

We zoned for density and got higher house prices: Supply and price effects of upzoning over 20 years

Mark Limb,^{*} Cameron K. Murray[†]

February 16, 2021

Abstract

Does planning for higher density increase housing development and decrease housing prices? We study the outcomes of planning for density in established suburbs over a twenty-year period using a large site-level dataset on dwelling stock, planning regulations, and prices, in 19 planned densification areas (activity centres) comprising 25,775 sites in Brisbane, Australia. Planning rules in these areas were repeatedly relaxed to allow for higher density; a policy change that should have observable price effects. To study the effect of zoning, we create a variable for each site called zoned capacity, which is the estimated number of additional dwellings able to be built under the planning code. Only 2% of the zoned capacity was taken up in any five-year study interval. Zoned capacity doubled over the whole twenty-year study period (going from 0.9x total dwellings to 1.4x), however despite these changes, 78% of sites with zoned capacity in the first period remained undeveloped. Higher rates of new housing supply are robustly related to higher prices despite demand arguably seeing a similar increase across locations. Our zoned capacity variable has no relationship to price across numerous regression models and is robust to various data selection choices. It could be that planning is not a binding constraint on new housing in Brisbane—yet price growth over our study period is comparable to other Australian cities. This evidence suggests that private housing markets will not rapidly supply new housing and cause significant price reductions, even if the planning system allows it.

Keywords: Zoning, planning, density, house prices.

^{*}Queensland University of Technology, Brisbane QLD 4000. Email: mark.limb@qut.edu.au

[†]Henry Halloran Trust, The University of Sydney, Camperdown NSW 2006. Email: c.murray@sydney.edu.au
This project was funded by the Henry Halloran Trust. <https://sydney.edu.au/henry-halloran-trust/>
Thanks to Chris Parker, Tim Helm and Peter Phibbs for comments on early drafts.

1 Introduction

The politics of planning and housing have become focused on zoning controls and their potential to limit housing density and new housing supply, thereby increasing home prices.¹ Globally, a broad alignment of academic, industry, and political support has formed into what is known as the YIMBY (Yes In My Backyard) movement, pursuing planning reform as the primary way to reduce home prices (Yglesias, 2012; Cowan, 2019; Monkkonen, 2019; Wiener, 2020; Hansen, 2020). The movement seeks in practice to change planning codes so that “missing middle” and high density housing is allowed in areas that have traditionally had detached housing, while also promoting densification around urban retail and commercial clusters. This approach to planning higher-density cities has been pursued for over two decades in Australia, and is also common in North American and European cities (Filion, 2009; Forster, 2004; Limb *et al.*, 2020a; Schmitt, 2013). For example, Sydney and Melbourne both have strategic plans based on these principles (GSC, 2019; DELWP, 2017) and Auckland, New Zealand, increased allowable housing densities in a large scale rezoning in 2016 (Greenaway-McGrevy *et al.*, 2020). Despite planning systems in many cities changing to permit much higher residential density, dwelling prices continue to rise and the property industry continues to call for further deregulation of land use planning in the name of housing affordability (PCA, 2013; UDIA, 2019).

Does rezoning for higher housing density increases the rate of new housing supply and reduce prices when it is applied? Recent analysis has shown both theoretically and empirically that there are strong private incentives to delay new housing development even on profitable sites (Murphy, 2018; Murray, 2020a,b). If new supply is limited by dynamic economic constraints, rather than planning constraints, then planning changes are unlikely to increase supply or decrease prices. Our main contribution is to utilise detailed planning, housing stock, and price data covering a 20 year time period to see if lower housing density constraints are related to observable supply and price effects in the long term.

We use a panel of 25,775 sites in 19 major activity centres earmarked in the planning system for densification in Queensland, Australia. Each site has five observations over a 20 year period (from 1996-2016) allowing us to observe whether there are long-term supply effects. This data is unique for a number of reasons. First, it contains all sites in a 1,200 metre walking distance of the main transit node of each activity centre and includes the number of dwellings on each site in each time period. This means that we can observe variation in new housing development across sites and between activity centres. Second, it contains complete matching planning information on allowable use types (e.g. detached dwelling, medium density dwellings, commercial and retail use, etc.) as well as current uses in each time period, with that planning information developed in (Limb *et al.*, 2020c; Limb, 2019). We use this high resolution planning information to create a variable we call zoned capacity, which is the estimated number of additional dwellings able to be built on a site under current planning regulations. In addition, we add residential price data for each site on a land-value-per-square-metre-of-lot-size basis, and apartment prices, based on local price indexes to represent the location value of the site for residential uses.

Our analysis of this data shows the following. First, zoned capacity is extremely large compared to both the existing dwelling stock and the rate of new housing supply, and hence cannot plausibly be a binding constraint on the rate of new housing supply in these areas. Total dwellings in our data went from 36,000 in 1996 to 47,000 in 2016, while our conservative zoned capacity estimate went from an estimated 33,000 dwellings to 66,000 over that period. Second, the relationship in

¹A recent JAPA issue dealt extensively with the key arguments in the planning profession for eliminating single-family zoning in the United States, though little comment on the economic barriers to densification was made (Michael Manville, 2019; Wegmann, 2019).

the data between zoned capacity, dwelling supply, and price, does not fit the logic of the YIMBY movement. If rezoning for higher density is a plausible way to decrease local prices, we should see activity centres with the highest zoned capacity have 1) faster growth in new housing and 2) lower price growth. The first step in the logical sequence is observable, with more dwellings built on sites with more zoned capacity. However, this is merely evidence that planning controls work to locate new housing where it is planned. The second step in the logical sequence is not evident in the data. Activity centres with the higher new housing supply saw faster price growth, not lower growth.

It may be the case that planning controls are not a binding constraint on housing supply in Brisbane over our study period. But such an explanation still challenges the supply side argument in general. Brisbane dwelling prices increased by more than Sydney prices from 2001-2016, and over the whole period increased by more than prices in San Francisco (250% versus 235%); both cities that are routinely argued to be supply-constrained (ABS, 2018; S&P Dow Jones Indices, 2020). These results suggest that changing planning systems to facilitate “missing middle” density by increasing zoned capacity is unlikely to result in noticeable housing price effects.

2 Literature

Links between planning regulations and housing supply are typically studied using aggregate measures at the jurisdictional level (Chakraborty *et al.*, 2010; Gyourko & Molloy, 2015; Quigley & Rosenthal, 2005). Due to the complexity of directly measuring land use regulations across multiple jurisdictions, surveys of planning authorities are often used to create metrics of regulatory stringency that are applied to the entire authority’s jurisdiction and compared to aggregate housing outcomes (Gyourko *et al.*, 2008; Pendall *et al.*, 2018).

Where market-led development is relied upon to supply new housing, the decision to develop an individual site will be based on economic opportunities and regulatory constraints imposed on that site alone, regardless of area wide metrics of regulatory stringency. A jurisdiction may have strict planning controls on average, but also may have many suitable housing development locations with few planning constraints to encourage development in these preferred locations. In such cases, the YIMBY argument is that those sites with relatively few planning constraints will be observed to develop more rapidly and have observable local price effects.

The limited site-level research on planning and housing supply is often ascribed to the difficulty of obtaining time series data and challenges in making comparisons between regulatory aspects that often differ in terms of their terminology and the aspects of development that are regulated (Dain, 2005; Gyourko & Molloy, 2015). Where attempted, such studies have selected key regulatory aspects for comparison such as minimum lot sizes or permitted numbers of dwellings/density at a particular point in time (Wheaton & Evenson, 2003; Glaeser *et al.*, 2006). Commonly overlooked are site level changes to planning regulations and land use over time, particularly over timeframes sufficient to permit development to occur in response to regulatory changes.

Addressing some of these limitations, Freemark (2019) analysed site-level sales data and area-level dwelling permit data from three years before and after specific zoning changes to maximum density and parking requirements in 16 Chicago transit-accessible areas in the 2010s. In their sales data they found a 15-23% relative price increase for rezoned sites, but found no increase in construction in the years after rezoning. It is possible that their three to five year time frame is too short to identify a construction response, something we overcome with our data from a 20 year study period.

In a similar vein, Greenaway-McGrevy *et al.* (2020) looked at the effect of upzoning in Auckland, New Zealand, on site values relative to non-upzoned sites. Like Freemark (2019), they find large value effects on underdeveloped sites that were upzoned, consistent with their conceptual framework whereby the value of underdeveloped sites comes from the option value of redevelopment. The least developed sites that were upzoned to the highest intensity zoning increased in relative value by 14.7% over the seven year study period, though more developed sites saw smaller price increases from upzoning. They note that their empirical test of relative value effects is consistent with no overall change in the city’s dwelling stock if upzoning simply reallocates the location of expected future construction, and hence they are unable to make conclusions about a supply response from rezoning.

Monkkonen *et al.* (2020) use a method the closest to ours. They look at the relationship between new dwelling permits and three different planning regulation metrics (a process index, prohibition index, and a zoned capacity measure), rental price, and other factors. Their planning process metric was unrelated to either apartment or housing permits over the 2013-17 period, while the prohibition index was negatively related to dwelling permits, with a much larger negative coefficient in the apartment permit models. Their zoned capacity measure was positively related dwelling permits, as expected if zoning works as designed, and negatively related to rents. Because of the cross-sectional nature of their data, however, potential price effect from variation to zoning controls cannot be observed.

Damiano & Frenier (2020) look at price effects of new housing supply using a panel of new dwelling construction and rental price data from Minneapolis, Minnesota from 2000-2018 matched with building age data to ascertain very localised effects of new housing on rents. Their difference-in-differences method identifies rental variation for existing buildings within 300 meters and 300-800 meters from new buildings after construction completion. They find no rental price effect on nearby rents from new dwelling construction, though they show that this is due more to rental convergence that involves an increase in rents for nearby low-rent dwellings, and a slight decrease for nearby high-rent dwellings.

In the Australian context, Woodcock *et al.* (2011) found that planned density failed to materialise in a case study of the suburb of Brunswick in Melbourne, Australia, using site-level planning applications, approvals, and construction data. Between 2002 and 2007, 80% of planning applications for redevelopment were approved. Had they been implemented this development housing stock in these areas would have increased by 13%. By 2009, fewer than half of the approved developments had commenced construction, with the largest and densest approved projects more likely to be delayed. The authors describe how the option to delay and seek future new approvals for even higher density projects was a factor at play, suggesting that economic rather than regulatory factors are the binding constraint on the rate of new housing supply.

In the few instances where site-level data is used to study the effect of planning changes, the evidence for significant construction responses is limited. Dodson (2010) suggests that market constraints explain why planned densification often fails to generate rapid private redevelopment. Prices must be high enough to make the cost of redevelopment viable but also make developing soon after upzoning more profitable than delaying.

We add to the evidence on the direct relationship between zoning/planning controls and dwelling prices with long-term site-level data that builds on work of Limb *et al.* (2020b). They developed a database of site-level planning and land use data across 19 activity centres in Greater Brisbane and investigated the raw correlations between the permissiveness of land use regulations in an activity centre, and the conformance with planning outcomes in terms of the intensification of

dwellings, greater dwelling mix, and employment. They found that regulatory planning policy was not predictive of the intensification of uses in activity centres.

We use a modified version of Limb *et al.*'s (2020b) data in our analysis that also incorporates residential price estimates at the site-level, and a new metric of site-level zoned capacity that accounts for the gap between current use and allowed uses under the planning controls. This allows us to address limitations of existing studies of the direct effect of zoning on dwelling prices and new supply by extending the time-frame of analysis to a 20 years period, and by incorporating greater variation in planning controls between sites and activity centres and across time.

3 Data and Methods

3.1 Data background

Brisbane is the capital of the State of Queensland, Australia, with a population in the greater metropolitan area of 2.3 million at the last census (ABS, 2016). Within the metropolitan area there are currently five local councils, the result of amalgamations of smaller councils in 2008. Planning for the metropolitan region occurs in a hierarchical manner; councils enact planning schemes and approval proposals, but they must comply with overarching state government policies. During the early 1990s the state government sought to encourage density near existing retail and commercial hubs with transit access, and a series of planning exercises led to the identification of numerous “major district centres” that were mostly already identified in council planning schemes (Limb, 2019).

With the release of the state government’s statutory South East Queensland Regional Plan (SEQRP) in 2005, local governments were legally required to incorporate planning for activity centres into their own regulatory planning controls. This policy has flowed through subsequent iterations of the regional plan, with the activity centre policy changing primarily in its encouragement of ever increasing residential densities within the centres.

Although local governments are required to reflect the principles of the policy in their own planning regulations, they have significant discretion in its detailed application. Local governments determine the extent of each centre, and the location and intensity of any up zoning in response to the policy. Despite this lack of strict top down control, there is strong evidence that local governments have been changing their planning regulations to accommodate the state government’s activity centre policies, particularly in terms of changes that up-zone land to permit higher residential densities (Limb *et al.* , 2020c).

These activity centres represent an ideal case to investigate the effects of zoning changes for infill development as they have been subject to two decades of consistent state and local government policy changes to encourage it, and consist of a variety of land use types and residential densities (Limb *et al.* , 2020a). Figure 1 shows the locations of the 19 activity centres in our data, which represent all infill based activity centres in the greater Brisbane area as identified in the SEQRP, with the blue outlines of SA2 statistical divisions which each have populations of around 10,000.² There is no consistent or precise spatial boundary for these named activity centres, however they are intended to be developed following transit-oriented development principles. We therefore

²The centres of Springfield, North Lakes, and Ripley were excluded from our analysis as these activity centres were established on greenfield sites and therefore do not conform to the normal understanding of infill development and densification. SA2 is a standard geographical area use in the Australian national statistics and on average contains 4,000 dwellings.

define the physical extent of each centre as a 1,200m catchment (network-based) from the key public transport node in each centre.³ The same geographical area persists in the data for each activity centre through each of the time periods in the data.

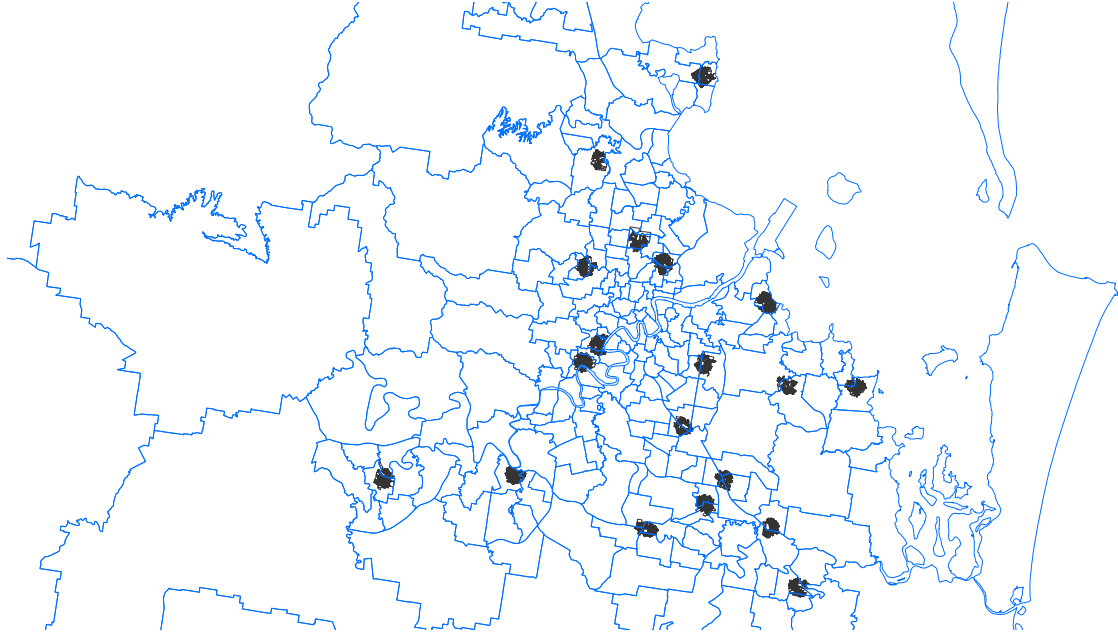


Figure 1: Location of 19 activity centres around Brisbane with SA2 areas marked

Across all 19 activity centres there are 25,775 sites, with data for each site for 1996, 2001, 2006, 2011 and 2016, providing a twenty year study period. Of these total sites, 721 were newly created within the study period through subdivision, and 2,611 of the original sites (10%) were involved in any change of use (subdivision, redevelopment, or use change) over the entire study period. Overall, the total number of dwellings in these activity centres increased by 33%.

Site-level data means that each lot in the cadastre of land titles at 2016 is a single data point, even if it is a single dwelling, an apartment building with 100 dwellings, or a shopping centre with dozens of tenants. Each site has data on the number of dwellings, building height in storeys, and a land use code (LUC) for both the current and planned use of that site (see Table 1). This final metric has been prepared to capture the planning intent of a site in a uniform way to be comparable across councils within the greater Brisbane region Limb *et al.* (2020a). This overall data is summarised in Table A1, of the Appendix, with Table A2 showing the change in area of different uses across each activity centre over the whole study period.

In addition, we include median home price data from each of the 198 SA2 regions in the data for each site on a per square metre basis (median price divided by median size detached dwelling site) for each time period to generate a reasonable approximation of the location value of residing at a site location (APM, 2019). For almost every site in the data, residential uses will be a dominant component of new development, even if new buildings contain a mix of other uses. These assigned site-level prices thus also serve as a proxy for economic returns to redevelopment and for the

³Consisting of an 800m walkable catchment as identified in the policy with an additional 400m buffer to account for a “ripple effect exerting extra market pressures beyond the boundary onto surrounding properties” (Newton & Glackin, 2014, pp.131-132).

Table 1: Land use code (LUC) criteria

Score	Description of land use
-	Under construction.
0	Vacant.
1	Low density dwellings. Detached housing or duplexes of 2 storeys or less.
2	Multi-unit low density dwellings. Townhouses and apartments up to 3 storeys.
3	Multi-unit medium density dwellings. Apartments from 4-6 storeys.
4	Multi-unit high density dwellings. Apartments above 6 storeys.
5	Commercial uses, including retail and office.
6	Industrial uses.
7	Community uses (such as churches, nursing homes, libraries and schools).
8	Open space.

Under construction only occurs in 2016 during the data collection. For subsequent analysis we replace this code with the planned LUC code, assuming that those developments take place at their zoned capacity.

relative location value of each site (within and across activity centres). We also assign the median apartment price data for the SA2 area as a price metric for each site, which is available only for the most recent two time periods for most activity centres, leaving 77,157 site-year observations with this price data (with 95 different SA2 level apartment and land prices). This allows us to check the robustness of our results to price effects from a potential change in preferences for apartments over houses (i.e. if the apartment stock increases relative to detached houses, the price premium for detached housing may increase).

3.2 Overview of zoned capacity, dwelling change and prices

We are specifically interested in the role of planning on housing supply and hence a key variable is the zoned capacity for each site in the data. This variable is the estimated gap between current use and planned use in terms of dwellings per site. We calculate zoning capacity as

$$\text{zoned capacity} = (LUC_{planned}^2 - LUC_{use}^2) \times \text{site area} \times 16. \quad (1)$$

The logic for doing so is that the mean housing density for sites being used for each LUC is proportional to (16x) the square of the LUCs themselves (see Table 2). If, for example, the current use for a one hectare site is detached housing ($LUC = 1$), and the planned use is medium density dwellings ($LUC = 3$), then the zoned capacity for that site is 128 dwellings (since $((3^2 - 1^2) \times 1 \times 16 = 128)$). Sites with current LUCs of 5 and 6 are treated as having the same zoned capacity as vacant sites if their planning LUC is one of the residential uses (LUC 1 to 4). We exclude LUC 7 and 8 (community use and open space) sites from our analysis.

In Figure 2 we show the observed redeveloped densities, or dwelling changes, over all sites in each time period in our data. The conformance of the observed increases in dwellings on a site and our lagged zoned capacity estimate (the grey line) give us confidence in our approach to estimated zoned capacity. The data points with a positive dwelling change and no lagged zoned capacity are those that were either (1) redeveloped to the same type of use, such as subdividing

Table 2: Description of the zoned capacity variable for 1 Ha site

LUC	LUC ²	Zoned capacity (LUC ² × 16)	Mean density (dwell/Ha)
0	0	0	0
1	1	16	16
2	4	68	68
3	9	144	149
4	16	256	249

Sites with LUC of 5 and 6 are coded as zeros to account for their lack of current residential uses.

a detached housing lot for two housing lots (grey), (2) developed beyond the planning code, which is possible in Queensland’s flexible performance-based planning system (black), or (3) were redeveloped within five years of a new planning code (blue). These data points make up 1.6% of site-year observations (happening 1,152 times in the data), but account for 48% of total residential developments and 25% of new dwellings in our data.

The vast majority, or 94.2%, of sites with zoned capacity five-years prior are not developed in that five-year window (green points in Figure 2). Of the 99,844 site-year observations with lagged zoned capacity information, 23,429 have a positive zoned capacity value. Of these, only 1,270 saw development occur within the five-year period (5.5%). Of the 5,940 sites with zoned capacity in 1996, 4,486 (or 71%) had no residential redevelopment in the subsequent 20 year period. Some sites with zoned capacity for dwellings were redeveloped to non-residential uses or to residential uses with fewer dwellings. Around 1.4% of sites with zoned capacity for new dwellings had this occur (334 out of 23,429). This shows that flexible planning systems can also allow for non-residential redevelopment to out-compete residential development.

Figure A1 of the Appendix shows the total dwellings and total dwellings plus estimated zoned capacity over time in each of the 19 activity centres. Total dwellings across all activity centres increased from 35,986 to 47,889 between 1996 and 2016 (a 33% increase), while zoned capacity increase from 32,791 to 65,883 (a 101% increase). In Table 3 we show the total change in the study areas of the area zoned for each LUC, the zoned capacity in areas (in terms of dwellings), and the number of dwellings of that LUC type. The major change to planning that occurred was additions to zoned capacity for LUC types 3 and 4, which includes all dwelling types in buildings above 4 storeys tall. A total of 42,247 dwellings of these types was added to the zoned capacity, even after accounting for addition of 5,122 dwellings of these types.

Some relationships in the data between zoned capacity, new dwellings, and price (in log form) at the activity centre level are in Figure 3.⁴ Those activity centres in time periods that saw increases to zoning capacity over the previous five year period typically saw lower new dwelling supply (left panel). Perhaps this is due to planning changes following the market and responding only after an upswing in prices and new supply. There is no clear relationship between change to zoned capacity and the change in price growth (centre panel of Figure 3). In terms of the mechanism that zoning capacity is thought to operate through to affect price, the supply of new dwellings, the

⁴Here the price is the area-weighted mean residential price (lot price per square metre for detached housing), and the marked curves are the linear best fit with 95% confidence intervals.

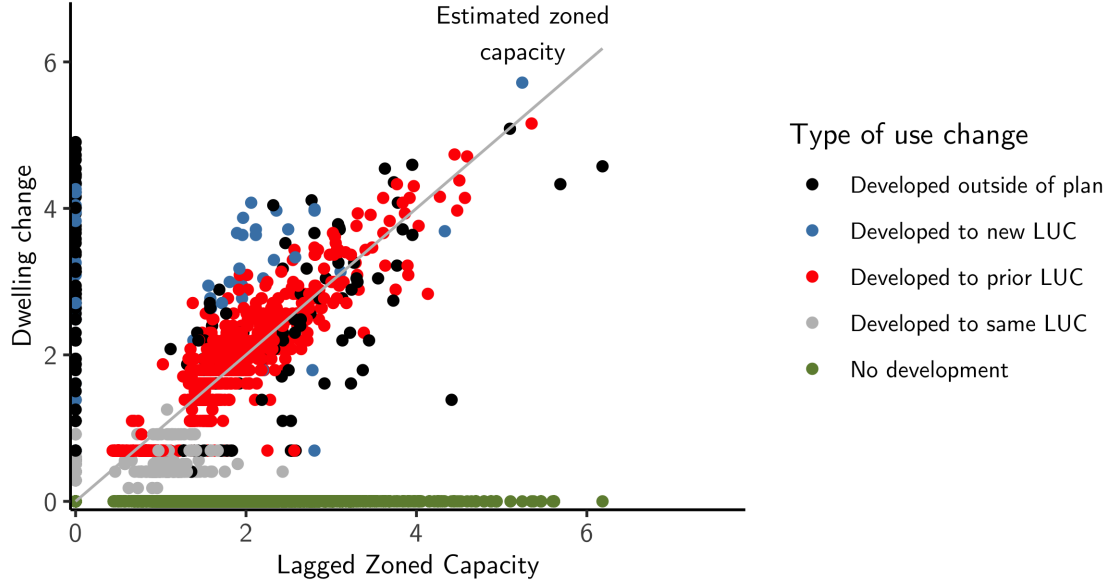


Figure 2: Site zoned capacity and dwelling change (log) for all sites by type of change

right panel of Figure 3 shows that, if anything, higher rates of new dwelling supply are related to higher price growth (right panel).⁵ The clustering of activity centre observations in each period in Figure 3 suggests that the variation in new dwelling supply and price is mostly driven by market cycles that affect all activity centres, rather than by zoned capacity. While the mean growth in dwellings across all activity centres was 33% over twenty years, five activity centres saw less than 10% growth in dwellings, and one even saw a decline. By comparison, across the Brisbane metropolitan area the number of dwellings increased 30% from 2001 to 2016.⁶ Looking at these basic patterns in the activity-centre level data, there is no clear evidence that increasing zoned capacity increased new dwelling supply and reduced prices.

3.3 Site analysis method

Our statistical approach isolates the relationship between zoned capacity, new dwellings, and price, and capitalises on the variation in the data across sites and between activity centres. Isolating the direction of the correlation between these key variables can allow us to distinguish whether the data is more consistent with one of two competing causal stories about the role of planning on dwelling supply and prices.

The first story is that planning regulations that limit density (i.e. less zoned capacity) lead to higher prices via lower new dwelling supply in response to a demand shock. We call this the “planning story” and represent it in the left panel of Figure 4. Supply is independent of demand and at any equilibrium point, such as marked by *A*, the existing dwelling stock will always be

⁵We looked at various data transformations of the overall activity centre level data, including price growth rates, change and growth rate of zoned capacity, and absolute unit variable changes. These same overall patterns of higher price growth being positively related to both higher zoned capacity and higher dwelling growth are evident across the board in our data, though the relationship is not statistically significant in some data transformations.

⁶ABS Census data for Brisbane (UCL). Geographic classifications for city regions from the 1996 census do not match later years, and hence the 2001-16 period is the basis for comparison.

Table 3: Planning and housing changes over the study period

LUC	Year	Area (Ha)	Zoned Capacity	Dwellings	Apartment price (\$'000)	House lot price (\$/sqm)
1	1996	1,362	1,873	20,616	109	165
	2016	1,110	398	19,964	380	727
2	1996	832	20,706	14,067	122	186
	2016	571	12,978	21,049	367	742
3	1996	107	5,508	712	141	165
	2016	356	22,014	3,395	348	659
4	1996	82	4,703	520	128	169
	2016	486	30,444	2,959	393	732

Area zoned for that use, and zoned capacity of those areas, and dwellings of that use type irrespective of the zoned uses on those sites. Apartment and house lot prices are area-weighted means.

supplied (the vertical portion of the supply curve) meaning that a negative demand shift will reduce price alone. A given positive demand shock from an equilibrium point will result in a price and quantity combination that depends on the slope of the supply curve, which is assumed to be caused by regulatory factors such as zoned capacity. A market with the S_{lowzc} curve will have fewer new dwellings and higher prices than one with the S_{highzc} curve in response to the same demand shock.⁷

If this planning story is true, we would expect to observe in our data a positive relationship between zoned capacity and new dwellings, and a negative relationship between price and dwelling quantity. This expectation is shown visually by the points marked B and C in Figure 4, which show two potential equilibria following a demand shock in a low zoned capacity scenario (supply curve S_{lowzc}) and a high zoned capacity scenario (supply curve S_{highzc}). We rely on the assumption of an equal demand shock at all locations in our data in this approach, meaning that any variation in price and quantity change is supply-related. This is a strong assumption but it is also the assumption of the planning story which says that more elastic supply due to fewer planning constraints will change the relative price of locations. If we do not assume this, we assume away this supply story altogether and instead must explain price variation by changes to the relative location demand (i.e. the preference for one location over another). Specifically, we expect a regression of price in the following form to reveal a negative relationship with lagged zoned capacity (i.e. estimated $\beta_1 < 0$ in Equation 2) after controlling for dwelling quantity.

$$p_t = \beta + \beta_1 zc_{t-1} + \beta_2 p_{t-1} + \beta_3 q_t + \beta_4 q_{t-1} + \beta_5 (zc_{t-1} \times p_{t-1}) + AC + Year + \epsilon \quad (2)$$

Additionally, if we include the interaction term of lagged price and lagged zoned capacity in Equation 2, the expectation of the planning story is that this coefficient will be negative; when prices are already high, zoned capacity should be more effective at alleviating price differentials.

⁷Note that the price here represents the rental price of housing not the asset price of housing which will vary from occupancy demand due to factors that affect the asset price, such as tax rates, interest rates, and expectations. However, we allow for the idea that market clearing may also occur via dwelling asset prices, which is a common part of the planning story of dwelling prices.

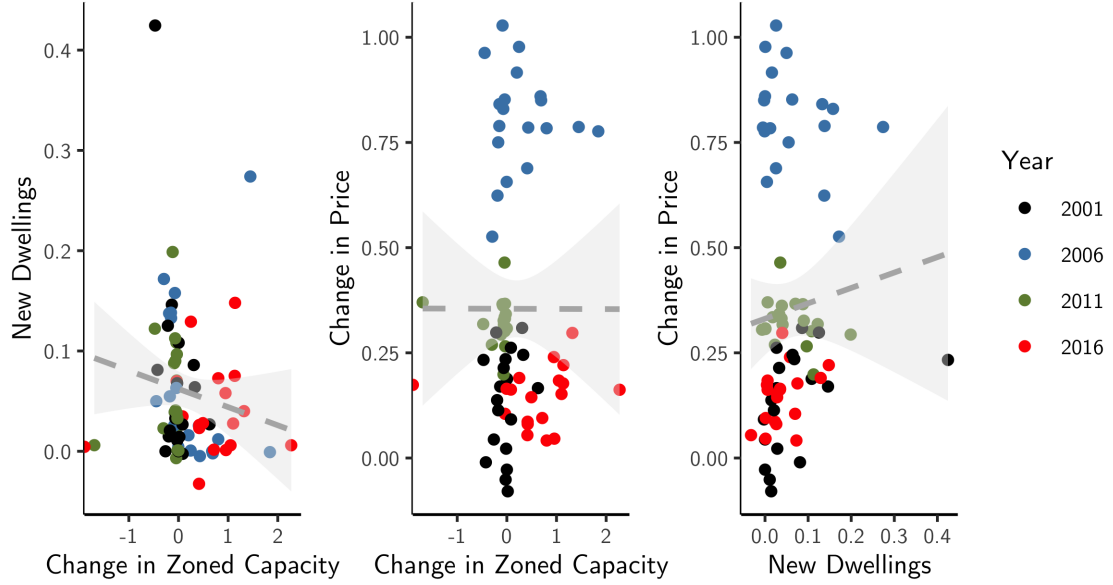


Figure 3: Activity centre changes in zoned capacity, dwellings, and prices (log)

Likewise, if this planning story accurately represents housing supply dynamics, we should expect that quantity of dwellings is positively related to lagged zoned capacity (i.e. estimated $\beta_1 > 0$ in Equation 3) and negatively related to price (i.e. estimated $\beta_2 < 0$) after controlling for lagged price and dwelling quantity. Adding a lagged price and lagged zoned capacity interaction term to this equation should have a positive coefficient (i.e. estimated $\beta_5 < 0$) as higher-priced areas will produce more new dwellings if zoned capacity allows for it.

$$q_t = \beta + \beta_1 zc_{t-1} + \beta_2 p_t + \beta_3 p_{t-1} + \beta_4 q_{t-1} + \beta_5 (zc_{t-1} \times p_{t-1}) + AC + Year + \epsilon \quad (3)$$

The alternative story is that planning regulations allow for additional dwellings, but that the price level determines the viability of redevelopment and price growth determines the rate of new supply out of these viable sites as landowners and developers schedule their new dwelling sales and development to maximise returns (the absorption rate model described in Murray (2020a)). In this story, potential housing developers sell into strong markets and wait during declining markets. We call this the “dynamic economic story” and represent it in the right panel of Figure 4. If this causal story is true, a positive correlation between price growth, zoned capacity, and the increase in dwellings, is expected. The logic of the dynamic economic story is that the rate of new supply responds to the rate of price growth and is mediated by factors such as the market thinness, interest rates, land taxes, and regulations on density, as per the absorption rate model of Murray (2020a).⁸ Because of this, the change in price and dwelling supply will be positively correlated and new supply will occur in areas that see an increase in their relative demand. Supply is not independent to demand in this story.

⁸We do not account for the effect of binding density constraints in the absorption rate model as they are mediated by interest rate and tax effects, with demand growth, via price growth, dominating the determination of the optimal rate of new dwelling supply.

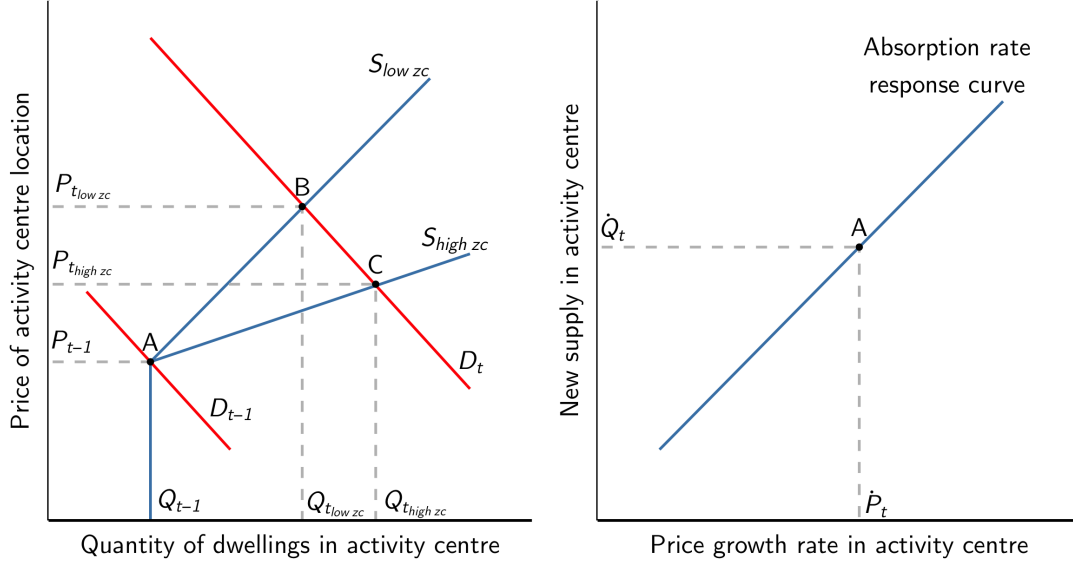


Figure 4: Alternative supply theories

This story therefore makes different predictions about the expected relationships in the data. The prediction for the Equation 2 coefficient estimates is that there will be a positive relationship between price and quantity, but a negative relationship between price and lagged quantity (i.e. estimated $\beta_3 > 0$ and $\beta_4 < 0$), capturing the expected positive relationship between price growth and quantity change.⁹ There is no expected relationship between price with zoned capacity (or its interaction with price) in this story; relative prices between locations are fully determined by demand (preferences).

The prediction of the dynamic economic story for the Equation 3 coefficient estimates is that there will be a positive relationship between quantity and price, and a negative relationship with lagged price, (i.e. estimated $\beta_2 > 0$ and $\beta_3 < 0$). Because development occurs out of a set of feasible sites where price covers cost, the expectation is that the quantity of dwellings is positively related to the interaction of lagged zoned capacity and lagged price (i.e. estimated $\beta_5 > 0$). However, because the planning regime in our study is flexible and around half of the observed dwelling developments in our data occurred outside of previously-codified plan limits, we are more confident of observing this effect on the subset of sites with positive zoned capacity. Table 4 summarises the expected relationships provided by the two causal stories.

To check which story fits the data we estimate Equations 2 and 3 on our data (log transformed) firstly without the interaction term, then include the interaction term to help untangle the potential dependence of planning constraints on prices. We also conduct two robustness checks. First, we repeat the analysis using only data for sites in each activity centre that have positive zoned capacity at some point over the time period (giving us 35,165 site-year observations across 8,706 sites.). This ensures that the bulk of the sites that may be judged to have limited development potential regardless of current planning regimes are removed from the data, increasing

⁹The logic is that the expected relationship between the growth rates is $\dot{Q}_t = \alpha \dot{P}_t$, where α is positive. Substituting $P_t - P_{t-1}$ for \dot{P}_t and $Q_t - Q_{t-1}$ for \dot{Q}_t gives the expected price level relationship of $P_t = \alpha^{-1}Q_t - \alpha^{-1}Q_{t-1} + P_{t-1}$.

the chance of planning variables having observable effects. Second, we repeat the analysis using the subset of data that has median apartment price information and use this as our price metric instead of residential land prices. This should overcome an issue with changes in preference and relative scarcity of detached housing and apartments over the time period.

Table 4: Coefficient sign predictions

		Planning story	Dynamic economic story
Eq. 1 (p_t)	zc_{t-1}	-	None
	p_{t-1}	+	+
	q_t	-	+
	q_{t-1}	+	-
	$zc_{t-1} \times p_{t-1}$	-	None
Eq. 2 (q_t)	zc_{t-1}	+	None
	q_{t-1}	+	+
	p_t	-	+
	p_{t-1}	+	-
	$zc_{t-1} \times p_{t-1}$	+	+

4 Results

Results for the Equation 2 and 3 models and their variations (excluding the interaction term) are in Table 5. There is no relationship between lagged zoned capacity and price except in Model (3) which has $p < 0.10$ when standard errors are clustered by activity centre. The Model (3) coefficient of 0.003 for lagged zoned capacity implies that a 1% increase in zoned capacity is associated with a 0.003% decrease in relative price five years later. The dwelling quantity coefficient is positive, and lagged coefficient is negative, but the effect is mostly washed out by our controls, suggesting that higher dwelling growth is clustered across activity centres and in particular time periods. In the dwelling quantity models, lagged zoned capacity is positively associated with additional dwellings on a site, as expected by both supply stories. However, the relationship between dwellings and price and lagged price in Model (4) goes against the prediction of the planning story. The way that time periods controls capture much of the price and quantity relationship in all models suggests that supply and price relationships are relatively common across activity centres, despite variation in zoned capacity, but vary mostly between time periods.

We include the interaction term for lagged zoned capacity and lagged price in the Equation 2 and 3 models in Table 6. There are no clear observable relationships between lagged zoned capacity and price. One would expect that if zoned capacity has observable price effects that these would be seen in these model results, especially if zoned capacity is more effective at curtailing price growth in already high-priced locations. In the Equation 3 models, from (4) to (6), the inclusion of the interaction term does not change the direction (or magnitude) of price and lagged price coefficients. However, the interaction term does capture much of the variation that was previously captured by lagged zoned capacity alone, and the positive interaction term coefficient in Model (4) is consistent with both housing supply stories.¹⁰

¹⁰Excluding the zoned capacity variable while retaining the interaction terms improves the statistical significance

Table 5: Model results

Dependent var:	$\log(p_t)$			$\log(q_t)$		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	-0.003	-0.000	-0.003*	0.020***	0.020***	0.021***
p_t				0.015***	0.023	0.012
p_{t-1}	0.885***	1.006***	0.806***	-0.010**	0.002	0.002
q_t	0.029***	0.007	0.003			
q_{t-1}	-0.014***	-0.005	-0.005	0.986***	0.984***	0.982***
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	90,800	99,627	99,627	99,627	99,627	99,627
R ²	0.84	0.98	0.98	0.87	0.87	0.87

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.

The results of our robustness checks using data on sites with positive zoned capacity only are reported in Tables A3 and A4 of the Appendix. Here the same patterns are visible, with the direction of all coefficients matching the previous analysis. The price models show no significant relationships with zoned capacity or lagged zoned capacity, but do show the expected directional relationships of the dynamic economic story for quantity and lagged quantity. The inclusion of the interaction term this time has no significant effect on dwelling quantity, though the magnitude and direction of the coefficient estimate is consistent with our main result. That the effect of zoned capacity on price or quantity is less apparent in this subset of the data goes against expectation, particularly of the planning story.

Finally, we apply the regression models to the subset of data with apartment price as the price variable rather than residential land price. These results are in Tables A5 and A6 of the Appendix. Here, dwelling quantity is related to lagged zoned capacity (Models (4) to (6) in Table A5) but also positively related to apartment prices. The inclusion of the interaction term does not reveal any significant new patterns in this data. Coupled with our descriptive data observations, these regression results and multiple robustness checks suggest that the planning story of housing supply explains very little of the dwelling price story.

5 Discussion and Conclusion

Using a large site-level database across twenty years and 19 activity centres that were targeted in the planning system for residential densification, we have tested which of two causal stories about housing supply is consistent with the empirical record. The expected and observed patterns are summarised in Table 7. Overall, rising prices appeared related to rising new housing construction, even after controlling for zoned capacity, and these results are robust to various data selection choices. This contradicts the predictions of the planning story, which argues that areas with more zoned capacity will see more dwellings construction and lower prices after a demand shock. Instead, the data shows patterns consistent with the dynamic economic story whereby viable

on the interaction term without changing its magnitude.

Table 6: Model results with interaction term

Dependent var:	log(p_t)			log(q_t)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	-0.002	0.032	0.018	-0.016	0.010	-0.000
p_t				0.015***	0.025	0.013
p_{t-1}	0.884***	1.009***	0.808***	-0.013***	-0.003	-0.001
q_t	0.032***	0.007	0.003			
q_{t-1}	-0.014	-0.006	-0.005	0.986***	0.984***	0.982***
$p_{t-1} \times zc_{t-1}$	-0.000	-0.006	-0.004	0.006*	0.005	0.004
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	99,627	99,627	99,627	99,627	99,627	99,627
R ²	0.84	0.98	0.98	0.87	0.87	0.88

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.

sites are developed at a rate that depends on price growth.

Table 7: Coefficient sign predictions and results

	Planning story	Dynamic economic story	Results
	zc_{t-1}	-	None
Eq. 1	p_{t-1}	+	+
(p_t)	q_t	-	+
	q_{t-1}	+	-
	$zc_{t-1} \times p_{t-1}$	-	None
	zc_{t-1}	+	None
Eq. 2	q_{t-1}	+	Uncertain (+)
(q_t)	p_t	-	+
	p_{t-1}	+	-
	$zc_{t-1} \times p_{t-1}$	+	Uncertain (+)

Like (Monkkonen *et al.*, 2020) we find that the interaction of our regulatory metric, lagged zoned capacity, to be positively related to new dwellings (though our result is not robust to all data selection choices). This is, of course, by design. Planning regulations are intended to locate new dwelling supply where it is planned rather than where it is not. Because of the lack of relationship between zoned capacity and price, even when interacted with a lag price, we also cannot conclude that regulation has most effect on the dwelling market in locations where prices are higher. Instead, we see this data as supporting the idea that higher prices are necessary for densification and for zoned capacity to be taken up at viable sites. This is consistent with the regression models of (Monkkonen *et al.*, 2020), whose negative relationship between existing density and multifamily permits also suggests that existing development reduces the economic

viability of redevelopment, which is an alternative way of saying that higher prices are required to make redevelopment of existing uses viable.

Our approach is limited in the following ways. First, our planning story assumption that there is common demand shock across all locations in our data at each time period could be wrong. This would mean that the planning story predictions about the relationship between price and quantity would be the opposite (i.e. consistent with the dynamic economic story). Yet, there should still be a large observable negative relationship between zoned capacity and price, which does not appear in most model variations. In the one instance it does, the relationship is extremely small, implying a price elasticity with respect to zoned capacity of 0.003. Put another way, a doubling of zoned capacity (a 100% increase) from this already high average amount might reduce prices five years later by 0.3%. Even if this occurred in every five-year period, that is only a 3% price effect after compounding over twenty years. Second, our price information may be too limited, as we do not have unique prices at each site, nor hedonic price indexes. But if supply variation does not affect these local averages over five year windows, then it is hard to argue that it has a meaningful price effect. While this analysis cannot exclude the possibility that there are small undetectable negative price effects from policy changes that increase zoned capacity, it can exclude the idea that if these price effects exist that they are large or important for explaining the overall pattern of housing prices.

The regression results coupled with the overall descriptive data supports the idea that zoned capacity alone is not a major determinant of the rate of new dwelling supply, nor dwelling price. Only 22% of the sites with zoned capacity in 1996 had any redevelopment in the subsequent twenty year period. Despite all the development that did occur, zoned capacity in every activity centre continued to grow over the 20-year study period, and in total zoned capacity was twice as high at the end of the study period than the start. Meanwhile, the increase in dwellings in these activity centres was in line with the city average, with many below it.

It may be the case that the rate of new housing supply in Brisbane is unconstrained by planning, either in these activity centre location or overall. If this is true, however, then any claim of large price effects from supply constraints runs into difficulty. Over the 2001-2016 period, for example, Brisbane dwelling prices grew more than those in Sydney and Melbourne ABS (2018). Yet when we study those periods in our data it seems that zoned capacity had no relationship to price. It is more likely that the planning story of housing supply assumed by the various policy interest groups in the YIMBY movement is not an accurate description of housing supply.

References

- ABS. 2016. *2016 Census QuickStats: Greater Brisbane*. Tech. rept. Australian Bureau of Statistics.
- ABS. 2018. *6416.0 Residential Property Price Indexes: Eight Capital Cities*.
- APM. 2019. *Timeseries Property Data (SA2 - ASGS2016)*. Tech. rept. Australian Property Monitors (accessed via AURIN).
- APM. 2020. *Median Detached House Prices*. Tech. rept. Australian Property Monitors (accessed via AURIN).
- CHAKRABORTY, ARNAB, KNAAP, GERRIT-JAN, NGUYEN, DOAN, & SHIN, JUNG HO. 2010. The effects of high-density zoning on multifamily housing construction in the suburbs of six US metropolitan areas. *Urban Studies*, **47**(2), 437–451.

- COWAN, JILL. 2019. Should California Get Rid of Single-Family Zoning? *New York Times*, June 20.
- DAIN, AMY. 2005. Residential land-use regulation in eastern Massachusetts. *The Pioneer Institute and the Rappaport Institute for Greater Boston at the Kennedy School of Government, Harvard University, December*.
- DAMIANO, ANTHONY, & FRENIER, CHRIS. 2020. Build Baby Build?: Housing Submarkets and the Effects of New Construction on Existing Rents.
- DELWP. 2017. *Plan Melbourne 2017-2050: Metropolitan Planning Strategy*. Tech. rept. Department of Environment, Land, Water and Planning. Victorian Government.
- DODSON, JAGO. 2010. In the wrong place at the wrong time? Assessing some planning, transport and housing market limits to urban consolidation policies. *Urban Policy and Research*, **28**(4), 487–504.
- FILION, PIERRE. 2009. The mixed success of nodes as a smart growth planning policy. *Environment and Planning B: Planning and Design*, **36**(3), 505–521.
- FORSTER, CLIVE. 2004. *Australian cities: continuity and change. 3rd Edition*. Oxford University Press.
- FREEMARK, YONAH. 2019. Upzoning Chicago: Impacts of a Zoning Reform on Property Values and Housing Construction. *Urban Affairs Review*, 1078087418824672.
- GLAESER, EDWARD L, SCHUETZ, JENNY, & WARD, BRYCE. 2006. Regulation and the rise of housing prices in Greater Boston. *Cambridge: Rappaport Institute for Greater Boston, Harvard University and Boston: Pioneer Institute for Public Policy Research*.
- GREENAWAY-MCGREVVY, RYAN, PACHECO, GAIL, & SORENSEN, KADE. 2020. The effect of upzoning on house prices and redevelopment premiums in Auckland, New Zealand. *Urban Studies*, 2020/09/22, 0042098020940602.
- GSC. 2019. *Greater Sydney Region Plan. Performance Indicator: 30-minute city*. Tech. rept. Greater Sydney Commission.
- GYOURKO, JOSEPH, & MOLLOY, RAVEN. 2015. Regulation and housing supply. *Pages 1289–1337 of: Handbook of Regional and Urban Economics*, vol. 5. Elsevier.
- GYOURKO, JOSEPH, SAIZ, ALBERT, & SUMMERS, ANITA. 2008. A new measure of the local regulatory environment for housing markets: The Wharton Residential Land Use Regulatory Index. *Urban Studies*, **45**(3), 693–729.
- HANSEN, MATT. 2020. *Adopt the Missing Middle Housing Act and provide zoning regulation requirements for certain cities*. Tech. rept. Nebraska 106th Legislature.
- LIMB, MARK. 2019. *Evaluating the implementation of compact activity centres in greater Brisbane*. Ph.D. thesis, Queensland University of Technology.
- LIMB, MARK, GRODACH, CARL, MAYERE, SEVERINE, & DONEHUE, PAUL. 2020a. Policy intent meets reality: the conformance of 20 years of metropolitan compact activity centre policy in greater Brisbane, Australia. *OSF Preprints*, <https://osf.io/5epxr>.
- LIMB, MARK, GRODACH, CARL, MAYERE, SEVERINE, & DONEHUE, PAUL. 2020b. Rethinking the Implementation of the Compact City: Factors Affecting Compact Activity Centre Policy Conformance in Greater Brisbane, 1996 to 2016. *Urban Policy and Research*, 1–16.

- LIMB, MARK, GRODACH, CARL, DONEHUE, PAUL, & MAYERE, SEVERINE. 2020c. When plans are used to no effect: Considering implementation performance of greater Brisbane’s compact activity centre policies. *Environment and Planning B: Urban Analytics and City Science*, 2399808320951583.
- MICHAEL MANVILLE, PAAVO MONKKONEN, MICHAEL LENS. 2019. It’s Time to End Single-Family Zoning. *Journal of the American Planning Association*, 1–7.
- MONKKONEN, PAAVO. 2019. The elephant in the zoning code: Single family zoning in the housing supply discussion. *Housing Policy Debate*, **29**(1), 41–43.
- MONKKONEN, PAAVO, LENS, MICHAEL, & MANVILLE, MICHAEL. 2020. *Built-out cities? How California Cities Restrict Housing Production through Prohibition and Process*. Tech. rept. Turner Center for Housing Innovation at the University of California, Berkeley.
- MURPHY, ALVIN. 2018. A dynamic model of housing supply. *American Economic Journal: Economic Policy*, **10**(4), 243–67.
- MURRAY, CAMERON. 2020a. A housing supply absorption rate equation. *OSF Preprints*.
- MURRAY, CAMERON K. 2020b. Time is money: How landbanking constrains housing supply. *Journal of Housing Economics*, 101708.
- NEWTON, PETER, & GLACKIN, STEPHEN. 2014. Understanding infill: Towards new policy and practice for urban regeneration in the established suburbs of Australia’s cities. *Urban Policy and Research*, **32**(2), 121–143.
- PCA. 2013. *Development Assessment Report Card*. Tech. rept. Property Council of Australia.
- PENDALL, ROLF, WEGMANN, JAKE, MARTIN, JONATHAN, & WEI, DEHUI. 2018. The growth of control? Changes in local land-use regulation in major US Metropolitan Areas from 1994 to 2003. *Housing Policy Debate*, **28**(6), 901–919.
- QUIGLEY, JOHN M, & ROSENTHAL, LARRY A. 2005. The effects of land use regulation on the price of housing: What do we know? What can we learn? *Cityscape*, 69–137.
- SCHMITT, PETER. 2013. Planning for polycentricity in European metropolitan areas—Challenges, expectations and practices. *Planning Practice & Research*, **28**(4), 400–419.
- S&P DOW JONES INDICES. 2020. *S&P Case-Shiller CA-San Francisco Home Price Index*. Retrieved from FRED, Federal Reserve Bank of St. Louis.
- UDIA. 2019 (January). *National Pre-Budget Submission 2019. “Building a Better Australia”*. Urban Development Institute of Australia. Australian Treasury Submission.
- WEGMANN, JAKE. 2019. Death to Single-Family Zoning... and New Life to the Missing Middle. *Journal of the American Planning Association*, 1–7.
- WHEATON, WC, & EVENSON, B. 2003. Local variation in land use regulations. *Brookings-Wharton Papers on Urban Affairs*, **4**, 221–260.
- WIENER, SCOTT. 2020. *SB-50 Planning and zoning: housing development: streamlined approval: incentives*. Tech. rept. California State Senate.
- WOODCOCK, IAN, DOVEY, KIM, WOLLAN, SIMON, & ROBERTSON, IAN. 2011. Speculation and resistance: constraints on compact city policy implementation in Melbourne. *Urban policy and research*, **29**(4), 343–362.

YGLESIAS, MATTHEW. 2012. *The rent is too damn high: What to do about it, and why it matters more than you think*. Simon and Schuster.

Appendix

Table A1: Site-level summary data for activity centres in 2016

Centre	Number of sites	Res. share	Share comm.	Density dwells/ha	Median \$/sqm	Price growth	Dwelling growth
Beenleigh	966	0.80	0.09	19	384	2.66	0.21
Browns Plains	948	0.80	0.07	12	409	2.56	0.09
Capalaba	499	0.51	0.02	19	612	3.27	0.26
Carindale	1,230	0.98	0.14	15	1,021	2.72	0.17
Chermside	1,575	0.90	0.07	35	880	3.65	0.93
Cleveland	956	0.80	0.15	19	687	2.63	0.81
Goodna	966	0.88	0.07	13	274	2.81	0.10
Indooroopilly	1,566	0.90	0.04	30	1,015	3.22	0.47
Ipswich	1,116	0.64	0.20	20	411	2.92	0.12
Logan Central	1,713	0.91	0.05	18	434	3.21	0.07
Logan Hyperdome	1,066	0.92	0.20	10	404	2.59	0.05
Mitchelton	1,929	0.93	0.06	20	959	4.23	0.28
Redcliffe	2,223	0.91	0.02	19	641	3.42	0.11
Springwood	1,091	0.74	0.28	15	633	2.75	-0.01
Strathpine	532	0.69	0.10	18	514	2.20	0.32
Toombul	1,819	0.89	0.06	40	1,298	3.88	0.55
Toowong	1,552	0.90	0.05	40	1,150	3.07	0.39
Upper Mt Gravatt	1,349	0.91	0.09	19	1,082	3.75	0.33
Wynnum Central	2,750	0.89	0.04	22	953	3.81	0.22
Total	25,775	0.87	0.08	23	780		0.33

Share of residential and commercial sites is on a “per site” basis, and hence does not reflect the physical scale of each use type, but does represent the relative magnitude of the number of redevelopment opportunities from each use type. Median residential price is the SA2 level median house price applied to each site in that SA2 area, then averaged across all sites in the activity centre (APM, 2020). Price growth is the proportional change in average land value per square metre for detached housing. Dwelling growth is the proportional change in total dwellings in the area over the twenty year study period.

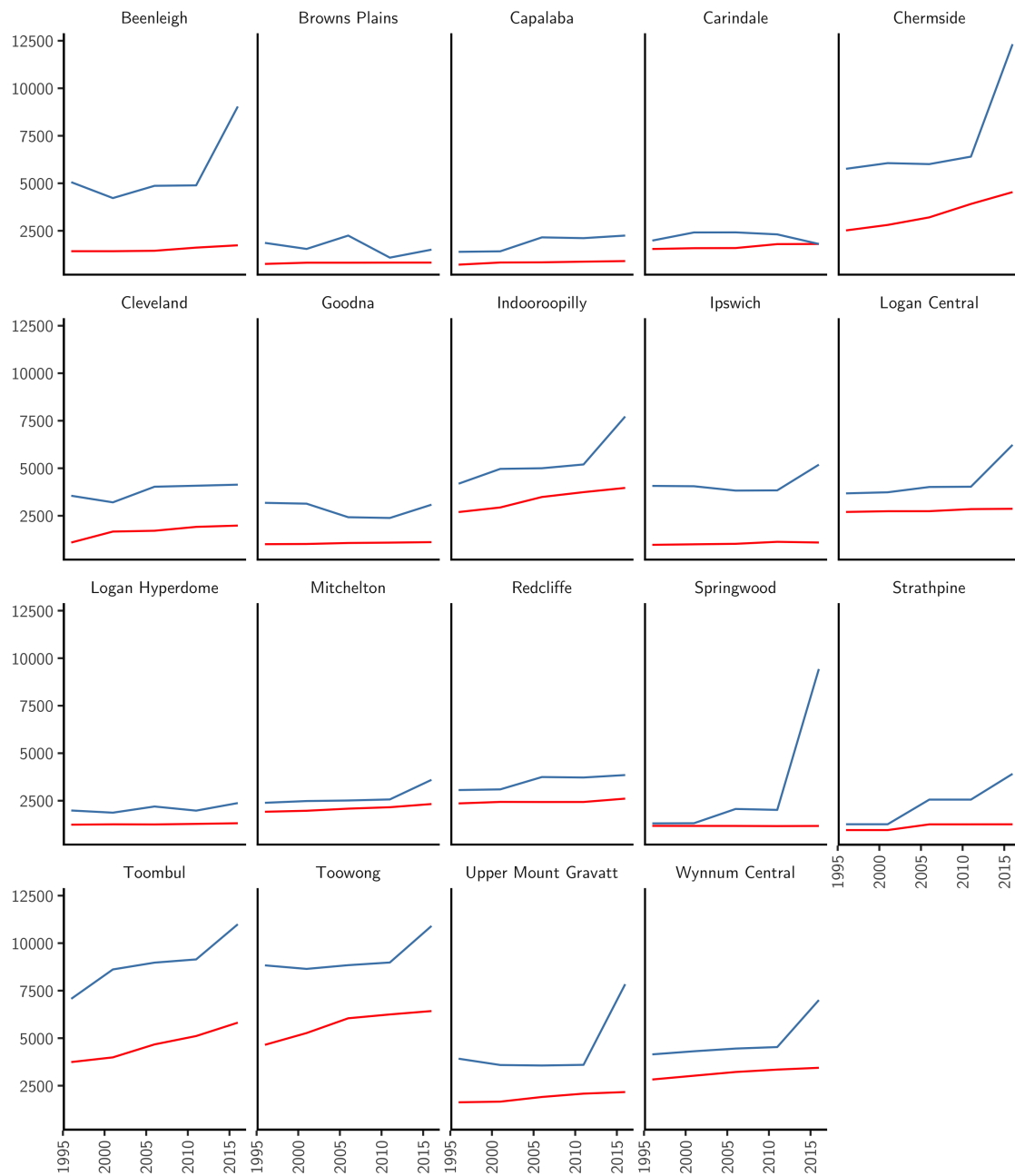


Figure A1: Total dwellings (red) and dwellings plus zoned capacity (blue)

Table A2: Land use percentage of activity centre area at beginning and end of panel (1996 → 2016)

Land Use Code	-	0	1 & 2	3	4	5	6	7	8
	Vacant	Low-density res.	Med-density res.	Med-density res.	High-density res.	Commercial	Industrial	Community use	Open space
Centre									
Beenleigh	6→3	32→28	6→8	0→0	0→0	8→12	1→1	20→20	26→27
Browns Plains	36→5	33→32	0→1	0→0	0→0	17→31	4→21	0→1	9→9
Capalaba	16→10	12→9	6→9	0→0	0→0	28→31	6→8	0→2	31→31
Carindale	4→0	39→40	5→7	0→0	0→0	8→9	0→0	5→5	39→39
Chermside	1→1	27→20	5→10	0→0	0→4	13→13	0→0	16→13	38→39
Cleveland	14→2	31→30	5→13	0→1	0→0	13→17	5→4	11→11	21→21
Goodna	8→5	50→50	4→6	0→0	0→0	6→7	4→4	7→7	20→20
Indooroopilly	1→1	47→41	8→12	1→2	0→1	9→9	0→0	22→22	12→12
Ipswich	1→3	25→21	1→2	0→0	0→0	14→22	4→2	26→20	28→28
Logan Central	4→3	48→46	11→13	0→0	0→0	13→12	0→0	12→13	13→12
Logan Hyperdome	5→2	65→63	4→4	0→0	0→0	23→26	1→1	0→1	2→3
Mitchelton	1→0	50→49	2→5	0→0	0→0	12→13	2→2	13→11	18→19
Redcliffe	1→0	57→54	3→3	0→1	0→0	9→9	3→4	13→13	16→16
Springwood	2→1	33→32	5→5	0→0	0→0	28→30	11→11	7→7	14→14
Strathpine	13→3	13→12	9→15	0→0	0→0	28→31	8→9	2→2	28→27
Toombul	2→1	36→28	14→20	0→1	0→1	10→9	2→1	10→10	27→28
Toowong	1→0	36→28	17→23	3→5	2→3	8→7	2→1	19→18	13→13
Upper Mt Gravatt	3→1	45→41	5→7	0→1	0→0	22→24	1→1	10→10	14→14
Wynnum Central	2→2	57→56	4→7	0→0	0→0	7→6	2→2	7→7	20→20
Total	6→2	39→36	6→9	0→1	0→1	14→16	3→4	11→10	21→21

Table A3: Model results—positive zoned capacity sites

Dependent var:	log(p_t)			log(q_t)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	-0.003	-0.000	0.003	0.011*	0.011*	0.012**
p_t				0.020***	0.089	0.067
p_{t-1}	0.911***	1.022	0.983***	-0.014**	-0.071	-0.069
q_t	0.031***	0.021	0.014			
q_{t-1}	-0.006	0.015	-0.014	0.981***	0.979***	0.975***
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	35,165	35,165	35,165	35,165	35,165	35,165
R ²	0.84	0.98	0.98	0.86	0.86	0.86

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.

Table A4: Model results with interaction term—positive zoned capacity sites

Dependent var:	log(p_t)			log(q_t)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	0.007	0.041	0.037	-0.018	-0.024	-0.015
p_t				0.021***	0.092	0.007
p_{t-1}	0.922***	1.028***	0.986***	-0.019***	-0.079	-0.073
q_t	0.032***	0.021	0.014			
q_{t-1}	-0.009	-0.017	-0.015	0.982***	0.980***	0.976***
$p_{t-1} \times zc_{t-1}$	-0.013	-0.007	-0.006	0.005	0.006	0.005
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	35,165	35,165	35,165	35,165	35,165	35,165
R ²	0.86	0.98	0.98	0.86	0.86	0.87

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.

Table A5: Model results—apartment prices

Dependent var:	$\log(p_t)$			$\log(q_t)$		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	-0.003	-0.000	0.004	0.024***	0.024***	0.024***
p_t				0.009*	0.024*	0.010
p_{t-1}	0.731***	0.805***	0.173	-0.008	0.007**	0.015
q_t	0.021*	0.120**	0.003			
q_{t-1}	-0.009	0.003	0.001	0.988***	0.988***	0.985***
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	73,215	73,215	73,215	73,215	73,215	73,215
R ²	0.66	0.93	0.96	0.87	0.87	0.87

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.

Table A6: Model results with interaction term—apartment prices

Dependent var:	$\log(p_t)$			$\log(q_t)$		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
zc_{t-1}	-0.086	-0.091	-0.004	0.047	0.041	0.038
p_t				0.009	0.025**	0.011
p_{t-1}	0.724***	0.798***	0.172	-0.006	0.007	0.015
q_t	0.021*	0.012**	0.003			
q_{t-1}	-0.009	-0.004	-0.001	0.988***	0.988***	0.985***
$p_{t-1} \times zc_{t-1}$	0.016	0.017*	0.001	-0.004	-0.003	-0.003
Time controls	N	Y	Y	N	Y	Y
AC controls	N	N	Y	N	N	Y
N	73,215	73,215	73,215	73,215	73,215	73,215
R ²	0.66	0.93	0.96	0.87	0.87	0.87

Notation: * is $p < 0.1$, ** is $p < 0.05$, *** is $p < 0.01$. All variables are log transformed. Standard errors are clustered by activity centre.