth	$176,875	23,525	$44,124	7.39	-8.34	$412,724	33,325	$58,687	7.61	-8.41
Whanganui	$133,633	15,340	$39,500	7.25	-8.30	$215,368	16,190	$47,243	7.34	-8.36
Greater Palmy	$197,137	42,728	$41,926	7.44	-8.26	$342,498	52,983	$52,601	7.60	-8.35
Horowhenua-Wairarapa	$143,727	20,133	$35,634	7.21	-8.18	$281,619	23,000	$44,656	7.35	-8.23
Greater Wellington	$317,091	177,760	$56,840	7.89	-8.45	$539,933	218,275	$65,430	7.97	-8.45
Nelson-Tasman-West Coast	$229,418	38,633	$39,552	7.39	-8.16	$456,765	51,543	$49,579	7.55	-8.22
Marlborough-North Canterbury	$205,939	17,380	$36,911	7.21	-8.12	$398,047	26,018	$48,323	7.43	-8.23
Rural Canterbury-Westland	$132,806	37,740	$37,891	7.35	-8.26	$314,874	52,443	$50,417	7.57	-8.33
Greater Christchurch	$259,588	158,823	$43,737	7.67	-8.23	$540,359	225,235	$55,973	7.86	-8.30
Queenstown-Central Otago	$271,487	12,410	$40,474	7.23	-8.15	$704,327	27,938	$47,546	7.43	-8.07
Dunedin	$163,511	45,320	$41,170	7.44	-8.29	$341,472	53,845	$51,401	7.58	-8.33
Southland	$105,371	39,885	$41,796	7.43	-8.41	$225,257	50,740	$50,169	7.56	-8.41

Australia	$346,258	209,640	$58,882	7.94	-8.46	$675,831	310,318	$66,974	8.04	-8.42
Share of workers in New Zealand		87.2%					86.4%			
Share of NZ-based employment in Auckland		33.1%					34.9%			

7.8. Analysis of counterfactual scenarios assuming no impacts on trans-Tasman migration

The following table presents results for an alternative model setup that excludes Australia and focuses only on inter-regional migration within New Zealand. This shows that the economic impact of redistributing workers within New Zealand is considerably smaller than the economic impact associated with increasing the size of the New Zealand labour force by reducing net migration flows to Australia.

Table 11: Outcomes from counterfactual scenarios for house price distortions, assuming no trans-Tasman migration

Outcome	Scenario 1: Reduce supply constraints in Auckland	Scenario 2: Reduce supply constraints nationally	Scenario 3: Reduce house price distortions to zero
Panel 1: Perfect labour mobility ($1/\theta = 0$)			
Increase in output per worker relative to observed outcome	0.5%	0.4%	0.8%
Increase in total output relative to observed outcome	0.5%	0.4%	0.8%
Share of NZers working in New Zealand	86.4%	86.4%	86.4%
Share of NZ workers located in Auckland	40.8%	41.3%	42.5%
Panel 2: Imperfect labour mobility ($1/\theta = 0.3$)			
Increase in output per worker relative to observed outcome	0.2%	0.2%	0.4%
Increase in total output relative to observed outcome	0.2%	0.2%	0.4%
Share of NZers working in New Zealand	86.4%	86.4%	86.4%
Share of NZ workers located in Auckland	37.2%	37.4%	37.9%

7.9. Estimating regional residual wages for robustness checks

My baseline estimates employed average incomes for employed people based on SNZ's (2018c) *LEED* data. These represent 'unconditional' average wages that do not control for worker characteristics.

As a robustness check, I construct estimates of 'residual' wages that control for regional differences in (measurable) worker characteristics. Following the approach outlined in Hsieh and Moretti (2015), I use a random sample of individual unit records from the 2001 and 2013 New Zealand Census to estimate the impacts of worker characteristics on incomes. I estimate the following regression model with national-level data, with minor variations due to changes in the way that some variables were coded between Census years. I filter the Census microdata to only include employed people aged 15 and up who reported their income.

Equation 21: OLS model of the impact of worker characteristics on incomes

$$\ln W_i = \alpha + \beta S_i + \gamma E_i + \delta A_i + \theta Q_i + \tau G_i + u_i$$

The dependent variable is the natural logarithm of annual earnings ($\ln W_i$).[25] The explanatory variables include a constant; a sex indicator (S_i, equal to 1 if the worker is female and 0 if they are male); a vector of dummy variables for Asian, European, Maori, and Pacific Island ethnicities, noting that people may report more than one ethnicity (E_i); a vector of dummy variables for age, broken into five-year bands (A_i); and a vector of dummy variables for the level of the highest qualification that the worker has obtained (Q_i). The Greek letters are coefficients to be estimated in the model, while u_i is the model residual.

I exclude variables for industry, occupation, firm size, and full/part-time status, which differ between regions. A similar worker may have different job opportunities as a result of the structure or composition of that region's economy, and hence a different income in different places. Thus controlling for these variables may control away the effect I am seeking to measure.

The following table summarises the outputs of this analysis for the 2001 and 2013 years. All variables have the expected signs, and most are highly statistically significant.

[25] I estimated individual incomes by taking the midpoint of the income band that Statistics New Zealand coded workers into.

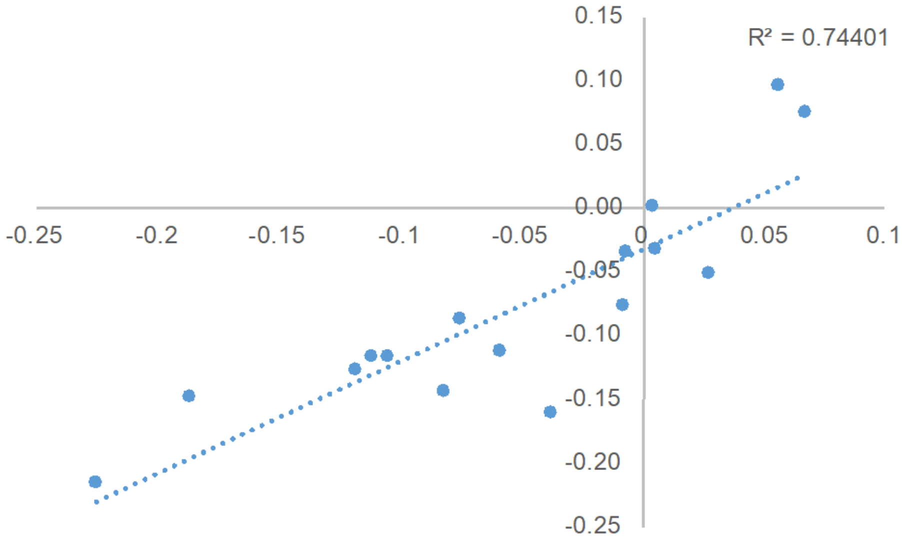
Table 12: Results of wage regressions estimated on Census microdata

2001 Census				**2013 Census**			
Dependent variable	**ln(Wi)**			**Dependent variable**	**ln(Wi)**		
Variable	**Coeff**	**Robust SE**	**p-value**	**Variable**	**Coeff**	**Robust SE**	**p-value**
Constant	8.081	0.059	0.000	Constant	8.308	0.038	0.000
Qual: 5th form	0.215	0.027	0.000	Qual: level 1/2	0.218	0.016	0.000
Qual: 6th form	0.368	0.027	0.000	Qual: level 3/4 / overseas	0.261	0.015	0.000
Qual: higher school	0.340	0.034	0.000	Qual: level 5 / 6	0.415	0.018	0.000
Qual: other secondary	0.042	0.047	0.365	Qual: bachelor degree	0.616	0.016	0.000
Qual: basic vocational	0.299	0.038	0.000	Qual: post-graduate degree	0.735	0.019	0.000
Qual: skilled vocational	0.370	0.028	0.000	Qual: not included	-0.146	0.035	0.000
Qual: intermediate vocational	0.439	0.033	0.000	Asian ethnicity	-0.277	0.024	0.000
Qual: advanced vocational	0.517	0.027	0.000	European ethnicity	0.212	0.018	0.000
Qual: bachelor degree	0.656	0.028	0.000	Maori ethnicity	0.030	0.016	0.053
Qual: higher degree	0.800	0.031	0.000	Pacific ethnicity	-0.113	0.027	0.000
Qual: not included	-0.019	0.041	0.636	Female indicator	-0.414	0.009	0.000
Asian ethnicity	-0.233	0.057	0.000	Age: 20-24	1.302	0.033	0.000
European ethnicity	0.215	0.038	0.000	Age: 25-29	1.825	0.033	0.000
Maori ethnicity	-0.017	0.033	0.607	Age: 30-34	1.922	0.033	0.000
Pacific ethnicity	-0.089	0.055	0.104	Age: 35-39	2.009	0.033	0.000
Female indicator	-0.450	0.015	0.000	Age: 40-44	2.021	0.033	0.000
Age: 20-24	1.249	0.043	0.000	Age: 45-49	2.052	0.033	0.000
Age: 25-34	1.753	0.040	0.000	Age: 50-54	2.024	0.033	0.000
Age: 35-44	1.807	0.040	0.000	Age: 55-59	2.012	0.033	0.000
Age: 45-54	1.861	0.041	0.000	Age: 60-64	1.876	0.035	0.000
Age: 55-64	1.757	0.044	0.000	Age: 65-69	1.982	0.036	0.000
Age: 65-74	1.648	0.055	0.000	Age: 70-74	1.842	0.043	0.000
Age: 75+	1.297	0.120	0.000	Age: 75-79	1.704	0.061	0.000
				Age: 80+	1.364	0.121	0.000
N	32,914			N	97,730		
R2	0.177			R2	0.160		
F-stat	230.64 ***			F-stat	523.9 ***		

Following Hsieh and Moretti (2015), I used the coefficients from these models to estimate the expected average income for employed people in each region, based on aggregated Census data on worker characteristics in those locations. I then compared the predicted average income against the actual average income to obtain an estimate of the wage premium or discount for a typical worker located in different regions. As incomes are log-transformed, the residual provides an estimate of the regional wage premium in percentage terms. I then applied these residual wage premia to national average wages estimated from LEED data in order to estimate average wages in each region.

I compared my estimates of wage residuals based on aggregate data for regional councils against the average wage residual from 2013 Census microdata for each region. The following graph compares these estimates, showing there is a strong positive correlation between these measures, albeit in a limited sample.

Figure 3: Comparison of wage residuals from microdata (x axis) with wage residuals from aggregate data (y axis)



The following table summarises the resulting estimates of average regional wages. Estimated conditional wages based on wage residuals are similar to (unconditional) average wages in each region presented in Table 10, suggesting that regional variations in measurable worker characteristics do not result in large bias to average wages. Interestingly, Census data indicates that the wage premium experienced by workers in Auckland and Wellington has *fallen* slightly over the 2001-2013 period.

Table 13: Estimated wages for an average worker, by region

Labour market area	Wage residual		Estimated conditional wage	
	2001	**2013**	**2001**	**2013**
Northland	-0.104	-0.151	$41,667	$45,554
Auckland	0.110	0.093	$51,610	$58,668
Thames-Coromandel	-0.038	-0.108	$44,740	$47,850
Greater Hamilton	-0.010	-0.009	$46,047	$53,158
Taranaki Rural	0.038	-0.027	$48,268	$52,202
North central NI	-0.001	-0.062	$46,451	$50,352
Greater Tauranga	-0.089	-0.097	$42,380	$48,456
Gisborne-Opotiki-Wairoa	-0.107	-0.133	$41,537	$46,491
Napier-Hastings	-0.106	-0.108	$41,551	$47,884
Central NI rural	-0.116	-0.175	$41,105	$44,280
New Plymouth	-0.068	-0.005	$43,353	$53,386
Whanganui	-0.140	-0.171	$40,009	$44,474
Greater Palmy	-0.075	-0.066	$43,004	$50,131
Horowhenua-Wairarapa	-0.136	-0.146	$40,191	$45,803
Greater Wellington	0.106	0.090	$51,417	$58,458
Nelson-Tasman-West Coast	-0.188	-0.162	$37,748	$44,956
Marlborough-North Canterbury	-0.184	-0.153	$37,941	$45,433
Rural Canterbury-Westland	-0.167	-0.090	$38,722	$48,798
Greater Christchurch	-0.092	-0.022	$42,225	$52,460
Queenstown-Central Otago	-0.158	-0.168	$39,158	$44,617
Dunedin	-0.155	-0.112	$39,283	$47,625
Southland	-0.072	-0.062	$43,153	$50,300
Correlation with unconditional average wages from LEED data (R^2)			0.71	0.87

7.10. Model robustness tests

Lastly, to ensure that my results are robust, I sensitivity test alternative parameters for production function factor shares, housing expenditure share, and degree of idiosyncratic preferences for specific locations. I also test the conditional wage estimates defined above as an alternative to unconditional average wages, and a scenario in which the number of workers in Australia who might be interested in moving to New Zealand is five times as large as the estimated population of New Zealanders working in Australia.

All sensitivity tests are conducted relative to Scenario 3, in which land price distortions are reduced to zero in all regions.

The following table summarises these results. Choosing alternative values for key model parameters does not affect my key conclusions about the direction and broad magnitude of impacts. Using lower capital or labour shares in the production function – which implies more strongly decreasing returns to employment in production – reduces the estimated economic impacts, although not to zero, while using a higher housing expenditure share results in a slightly higher estimate of economic impacts.

Using conditional wage estimates rather than unconditional average wages has almost no impact on the results. This suggests that my results are unlikely to be biased by differences in worker characteristics between regions.

Conversely, if there is a significantly larger pool of people working in Australia (or other overseas locations) who may want to live in New Zealand if house prices were lower, then the economic impacts of regional house price distortions may be significantly larger.

Lastly, choosing significantly different parameters for workers' degree of idiosyncratic preferences to live in specific places (the 'stickiness' parameter) affects the level of estimated impacts, but does not eliminate the impacts.

I therefore conclude that it would be necessary to make implausible assumptions about New Zealanders' unwillingness to move between regions in response to wage or price differentials in order to fully eliminate the estimated economic impacts of house price distortions. The fact that roughly one in seven New Zealanders works in Australia provides *prima facie* evidence that many New Zealanders are willing to move in response to economic opportunities.

Table 14: Sensitivity tests on key model parameters, relative to Scenario 3 for reducing house prices.

Sensitivity test	Model parameter selection	Increase in output per worker	Increase in total output
Baseline with perfect mobility	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0$	0.9%	7.7%
Baseline with perfect mobility, conditional wage estimates	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0$	0.9%	7.7%
Baseline with perfect mobility, pool of potential migrants in Australia is 5x as large	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0$	2.5%	28.9%
Perfect mobility, lower capital share	$\alpha = 0.6;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 0$	1.2%	5.7%
Perfect mobility, lower labour share	$\alpha = 0.5;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0$	1.2%	5.7%
Perfect mobility, lower labour and capital shares	$\alpha = 0.5;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 0$	1.3%	4.8%
Perfect mobility, higher housing expenditure share	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.3; 1/\theta = 0$	0.9%	8.8%
Baseline with imperfect mobility	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0.3$	1.4%	4.5%
Baseline with imperfect mobility, conditional wage estimates	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0.3$	1.4%	4.5%
Baseline with imperfect mobility, pool of potential migrants in Australia is 5x as large	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0.3$	4.5%	15.6%
Imperfect mobility, lower capital share	$\alpha = 0.6;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 0.3$	1.5%	4.0%
Imperfect mobility, lower labour share	$\alpha = 0.5;\ \eta = 0.25;\ \beta = 0.25; 1/\theta = 0.3$	1.5%	4.0%
Imperfect mobility, lower labour and capital shares	$\alpha = 0.5;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 0.3$	1.5%	3.6%
Imperfect mobility, higher housing expenditure share	$\alpha = 0.6;\ \eta = 0.25;\ \beta = 0.3; 1/\theta = 0.3$	1.7%	5.4%
Imperfect mobility, lower 'stickiness' parameter	$\alpha = 0.6;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 0.1$	1.2%	6.1%
Imperfect mobility, higher 'stickiness' parameter	$\alpha = 0.6;\ \eta = 0.1;\ \beta = 0.25; 1/\theta = 1$	1.6%	2.9%

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