University of New South Wales
School of Economics

Honours Thesis

Zoned Out of the Market:
How Zoning Restrictions Increase House Prices in Sydney

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Declaration

I declare that this thesis is my own work and that, to the best of my knowledge, it contains no material which has been written by another person or persons, except where acknowledgement has been made. This thesis has not been submitted for the award of any degree or diploma at the University of New South Wales Sydney, or at any other institute of higher education.

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Jim Xu
22$^{\text{nd}}$ November, 2019

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Contents

Abstract

Why are house prices in Sydney so high? This thesis argues zoning restrictions that constrain the supply of houses are the primary driver. First, I quantify the effect of zoning restrictions on house prices over time. I find that zoning restrictions increase Sydney house prices by \$514,271 above marginal costs in 2018 (or 43% of average house prices). I also find the effect of zoning restrictions on house prices has increased significantly over time. Second, I analyse how the effect of zoning on house prices varies across Sydney due to differences in zoning restrictions. I show that moving from the 10^{th} to the 90^{th} percentile of approval times, minimum lot sizes and maximum floor space ratios adds \$245,341, \$80,000 and \$71,534 to house prices.

1 Introduction

Why are Sydney house prices so high? Median house price to income ratios in Sydney have risen from 5.8 times in 2001 to 9.3 times in 2018 (CoreLogic, 2018). Negative implications of high house prices include higher rates of homelessness, higher wealth and intergenerational inequality, less flexible labour markets and increased debt (Yates & Milligan, 2007). With house prices starting to rise again, housing affordability is now a key issue for policymakers.

In Australia, housing density is limited by zoning restrictions. These zoning restrictions reduce supply, increase house prices and are a key driver of housing unaffordability (Kendall & Tulip, 2018). But by how much do these zoning restrictions raise house prices and how do different zoning restrictions add to house prices? In answering these questions, my thesis aims to understand what drives high house prices in Sydney and how policymakers should address housing affordability.

My thesis consists of two components. First, I quantify the extent to which zoning restrictions increase house prices in Sydney. Second, I consider specific classes of zoning restrictions - mean approval times, minimum lot sizes and maximum floor space ratios - and quantify how these restrictions impact house prices.

To estimate the effect of zoning on house prices, I use the method introduced by Glaeser & Gyourko (2003) and decompose house prices into three components:

$$\begin{array}{c}\text{value of the building}\\ + \\ \left.\begin{array}{c}\text{free market value of the land}\\ + \\ \text{effect of zoning}\end{array}\right\}\ \text{land price}\\ = \\ \text{house price}\end{array}$$

This approach relies on two assumptions about land prices. The first assumption is that the free market value of land is exactly proportional to land size: doubling a plot size doubles its free market value. This follows from a no arbitrage principle: if prices were not exactly proportional to land size, then a developer in a free market could arbitrage by splitting a plot into smaller plots, or by buying contiguous plots of land and amalgamating them into a larger plot. The second assumption is the zoning effect is constant, regardless of land size. Figure 1 illustrates my estimate of the zoning effect for Sydney.

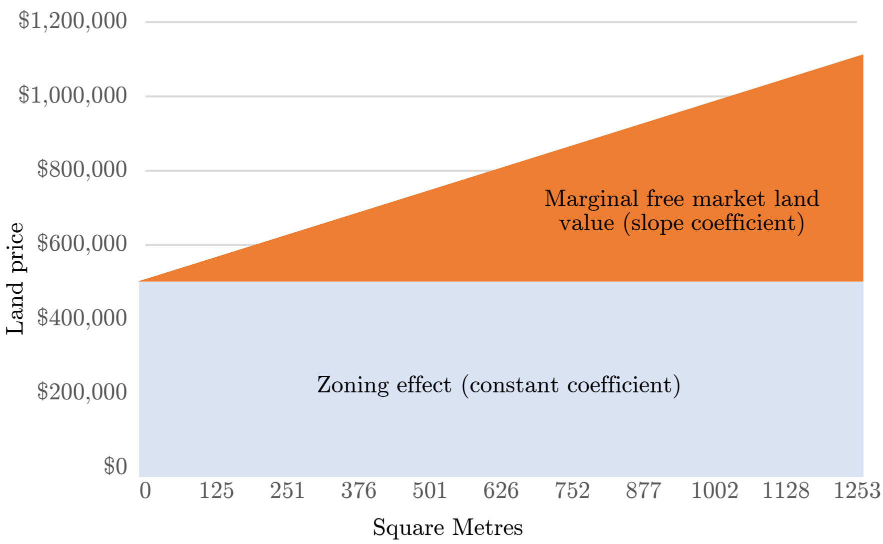

Figure 1: Graph of linear regression of land price on land size for Sydney in 2018

The combination of these two assumptions implies the average price of land per square metre is decreasing in land size and higher than the free market marginal value of land. Hence, land prices are concave in, rather than proportional to, land size. This is consistent with how zoning restrictions - in particular, minimum lot sizes - prevent subdivision of plots. Thus, the arbitrage argument above only works in one direction: developers cannot exploit concavity in land prices by subdividing plots. Indeed, my estimates imply a substantial zoning effect, and thus substantial concavity in land prices.

There are alternative explanations for the size of the zoning effect (and thus the concavity of land prices). These include fluctuations in demand and imperfect competition in construction. However, these explanations cannot account for the persistence and size of the zoning effect. Hence, my thesis takes the view that the only plausible explanation for the degree of concavity is due to zoning restrictions.

As Figure 1 illustrates, my assumptions allow for a straightforward identification of the size of the zoning effect: it is the y-intercept in a simple linear regression of land prices on land size. Hence, to estimate the zoning effect, I run separate simple linear regressions of land price on land size for each of the 43 Local Government Areas (LGAs).

I find the zoning effect in Sydney is large. For example, in 2018, the average price of a house in Sydney was $1,189,617, which could be decomposed into a building worth $375,513 and land worth $814,104. However, regressions of land price on land size show the marginal free market value of land is only worth $479 per square metre. For an average lot of 626 square metres, this means the free market value of the land is only $299,833, yet homeowners are willing to pay $814,104 for the land. The difference of $514,271 is a premium due to zoning restrictions and represents the effect of zoning on house prices.

Using the derived zoning effects, I then examine the contribution of specific zoning restrictions to high house prices by running balanced panel regressions of zoning effects for each LGA from 2012 to 2017 on zoning restrictions, while controlling for income and distance to the CBD.

The three zoning restrictions I analyse are mean days to approve the construction of a single new dwelling, minimum lot size and maximum floor space ratio. The variables were selected based on their use in the literature and importance under NSW planning legislation.

Mean approval days is a non-legislated, or soft, restriction. There is considerable evidence soft zoning restrictions have a large effect on house prices; Glaeser & Gyourko (2003), Kok, Monkkonen & Quigley (2014), PC (2017) and Stevens (2017). Other examples of soft zoning restrictions include the complexity and enforcement of planning rules.

Maximum floor space ratios and minimum lot sizes are legislated, or hard, zoning restrictions. Minimum lot sizes affect house prices by placing size restrictions on subdivision. For example, in Ku-ring-gai, the typical minimum lot size is 930 square metres, more than three times larger than in Liverpool. Floor space ratios affect house prices by requiring homeowners to buy more land than needed to build a house. For example, in Blacktown, the typical maximum floor space ratio is 1.75, while in Ku-ring-gai it is 0.30, which means building the same house in Ku-ring-gai requires nearly six times more land.

My estimates show moving from the 10^{th} to the 90^{th} percentile of mean approval times, minimum lot sizes and maximum floor space ratios adds $245,341, $80,000 and $71,534 to house prices. These estimates are economically important as they represent 19.0%, 6.2% and 5.5% of average house prices. They suggest policymakers interested in housing affordability should not only consider reducing minimum lot sizes and increasing maximum floor space ratios, but also consider reforms to decrease approval times.

There are some limitations with the methodologies adopted in this paper. There are likely endogeneity issues because zoning restrictions reflect the preferences of people and these preferences may also affect house prices. To help address endogeneity concerns, I instrument mean approval days with council staff per development approval. I also explore another potential source of endogeneity in the relationship between housing activity and approval times. However, potential endogeneity concerns mean the model's quantification of how specific zoning restrictions affect house prices should only be interpreted as a correlation and not a causal effect.

My thesis contributes to the literature in three key ways. First, I create a new dataset on minimum lot sizes, maximum floor space ratios and maximum building heights for low-density residential land in Sydney. Second, my thesis provides the first estimates of how variations in zoning restrictions affect the zoning effect for low-density residential land in Sydney. Finally, by analysing both hard and soft zoning restrictions, my thesis contributes to the ongoing debate between the relative role of hard and soft zoning restrictions in raising house prices.

2 Literature Review

2.1 Housing Demand

Most of the literature on house prices has examined the role of housing demand to explain high house prices. Most studies have focused on taxation policy, interest rates and population growth. These papers include Daley & Wood (2016), Gonzalez & Ortega (2013), IMF (2018), Larkin, Askarov, Doucouligaos, Dubelaar, Klona, Newton, Stanley & Vocino (2018) and Saunders & Tulip (2019), among others. Generally, papers find tax concessions and lower interest rates increase house prices, while immigration and faster population growth have a larger effect on rents than house prices.

My methodology, which uses a log-log specification to estimate how the effect of zoning on house prices varies across Sydney, implicitly acknowledges zoning restrictions are more binding in areas with high demand. While I do not explicitly account for demand when quantifying the effect of zoning on house prices, the increase in the estimated effect of zoning on house prices over time can be interpreted as zoning restrictions becoming more binding as demand rises over time. My models for explaining how the effect of zoning on house prices varies across Sydney in Section 5 also have time fixed effects, which control for time varying demand factors. Hence, my thesis implicitly acknowledges the role of demand factors in increasing house prices.

2.2 Housing Supply

While housing demand has been studied much more extensively than supply (Glaeser & Gyourko, 2003), in recent years there has been more literature examining the contribution of supply restrictions to high house prices. Gyourko and Molloy (2015) provide evidence that the housing construction sector is very competitive in the United States, but government policies that limit the supply of housing (i.e. zoning restrictions) are raising prices well above theoretical marginal costs of supply in certain regions. My thesis finds similar results, but with improved datasets available in Sydney. I use Australian Taxation Office data to estimate competition in the house construction sector, while for estimating the effect of zoning on house prices, I use the universe of land prices, rather than a sample of housing sale prices.

For Australia, several papers demonstrate that a restricted supply of land has increased house prices. These include, but are not limited to; Daley, Coates & Wiltshire (2018); Kulish et al (2011); PC (2017); RBA (2014) and Stevens (2017). Generally, these papers conclude that the construction of new dwellings in Australia has not increased in-line with population growth. The main obstacles for extra supply are planning rules that delay or prevent development, with longer approval times and delayed housing supply in areas where zoning restrictions are more complex. However, these papers do not quantify the effect of zoning restrictions on house prices. My thesis differs by both quantifying the effect of zoning restrictions on house prices and then estimating the effect of different planning rules on house prices. While limited to Sydney, I am also able to quantify the effect of long approval times on the cost of supplying housing.

2.3 Models of Zoning Restrictions and Effects

Other papers attempt to quantify how zoning impacts house prices. Several international studies, mainly in the United States, have also found that zoning restrictions have large effects on house and land prices; Ihlanfeldt (2007), Kok, Monkkonen & Quigley (2014), Pollakowski & Wachter (1990) and Quigley & Raphael (2005). Gyourko and Molloy (2015) provide a comprehensive literature review.

The Alonso-Muth-Mills model is an early model that examined variations in house prices within a city. It assumes all workers commute to the CBD to work and households prefer to live closer to the CBD, but as land prices are higher closer to the CBD, dwellings are smaller in size and buildings are taller. Therefore, households choose either to live in smaller dwellings closer to the CBD or larger dwellings further away from the CBD.

One way of estimating the effect of zoning restrictions on house prices would be to add a restriction to the Alonso-Muth-Mills model. Kulish et al (2011) add a building height restriction to the Alonso-Muth-Mills model to examine the theoretical effect of zoning on house prices. They find the effect would be to raise house prices, but lower equilibrium land prices close to the CBD. The output from this theoretical model of house prices is consistent with the conclusions from an analysis of actual land price data. McIntosh, Trubka and Hendriks (2016) regress land values in Sydney on zoning regulations and other controls, such as distance to CBD, lot size and proximity to various transport options. They find rezoning a property from a maximum gross floor area to land area ratio of 0.5 to 4 would increase the land value by 167%.

However, there are limitations with analysing the effect of zoning by adopting the variation in zoning approach. This is because models based on changes in zoning policies can only determine marginal effects, not aggregate effects, and there is also an issue with endogeneity between house prices and zoning (Saiz, 2010).

An alternative approach is to examine the wedge between average land prices and marginal land prices. Glaeser & Gyourko (2003) find that given the construction sector is very competitive in the United States, comparing house prices to the marginal cost of supply allows for an estimation of the aggregate effect of zoning on house prices. They find a significant wedge between marginal costs and prices in highly regulated coastal cities, while zoning restrictions are negligible in the south and mid-west, where zoning restrictions are less restrictive. My thesis uses the methodology of Glaeser & Gyourko (2003) to estimate the aggregate effect of zoning on house prices.

A current gap in the literature is examining how zoning restrictions contribute to variations in the aggregate effect of zoning on house prices in Sydney. Kendall & Tulip (2018) estimate that in 2016, zoning raised the price of detached houses in Sydney by 73% (or A$489,000) above marginal costs. However, unlike Glaeser & Gyourko (2003), they did not investigate the relationship between zoning restrictions and the effect of zoning on house prices. This is a gap my thesis attempts to fill.

3 Overview of the Planning System in NSW

This section provides an overview of the planning system in NSW. The rules around development are very complex and readers should only use this section as a general guide. The section draws extensively on Harris, Harris-Roxas and Harris (2007) and NSW Department of Planning and Environment (2018).

3.1 Key Legislation

The planning system in NSW has a hierarchical structure, with four main pieces of legislation that govern what, where and how development can proceed.

(1) Environmental Planning and Assessment Act 1979

(2) Environmental Planning and Assessment Regulation 2000

(3) Environmental Planning Instruments
State Environmental Planning Policies
Local Environmental Planning Policies

(4) Development Control Plans

Figure 2: Overview of the Planning System in NSW

The Environmental Planning and Assessment Act (1) considers over 70 issues of significance to the people of NSW. The Act sets up the framework for the planning system by determining how development rules are made and how development is measured against these rules.

Environmental Planning and Assessment Regulations (2) detail the processes that local councils must follow when assessing development applications. It also outlines the fees that a council can charge upon the receipt and assessment of a development approval.

Environmental Planning Instruments (3) are the set of legislative controls that govern development in each LGA. These environmental planning instruments are split into two types. The first is State Environmental Planning Policies (SEPPs) and the second is Local Environmental Plans (LEPs). In the event of a clash between SEPPs and LEPs, SEPP regulations dominate.

SEPPs deal with issues of importance to the people of NSW. SEPPs can cover the whole state, or just certain regions. The most relevant SEPP for most home builders is the Building Sustainability Index, more commonly known as BASIX, which sets standards for sustainable development.

Regulations on building standards are ignored in my thesis as they are assumed to add to house prices through construction costs rather than through land prices. Costs involved with building regulations are also relatively minor. For example, compliance with BASIX requirements are estimated to be only add between $1,114 and $21,902 to new house construction costs (Kemp, Graham & Mollard, 2010).

LEPs deal with the minutia of local issues. These include determining land zoning, heritage status, environmental issues (e.g. flooding, bushfire and acid sulfate soils) and principal development standards, which include maximum floor space ratios and minimum lot sizes.

For low-density residential property, LEPs generally zone land as either R1 or R2. R1 zoned land is land zoned for general residential purposes, but it can be used for some limited commercial purposes, such as hostels or seniors housing. R1 and R2 zoned land tends to differ little in value, but the allowable uses for R2 land are more restrictive as it typically only allows for low-density general residential. Land zoned R3 (medium density) and R4 (high density) is typically used for high-density residential purposes. Land zoned R3 (medium density) can generally be used for townhouses, villas or 2-3 storey flats, while land zoned R4 (high density) is typically used for high-density residential purposes, such as high-rise apartments.

In 2016, the NSW Government announced a series of LGA amalgamations (Gerathy, 2016). The amalgamations reduced the number of LGAs in Sydney from 43 to 35. I assume the amalgamations had no effect on land prices and continued to use LGA classifications from before the amalgamations. The assumption is likely appropriate given the new amalgamated LGAs continued to operate under prior LEPs (NSW Department of Planning and Environment, 2016). For example, the new Northern Beaches Council retained Manly, Pittwater and Warringah LEPs (Watermark Planning, 2016).

Finally, Development Control Plans (4) contain more detailed design and planning requirements. These include, but are not limited to, access to sunlight, building design, view sharing, landscaping, car parking requirements and stormwater treatment.

For most dwellings, LEP and SEPP rules are the most important (NSW Department of Planning and Environment, 2018). Hence, when I examine zoning variations across Sydney I only analyse zoning restrictions determined by these two layers of legislation, with a focus on land zoning, principal development standards and approval times.

3.2 Types of Development Permitted

The planning system is used to govern three types of development; exempt development, complying development and development that requires consent.

	Exempt development	Complying development	Development that requires consent
Approval required?	No	Yes, but streamlined	Yes, requires a full development approval (DA)
What activities are typically allowed?	Limited, examples included installing barbecues & small fences	Used for routine applications, including for low-rise homes & renovations.	Used for all other activities
Average approval time in 15/16	Not applicable	22 days	75 days

Figure 3: Overview of the three types of development

Figure 3 summarizes the types of development activity allowed in NSW. Exempt development requires no approvals and may include activities such as the installation of barbecues and small fences. Complying development is a cheaper and faster approval process for routine developments such as building a typical low-density family home and renovations. Complying developments accounted for one-third of approvals across NSW in FY15/16 (Department of Planning, Industry and Environment, 2018). Development approvals are an application procedure that requires formal council approval.

Given the low value of exempt development activity and their generally limited scope, my thesis will focus on examining the zoning restrictions that affect complying developments and development that requires consent.

4 Quantifying the Effect of Zoning on House Prices

To quantify the effect of zoning on house prices in Sydney, I use the zoning model for housing introduced by Glaeser & Gyourko (2003), rather than the Alonso-Muth-Mills model. The key reason is because the Alonso-Muth-Mills model assumes land prices are high because land is limited. If this were true, then observed marginal values of land would be high. However, observations by Glaeser & Gyourko (2003) find that high house prices are not predominantly driven by limited land in the United States, while Kendall & Tulip (2018) show implied marginal prices of land are much lower than average prices of land.

4.1 The Zoning Model of Housing

Consider the following model for the construction cost of a house used by Glaeser & Gyourko (2003):

$K =$ house construction cost (observed)

$T =$ zoning effect (unobserved)

$p =$ marginal free market price of land (unobserved)

$L =$ square metres of land (observed)

The cost of supplying one house is K+T+pL. As with Glaesar & Gyourko, I interpret p as the marginal free market value of land and T as the zoning effect. Note that in this model, the zoning effect T is independent of land size. If construction is perfectly competitive, then in equilibrium, the price of a house with L units of land would be:

$$Price_{house}(L) = K + T + pL$$

However, if land prices are known, then the model simplifies to:

$$Price_{house}(L) - K = Price_{land}(L) = T + pL$$

This model is just a simple linear regression of land size, with the marginal free market value of land determined by the slope, and the effect of zoning on house prices determined by the constant.

$$Price'_{land}(L) = p = \text{marginal free market value of land}$$

$$T = \text{effect of zoning on house prices}$$

The zoning effect, T, is the wedge between the current market value of land and the free market value of land. For example, under current market prices, a developer could buy a plot of size 1,253 square metres for $1,113,729 and split it into two lots of 626 square metres worth $814,104 each and make an arbitrage of $514,271. However, zoning restrictions prohibit these subdivisions. Thus, in a market without zoning, the value of land should be perfectly proportional as any deviation would allow for arbitrage through subdivision.

The interpretation of the constant coefficient as capturing the zoning effect requires the strong assumption that marginal free market land values are not affected by zoning. I explore this assumption in Section 4.3, but conclude it is largely appropriate. The size of the zoning effect is not how much house prices would fall from the removal of zoning restrictions. Estimating the change in price would require knowledge of demand and supply curves, as well as general equilibrium effects.

4.2 Land Value Data

The main source of data used to estimate the equations in Section 4.1 comes from Valuer General estimates of land values in NSW. The dataset includes details on all properties in NSW, including address, LGA, taxable land value of as at 1 July from 2012 to 2018, zoning code and size. As I am only interested in the effect of zoning on low-density residential house prices, I only include land that is zoned R1 or R2[1]. My analysis excludes medium or high-density zoned land as estimating the zoning effect on medium or high-density land prices requires further assumptions about building costs (Kendall & Tulip, 2018). Most of the literature, Chakraborty, Knapp, Nguyen & Shin (2010), Mayer & Somerville (2000) and Glaeser & Gyourko (2003), also only examines the effect of zoning on low-density residential structures.

NSW taxable land value data is subject to annual changes and is physically revalued at least once every three years (Property NSW, 2019). Hence, the data is less likely to be undervalued compared to land and property value data in other regions, which can be based on

[1] See Section 3 for a description of residential zoning codes

historical acquisition prices (Calif. Const. art XIII A). Nonetheless, there is a perception taxable land values are under-estimated, with anecdotal reports suggesting a large bias.

An alternative to using land value data is to derive land values from house sale prices through hedonic regressions. Kendall & Tulip (2018) use this technique to alleviate concerns around the undervaluation of land value data. However, I was unable to obtain sales data prior to 2017, limiting the usefulness of the sales data to estimate a panel regression. Furthermore, the results I obtain from the land value data are similar to estimates derived by Kendall & Tulip (2018). Hence, despite potential issues with undervaluation, I continue to use the NSW taxable land value data as the main source of data in my thesis.

4.3 Zoning Model Assumptions and Limitations

The zoning model makes five significant assumptions. The first assumption is that the marginal free market value of land is constant. This assumption is broadly accurate, and can be seen in Figure 4, which plots the land values for R1 zoned land in Kensington. Land prices grow linearly with respect to land size, but the price of a plot of 400 square metres is less than the price of 2 plots of land of 200 square metres, so land prices are also concave.

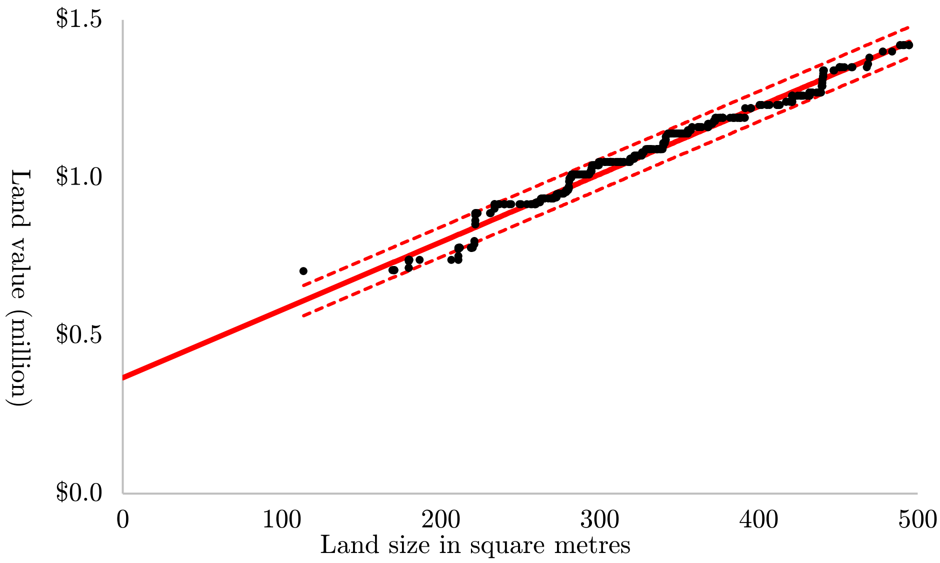

Figure 4: Land value of R1 land in Kensington

If land prices did not grow linearly, then the empirical results could be biased. In Appendix 8.1, I conduct robustness checks, which include adding a squared term for land size. Overall, I find that adding a squared term slightly improves the fit but has minimal impact on estimating the aggregate zoning effect. Hence, I continue to use the simple linear specification as the main model for estimating the zoning effect. Graphs of land prices against land size, such as Figure 4, also show land prices grow linearly with respect to land size, consistent with zoning not affecting the marginal free market value of land.

However, robustness checks show a non-linear relationship between land prices and size for very high value land. This could be driven by wealthy households competing for the largest block of land and is less likely to be due to economic fundamentals. As the economic issue of housing affordability is typically more important for low-income households, I am uninterested in examining the factors that determine the valuation of highly valued land. Hence, I exclude the top percentile of land prices in Sydney and the top percentile of land prices in each LGA when running my regressions. Land prices for the bottom percentile in Sydney and each LGA are also omitted to remove outliers.

The second assumption is that the zoning effect is unrelated to land size. If this assumption is incorrect, then the slope coefficient of the regression is also affected by zoning restrictions. There are several reasons why the assumption may not hold. For example, governments typically charge progressive fees based on the value of construction costs and holding costs for a developer are likely to be higher due to the progressive nature of land taxes. I explore this issue further in Appendix 8.1, but conclude that the variation and unpredictability of fees charged means it is difficult to justify a model where land prices do not grow linearly with respect to land size.

The third key assumption is that the construction industry is perfectly competitive. Gyourko and Molloy (2015) demonstrate that in the United States, this assumption is reasonable given the large number of participants in housing construction. In Australia, there were 13,927 entities engaged in the residential construction sector in 2016/17 and the median company made a net profit margin of just 3% (ATO, 2019 & Author's calculations); consistent with strong competition in the sector. Another measure of competition in the sector is the four-firm concentration ratio. According to HIA (2018a), the largest four companies built 15,580 dwelling in 2018. This corresponds to a four-firm concentration ratio of just 6.8%. While perfect competition is associated with a four-firm concentration ratio of 0%, typically values below 40% are considered very competitive (Naldi & Flamini, 2014). Hence, I view the perfect competition assumption as reasonable.

The fourth and fifth assumptions are that marginal land prices are constant through a city and that the zoning effect only measures the effect of zoning on house prices. These two model limitations are discussed throughout Section 4.5.

4.4 Summary Statistics and Graphs

	Year	Units	Mean	Std	10th percentile	Median	90th percentile
Land value	2018	$	814,104	705,842	348,000	649,000	1,500,000
Land value	2017	$	800,014	676,611	327,000	659,000	1,480,000
Land value	2016	$	697,066	598,050	271,000	590,000	1,260,000
Land value	2015	$	633,960	556,123	240,000	541,000	1,140,000
Land value	2014	$	504,003	475,529	189,000	416,000	903,000
Land value	2013	$	436,373	422,093	165,000	348,000	783,000
Land value	2012	$	421,631	430,985	152,000	327,000	754,000
Land size		m^2	626	252	341	596	923

Table 1: Mean and standard deviation calculated as across 904,906 R1 and R2 zoned lots in Sydney. 1^{st} and 99^{th} percentile of land values excluded to remove outliers. Land size is assumed to be constant over time because data is only provided for land size in the latest year, hence plots of land subdivided in previous years are excluded. This is unlikely to significantly bias results given few subdivisions occur every year; only 2,052 subdivision permits were issued in 2015/16 (NSW Department of Planning, Industry and Environment, 2018 & Author's calculations).

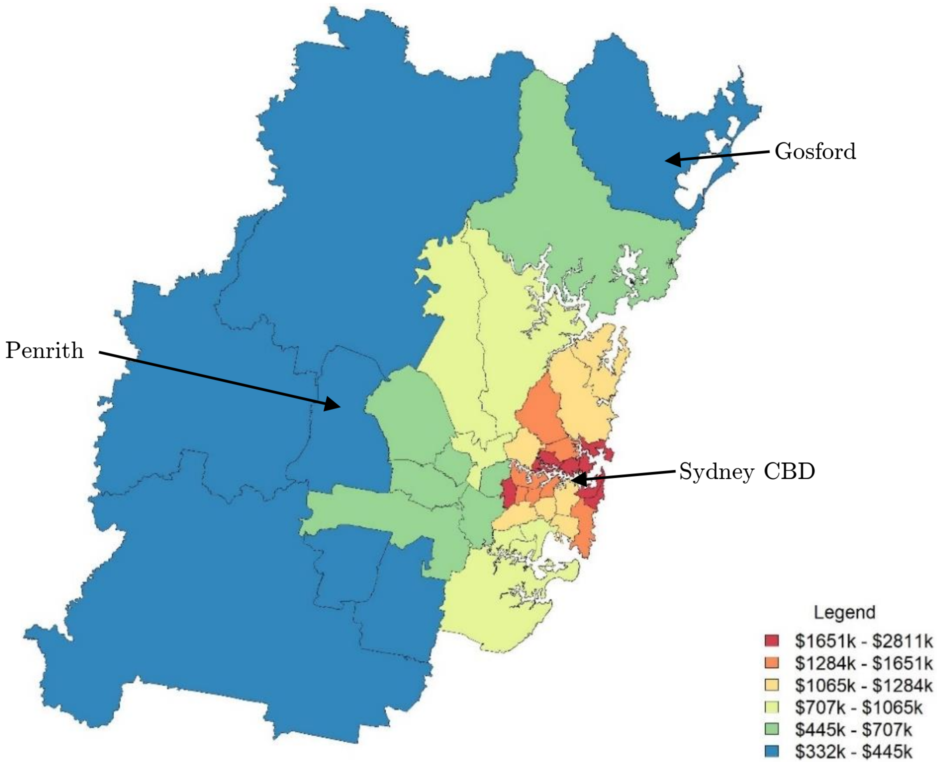

Figure 5: Average land value by LGA in 2018

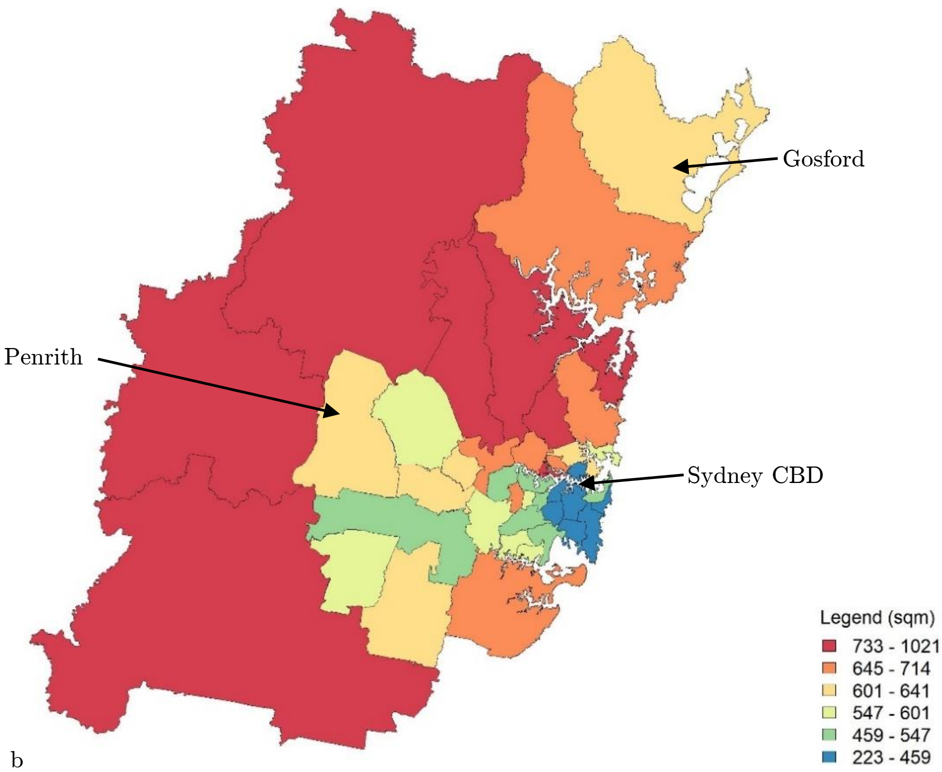

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Figure 6: Average land size by LGA

4.5 Results

Simple linear regressions of land price on land size for the 43 LGAs in Sydney were run separately to estimate the effect of zoning on house prices for each LGA. I adopted this approach because the model assumes marginal free market land values are constant. This assumption is unlikely to hold for all of Sydney but is likely to be appropriate for land prices within each LGA.

The results suggest that zoning restrictions raised house prices in Sydney by $514,271 above marginal costs in 2018. To calculate the effect of zoning restrictions on house prices in Sydney, I aggregate results by the number of lots in each of the 43 LGAs.

The simple linear regression for each LGA is based on the following:

$$land\ price = constant + marginal\ value\ of\ land \times land\ size$$

As per Section 4.1, if the marginal value of land is assumed to be unaffected by zoning restrictions and construction is perfectly competitive, then the constant coefficient captures the effect of zoning on house prices. For example, the constant coefficient in Ashfield council is $467,807. As the standard error on the constant coefficient is just $7,371, the constant coefficient is significantly different from zero at any normal level of significance. Hence, the analysis shows that zoning has a statistically and economically significant effect on house prices in Ashfield council.

While I have defined the effect of zoning on house prices as the constant coefficient, i.e. the price of land with zero square meters, this definition should not be taken literally. This is because the price of land with zero square metres should be zero. Instead, the constant coefficient is a simple way of measuring the concavity of land prices. It also represents the wedge that exists between average and marginal land values that should not exist without zoning restrictions.

Table 2 presents the results for 2018 in a table format. The constant coefficient in the regression of land values on land size is the estimated effect of zoning on house prices. The slope coefficient in the regression of land values on land size is the estimated marginal free market value of land. All constant and slope coefficients are statistically significant across all typical levels of significance.

Figure 7 and Figure 8 present maps of the estimated effect of zoning on house prices and the marginal value of land for each LGA in 2018. A visual comparison of the figures reveals two important observations. Firstly, both the marginal value of land and zoning effects tend to be higher closer to the CBD. However, LGAs with the highest zoning effects do not necessarily have the highest marginal land values. I examine this relationship further in Appendix 8.3 and conclude that while there is no significant relationship between zoning effects and marginal land values, a removal of zoning restrictions could plausibly increase the value of houses on large lots, while decreasing the value of houses on small lots.

I emphasise the results do not mean removing zoning restrictions would see house prices fall by $514,271. Estimating the change would need an analysis of general equilibrium effects as well as demand and supply curves. In Appendix 8.5, I make the strong assumption housing demand is perfectly inelastic and calculate potential tax revenue implications from a removal of zoning.

LGA	Land Size		Constant (Zoning Effect)		Number of lots
	Coef.	Std. Err.	Coef.	Std. Err.	
Ashfield	1778***	(16)	467807***	(7371)	7345
Auburn	637***	(12)	367849***	(5959)	8522
Bankstown	586***	(4)	325355***	(2097)	44789
Blacktown	125***	(2)	378007***	(1141)	86749
Blue Mountains	118***	(4)	252799***	(3253)	6224
Botany bay	1114***	(20)	741285***	(8111)	6518
Burwood	1528***	(28)	571172***	(14722)	6267
Camden	210***	(2)	320465***	(1331)	25007
Campbelltown	200***	(2)	275557***	(1367)	39676
Canada Bay	1029***	(21)	978887***	(10590)	12190
Canterbury	672***	(21)	767371***	(10781)	5682
City of Sydney	2735***	(51)	674536***	(9738)	11327
Fairfield	267***	(3)	375157***	(1759)	41076
Gosford	177***	(4)	338127***	(2891)	49849
Hawkesbury	126***	(3)	317103***	(2187)	8356
Holroyd	580***	(6)	250253***	(3287)	18306
Hornsby	207***	(5)	702335***	(4101)	38402
Hunters Hill	2692***	(81)	431991***	(54687)	2967
Hurstville	712***	(14)	533265***	(7624)	17846
Kogarah	568***	(16)	725581***	(9236)	9063
Ku-Ring-Gai	359***	(9)	993626***	(9385)	23482
Lane Cove	984***	(41)	1057638***	(26562)	6093
Leichhardt	2754***	(26)	660775***	(6284)	14111
Liverpool	323***	(3)	309735***	(1642)	35258
Manly	1063***	(26)	1235925***	(14851)	7733
Marrickville	1550***	(15)	664333***	(4183)	18369
Mosman	2652***	(59)	1139970***	(33770)	4043
North Sydney	2426***	(39)	759186***	(14421)	4386
Parramatta	603***	(8)	378746***	(4842)	30098
Penrith	141***	(2)	290012***	(1217)	44674
Pittwater	399***	(14)	920817***	(10665)	6422
Randwick	1255***	(22)	889308***	(9833)	17050
Rockdale	803***	(11)	563186***	(5592)	16298
Ryde	694***	(11)	746827***	(6976)	21681
Strathfield	1950***	(39)	374790***	(27147)	5282
Sutherland	390***	(11)	628255***	(7041)	24197
The Hills Shire	458***	(5)	476322***	(3916)	39213
Warringah	56***	(9)	1135505***	(6233)	31763
Waverley	3511***	(35)	686300***	(11185)	6963
Willoughby	725***	(18)	1210027***	(10416)	11143
Wollondilly	75***	(2)	340627***	(2226)	8206
Woollahra	3560***	(34)	849396***	(12097)	6848
Wyong	138***	(3)	244240***	(1590)	49589
Sydney	479		514271		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Regression output for each LGA in 2018, robust standard errors

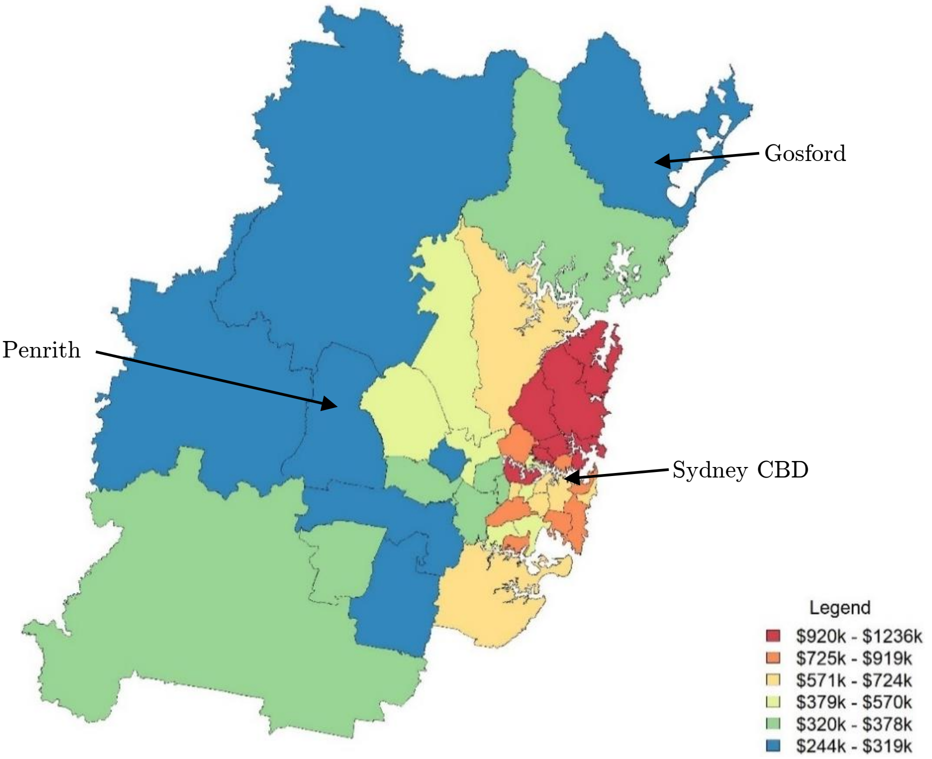

Figure 7: Effect of zoning on house prices by LGA

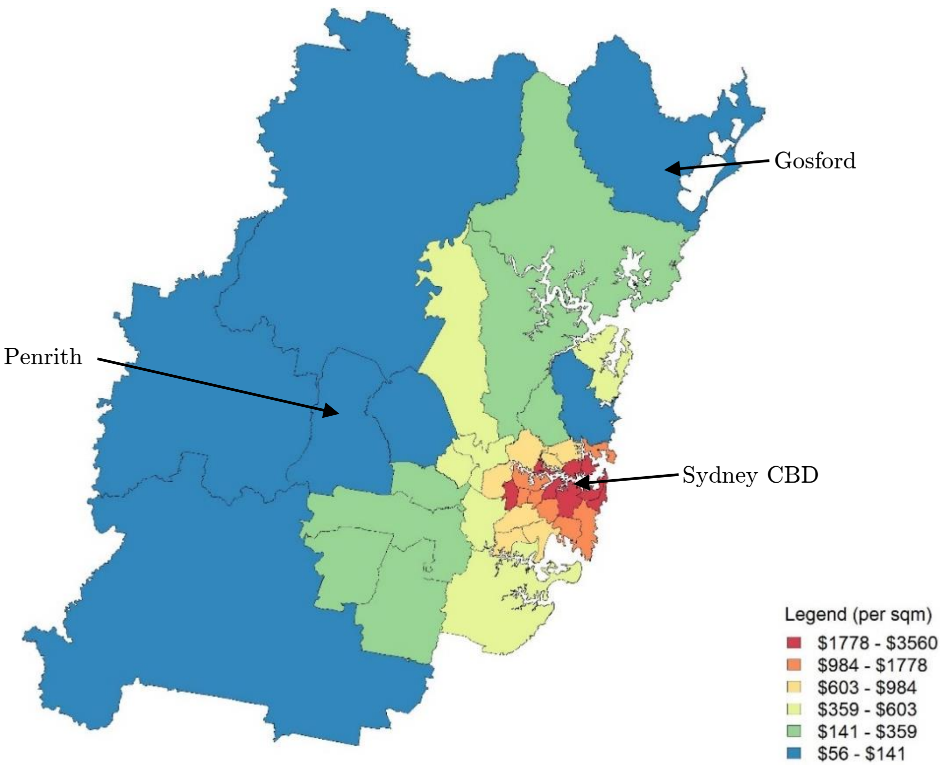

Figure 8: Marginal value of land per square metre by LGA

The estimated effect of zoning is economically important as it represents 43% of the average house price in Sydney. This is close to the 42% share of average house prices estimated by Kendall & Tulip (2018) for Sydney. Table 3 shows that my estimates are also similar to estimates of the effect of zoning on house prices for large cities in other countries with tight zoning restrictions.

City	Zoning Effect share of House Price	Year	Source
Auckland	56%	2016	Lees (2018)
San Francisco	53%	1998-99	Glaeser, Gyourko & Saks (2005)
Wellington	48%	2016	Lees (2018)
San Jose	47%	1998-99	Glaeser, Gyourko & Saks (2005)
Miami	40%	2005	Cheung, Ihlanfeldt & Mayock (2009)
Los Angeles	34%	1998-99	Glaeser, Gyourko & Saks (2005)
Sydney	43%	2018	Author's calculations

Table 3: International estimates of the effect of zoning on house prices

Figure 9 shows the argument that house prices are high because of a scarcity of land is incomplete. While limited land is a necessary condition for high house prices, the marginal value of land of $299,883 accounted for just 25% of the average Sydney house price in 2018. In contrast, the estimated effect of zoning was $514,271, or 43% of the average Sydney house price. Hence, zoning restrictions are a much larger contributor to high house prices in Sydney than land scarcity.

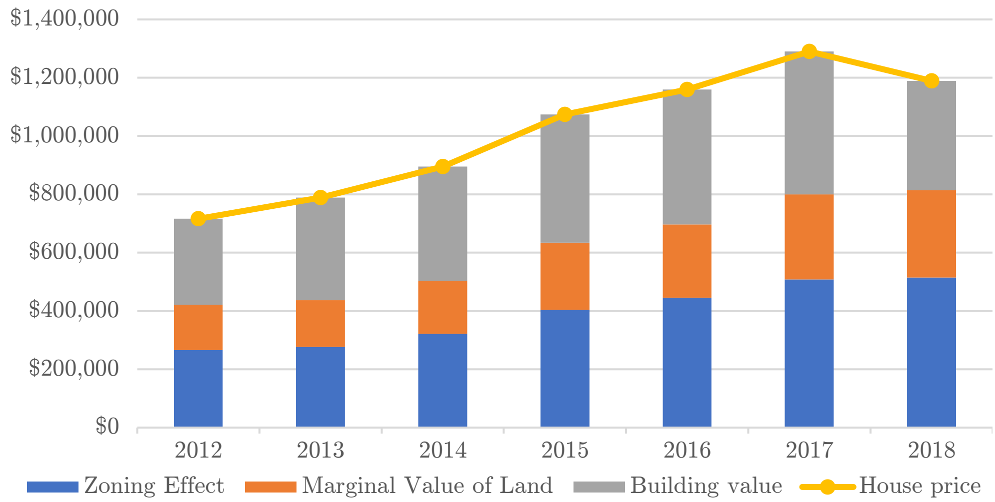

Figure 9: Decomposing the average house price in Sydney

The effect of zoning on house prices has also become significantly more binding over time as demand for housing has increased. Figure 9 shows that in 2012, the estimated effect of zoning on house prices was only \$266,089 or 37% of the average house price, while by 2018, the estimated effect of zoning was \$514,271 or 43% of the average house price. Zoning restrictions have become more binding since 2012 because demand for housing has increased and not because zoning restrictions have tightened. This is because the effect of zoning on house prices is more binding as demand increases. Hence, zoning restrictions are a necessary, but insufficient condition, for high house prices.

4.6 Alternative Explanations

The results show a large and persistent positive constant coefficient in the regression of land price on land size. My interpretation of the positive constant coefficient is that it captures the concavity of land prices and represents the effect of zoning on house prices in Sydney. However, there are two alternative explanations for the size of the positive constant coefficients other than zoning restrictions; imperfect competition in construction and fluctuations in demand. While these two explanations are plausible, in my view, the most likely explanation for concave land prices is that zoning restrictions prohibit landowners from subdividing their plots of land into smaller lot sizes.

The first possible explanation for the zoning effect is due to imperfect competition allowing construction companies to charge above marginal costs. However, I argue the assumption of perfect competition in the construction sector is largely appropriate; construction companies have low margins and the sector is characterized by low market concentration (see Section 4.3).

Another possible explanation for the size of the constant coefficient is that it is simply capturing cyclical swings in demand. For example, delays between when housing demand increases and new dwellings are constructed could temporarily increase prices and upwardly bias estimates of the zoning effect. However, the size and persistence of the zoning effect over the cycle suggests that it is not just due to a cyclical swing in demand (Kendall & Tulip, 2018).

While the two alternative explanations are plausible, in my view, the most likely explanation for the size and persistence of the constant coefficient is that government regulations prohibit landowners from subdividing their plots of land into smaller lot sizes. If no such restrictions existed, then under current market prices landowners could make arbitrage profits by subdividing their land into smaller parcels. Yet in 2015/16, only 2,052 subdivision permits across Sydney were issued by local governments, representing less than 0.2% of all lots (NSW Department of Planning, Industry and Environment, 2018 & Author's calculations).

The following section provides further evidence that the concavity of land prices as measured by the constant coefficient is due to zoning restrictions by examining how the constant coefficient varies in Sydney due to variations in zoning restrictions.

5 Explaining Zoning Effect Variations in Sydney

House prices vary significantly across Sydney. The average Point Piper house price in 2018 was \$8.9m, while the average Minchinbury house price in 2018 was \$563k (Author's calculations). This section analyses the potential drivers behind variations in house prices across Sydney.

In the zoning model of housing (see Section 4.1), variations in house prices are due to three factors: building values, the free market value of land and the zoning effect. Figure 9 shows the value of residential buildings has contributed little towards the growth in average house prices in Sydney since 2012. Accordingly, I ignore the contribution of building values to high house prices[2].

Other papers analysing zoning restrictions typically show how land values vary in Sydney due to different zoning restrictions (McIntosh, Trubka & Hendriks, 2016). However, in the zoning model, land values are comprised of a zoning effect and the free market value of land, which is assumed to be unaffected by zoning restrictions. Hence, an analysis of how zoning affects house prices should only analyse how variations in zoning restrictions affect the zoning effect.

Having quantified the effect of zoning on house prices in Section 4, I now examine zoning effect variations in Sydney due to different zoning restrictions. Quantifying the effect of different policies is important as policymakers interested in housing affordability need quantitative estimates of what policies contribute most to high house prices.

5.1 Model for Zoning Effect Variations

To explain how the zoning effect varies in Sydney, I first estimate the zoning effect for each of the 43 LGAs in Sydney from 1 July 2012 to 1

[2] High average house sizes contribute to high house prices. The average Australian new dwelling size of 186.3 m^2 is double the average new dwelling size of 90-96 m^2 for the UK, Germany, Italy and France (James & Felsman, 2018). The GST also increases the cost of building an average new house by \$49,392 (HIA, 2018b). However, there is little evidence residential construction companies charge above marginal costs (see Section 4.3). Hence, I ignore building costs in my analysis and only examine how land values vary across Sydney.

July 2018 to create a panel data set. This was done in Section 4. I then regress the estimated zoning effects on key zoning restriction variables.

However, a panel analysis of the zoning effect is complicated as the estimated zoning effect in any given year likely does not just capture the effect of zoning on house prices. As discussed in Section 4.6, cyclical swings in housing demand mean that the effect of zoning in any given year could be upwardly or downwardly biased. This is likely to affect the use of the zoning effect variable in a time-series or panel regression.

A time series analysis of zoning is further complicated by data quality issues. Figure 9 shows the building value of an average house in Sydney in 2018 fell, while land values (sum of zoning effect and marginal value of land) rose. Between 2017 and 2018, average house prices fell 7.8% in Sydney and housing construction costs rose (ABS, 2019b). This suggests average land values should have fallen by more than 7.8% in Sydney in 2018. Instead, the Valuer General assessed residential land values increased by 4.4% (Valuer General, 2019), while R1 and R2 land values in Sydney rose by 1.8%. The unexpected rise in land values in 2018 suggests the zoning effect calculated in 2018 may be biased upwards relative to the estimates derived from 2012 to 2017. Hence, I exclude the 2018 data from my analysis of how the zoning effect varies.

Within Sydney, there is also significant variation in the effect of zoning restrictions on house prices. Table 2 shows that while the average effect of zoning on house prices in Sydney is $514,271, the effect of zoning on house prices varies from $244,240 in Wyong to $1,235,925 in Manly.

Strong time variant and LGA specific factors means an analysis of how the effect of zoning on house prices varies across Sydney should include time and individual fixed effects. However, while my measures of hard zoning restrictions are different across councils, they are assumed to be time invariant. Thus, having both individual and time fixed effects would remove the ability to examine how council policies are correlated with the zoning effect. A random effects model is also unsuitable because my measures of council zoning restrictions are likely to be highly correlated with individual specific effects.

Hence, I only use a time fixed effect when estimating the effect of council policies on the zoning effect. A time fixed effect allows for the control of demand factors, including interest rates, immigration and tax policy, that changes over time. The specific model used is:

$$\begin{aligned}
&\log(zoning\ effect_{it}) \\
&\qquad = \beta_0 + \beta_1 \log(approval\ time_{it}) + \beta_2 \log(min\ lot\ size_{it}) \\
&\qquad + \beta_3 \log(max\ floor\ space\ ratio_{it}) + \beta_4 \log(controls_{it}) \\
&\qquad + c_t + \epsilon_{it}
\end{aligned}$$

I use a log-log specification as the effect of different policies on the zoning effect is likely to be proportional to the level of prices (Glaeser & Gyourko, 2003). For example, a large minimum lot size requirement likely raises land prices for highly valued land in nominal terms by more than low value land. In Appendix 8.2, I use different specifications, including log-lin, lin-log and lin-lin models. Overall, my results are relatively robust to specification changes and I continue to use the log-log specification because it is most theoretically sound.

The model controls for income and distance to CBD. A visual examination of Figure 7 reveals a strong negative correlation between the estimated zoning effect and distance to the CBD. This is consistent with theoretical models of zoning that suggest zoning restrictions bind more in neighbourhoods with more highly valued land (Glaeser & Gyourko, 2003). Hence my analysis of variations in the zoning effect controls for both income and distance to the CBD.

In Appendix 8.2, I consider an extension to the model, which adds an interaction term between floor space ratio and minimum lot size. This is because these two restrictions could work together to restrict residential activity. For example, a large minimum lot size is a restrictive zoning restriction, but if the floor space ratio is large, then the effect of a large minimum lot size would be less. The model is largely robust to the addition of the interaction term, but for parsimony, I remove the interaction term from my main analysis.

5.2 Zoning Restrictions Data

The zoning restrictions data used in my analysis consist of soft and hard restrictions. Soft restrictions are non-legislated zoning restrictions, while hard restrictions are legislated zoning restrictions.

5.2.1 Soft Zoning Restrictions

The key soft zoning restriction used is mean gross days to approve a single new dwelling. Other soft zoning restrictions, such as the enforcement of planning rules and the development appetite of a council, are also likely to have a significant influence on house prices, but data on these variables are unavailable. Correlations between the omitted variables and mean approval days mean the coefficient for mean approval days likely overestimates the effect of mean approval days and captures the effect of other soft zoning restrictions as well. I explore this bias further in Section 5.3.

Mean approval days is sourced from the NSW Department of Planning, Industry and Environment. It is available for all LGAs in NSW on a financial year basis between FY05/06 and FY15/16. For LGAs with missing data, the value in the previous financial year was used. I apply a one-year lag as typically there is a one-year lag between when approval for a single new dwelling is sought and new housing supply is completed (ABS, 2018 & Author's calculations).

5.2.2 A New Dataset on Hard Zoning Restrictions

To measure how variations in hard zoning restrictions impact the zoning effect in Sydney, I create a dataset of zoning restrictions for the 43 LGAs. The dataset contains minimum lot size, maximum floor space ratio and maximum building height restriction variables.

I use geospatial techniques to filter the raw data as the data provided is for all land uses, including non-residential. Hence, to find zoning restrictions for R1 and R2 land, I find the intersection between three layers of maps; 1) maps of each LGA, 2) maps of land use and 3) maps of zoning restrictions. Figure 10 summarises the geospatial techniques used to create my data on low-density residential zoning restrictions.

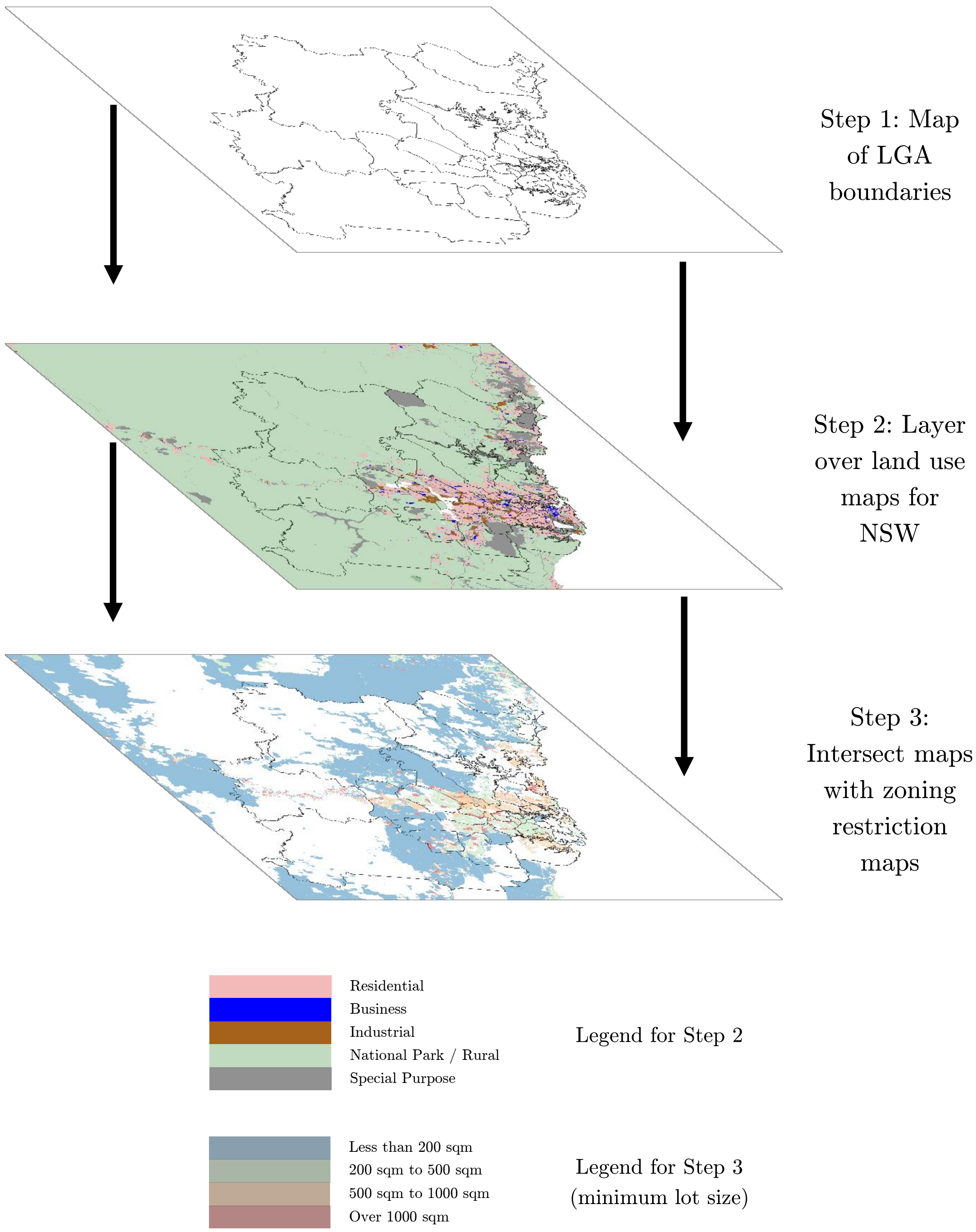

Figure 10: Summary of geospatial techniques used to develop new dataset on legislated zoning restrictions

The weighted median for the three hard zoning restrictions in each LGA is used, instead of the mean, because highly valued land is removed in my regressions to estimate the zoning effect and the weighted median is less likely to be skewed. As the data is only available for the latest year, a key assumption is that hard zoning restrictions are unchanged over time.

The two key hard zoning restriction variables used in my analysis are maximum gross floor area to land area ratio and minimum lot size. Maximum building height was not included in the regressions because there is typically less variation in maximum building heights across LGAs; most LGAs permit single new dwellings up to three storeys.

I use the share of dwellings over the minimum lot size as a control variable. It was calculated using land size data in the land value dataset. As the dataset only has the latest available land size, I assume the share of dwellings over the minimum lot size is unchanged through time. The assumption is likely to be appropriate given the number of houses increased by less than 0.2% p.a. between 2011 and 2016 in Sydney (ABS (2017) & Author's calculations).

5.2.3 Political Power and Zoning Restrictions

The zoning system in NSW means zoning presents an endogeneity issue. This is because zoning restrictions reflect the preferences of people and these preferences may also affect house prices. For example, residents in areas with high house prices may prefer to live in communities with large lot sizes and may form groups to lobby to maintain tight zoning restrictions. In NSW alone, there are over 60 local groups dedicated towards anti-development causes (BPN, 2019).

Lobbying by residents thus presents an endogeneity issue. Are house prices high because zoning restrictions are tight or are zoning restrictions tight because house prices are high (caused by resident political power)? To address potential endogeneity concerns, I extend the model by using staff numbers per development approval as an instrument for mean approval days.

The instrument is relevant as there is a strong negative correlation between staff numbers and mean approval days. Figure 11 shows a strong negative correlation between mean approval days in 2017 and the number of full-time employees per development approval in 2015/16. Table 4 shows the output of an individual and time fixed effect regression of mean approval days from 2012 to 2017 on the number of full-time employees per development approval from 2011 to 2016. The estimated coefficient of -0.12 is significant at the 5% level and implies that a 1% increase in the number of full-time employees per development approval decreases mean approval times by 0.12%.

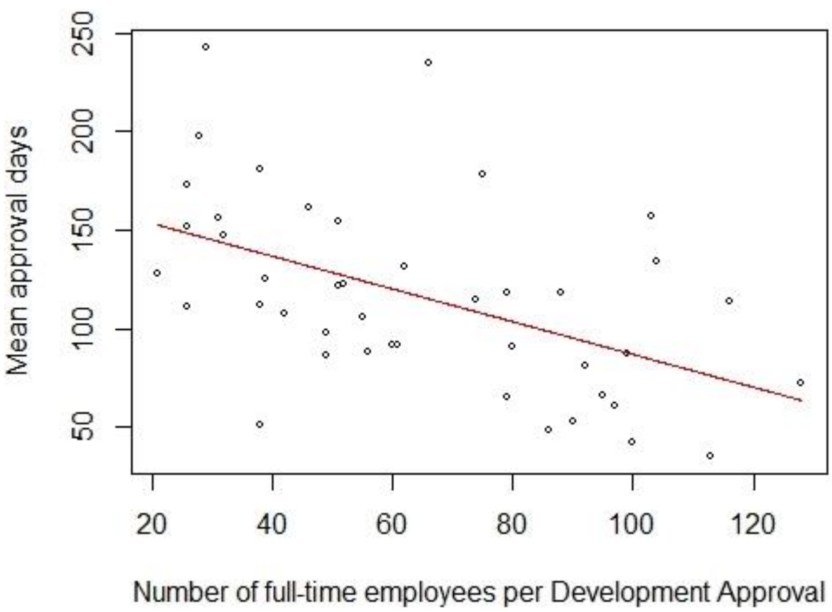

Figure 11: Mean approval days by LGA in 2017 on number of full-time employees per development approval in 2015/16

Dependent Variable: Mean Approval Days	FE Model
Number of full-time employees per development approval	-0.12**
	(0.05)
Time fixed effect?	Yes
Individual fixed effect?	Yes
T	6
n	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01	

Table 4: Individual and time fixed effect regression of mean approval days by LGA from 2012 to 2017 on number of full-time employees per development approval from 2011 to 2016. Robust standard errors, clustered by LGA.

The instrument should also be exogenous because council revenue, which is the key determinant of staffing, is largely exogenously allocated and not a function of revenue raised by a council through taxes. This is because of the Horizontal Fiscal Equalisation (HFE) Framework (*Local Government (Financial Assistance) Act 1995* (Cth)). Under the HFE framework, the revenue support LGAs receive is designed so that all councils can deliver the same level of services, regardless of the ability for councils to raise their own revenues.

For example, suppose Auburn and Manly were assessed to require the same level of expenses to operate and both took the average of all revenue policies. If Auburn raised less revenue than Manly from low land values leading to low rates revenue, then Auburn would receive a greater subsidy. The size of the subsidy would allow it to provide the same level of services as Manly. Thus, the HFE framework aims to achieve full HFE across LGAs (CGC, 2019), rather than just aiming to reduce the gap between well-funded and poorly-funded LGAs.

The consequence of a full HFE framework is that the Local Government Grants Commission, an independent authority, largely decides the level of revenue available for LGAs. Figure 12 shows revenue drives hiring; the consequence of this is that staffing levels at LGAs are largely not determined by local government officials. Hence, I argue that the instrument used should be exogenous.

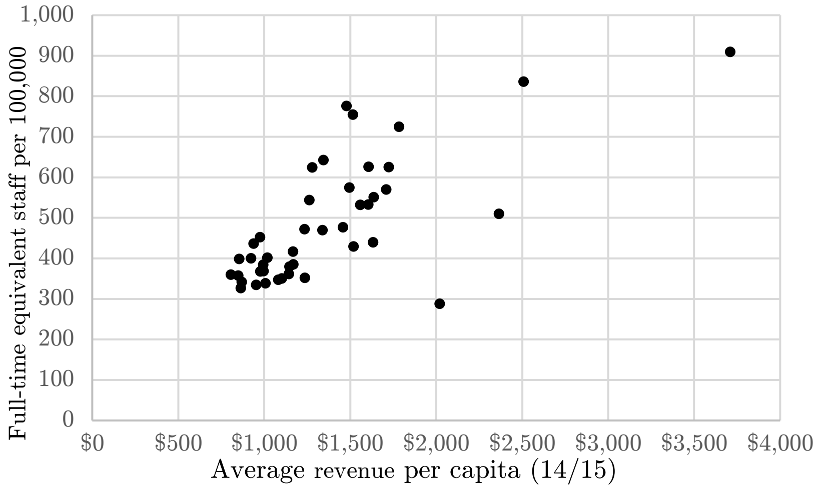

Figure 12: Staffing levels at LGAs are largely a function of revenue

5.3 Model Assumptions and Limitations

The model for zoning effect variations in Sydney makes four key assumptions. The first assumption, from the log-log specification, is the effects of zoning restriction variations are proportional to prices across LGAs. This is likely to be an appropriate assumption as zoning restrictions bind more, in nominal terms, for highly valued land (Glaeser & Gyourko, 2003). Nonetheless, I test lin-lin, log-lin and lin-log specifications in Appendix 8.2 and find that the model is relatively robust to changes in specifications.

As I have not used individual fixed effects, the second key assumption is that the intercept is constant across LGAs. This requires the three controls used (income, distance to the CBD and share of dwellings with lot sizes above the minimum) to capture all variation in house prices unrelated to the zoning restrictions analysed. I include the share of dwellings with lot sizes above the minimum because an increase in minimum lot sizes is likely to have a larger impact on house prices for LGAs where all lot sizes are at the minimum.

I considered other controls, such as demographics (share of population over 55) and sex (share of females), but neither was significant. Adding a fixed effect for regions (such as Western Sydney or the North Shore) could help account for unobserved location specific factors. However, zoning restrictions tend to be similar in LGAs within each region. Hence, including region fixed effects would affect the ability to examine how zoning restriction variations are correlated with house prices.

The third key assumption is that the effect of zoning on house prices and the marginal value of land estimated in Section 4 are correct. As the zoning effect and the marginal value of land are derived from land value data, there are error bands around the estimates. Data and measurement error could result in the true value deviating from the central estimates. However, the standard error of the estimates is relatively small and it is impossible to perfectly derive zoning effects and the marginal value of land as they are inherently unobserved. Hence, I continue to use the central estimates derived in Section 4.

The fourth key assumption is of exogeneity. This is unlikely to hold due to omitted variables. However, the direction of the bias due to omitted variables is likely to underestimate the effect of floor space ratio restrictions. Furthermore, while the coefficient for mean approval days could be overestimated, I instrument it with staff numbers (see Section 5.2.3) and find little evidence for potential simultaneity bias.

Two omitted variables include the share of dwellings with floor space ratios below the maximum and the development appetite of a council. The share of dwellings below the maximum floor space ratio is likely positively correlated with the maximum floor space ratio, but negatively correlated with the effect of zoning on house prices. Hence, the coefficient for maximum floor space ratio restrictions could be underestimated.

However, the development appetite of a council is likely to be both negatively correlated with mean approval days and the effect of zoning on house prices. Hence, a caveat of the analysis is that the coefficient for mean approval days is likely overestimated. Mean approval days is likely confounded with the development appetite of a council and other soft zoning constraints.

The proposed instrumental variable in Section 5.2.3 helps control for endogeneity related to the mean approval days variable. However, there is also potential endogeneity in the minimum lot size and maximum floor space ratio variables. For example, it is likely that LGAs partly determine minimum lot sizes and maximum floor space ratios based on historical zoning restrictions and the level of house prices. Hence, the model's quantification of how specific zoning restrictions affect house prices should only be interpreted as a correlation and not a causal effect.

Another concern is simultaneity; higher house prices could cause longer mean approval days by encouraging more development. I explore this issue in Appendix 8.2, but do not find any evidence that supports this potential source of endogeneity.

5.4 Summary Statistics and Graphs

	Year	Units	Mean	Std	10th percentile	Median	90th percentile
Mean approval days	2015/16	days	116	49	55	114	177
Minimum lot size	2019	m^2	518	180	400	500	700
Maximum building height	2019	m	9.0	0.5	9.0	8.5	9.5
Maximum floor space ratio	2019	ratio	0.68	0.36	1.00	0.50	0.45
Mean taxable income	2010	$	73,614	28,355	50,879	62,607	106,839
Distance to CBD		km	25	23	6	15	68
Share of lots over minimum lot size	2018	ratio	0.68	0.22	0.40	0.70	0.93

Table 5: Mean approval days calculated as difference between when a development approval is lodged and determined by a council. Minimum lot size, maximum building height and maximum floor space ratios assumed to remain constant over time due to unavailability of data. Floor space ratio percentiles reversed because increases in floor space ratio indicate a loosening in zoning restrictions. Mean taxable income is for 2010 only as amalgamations of LGAs did not allow for consistent calculations. Distance to CBD is measured as geodesic distance (as the crow flies) from the mid-point of each LGA. Share of lots over minimum lot size calculated using 2019 minimum lot size zoning restrictions and 2018 lot size data.

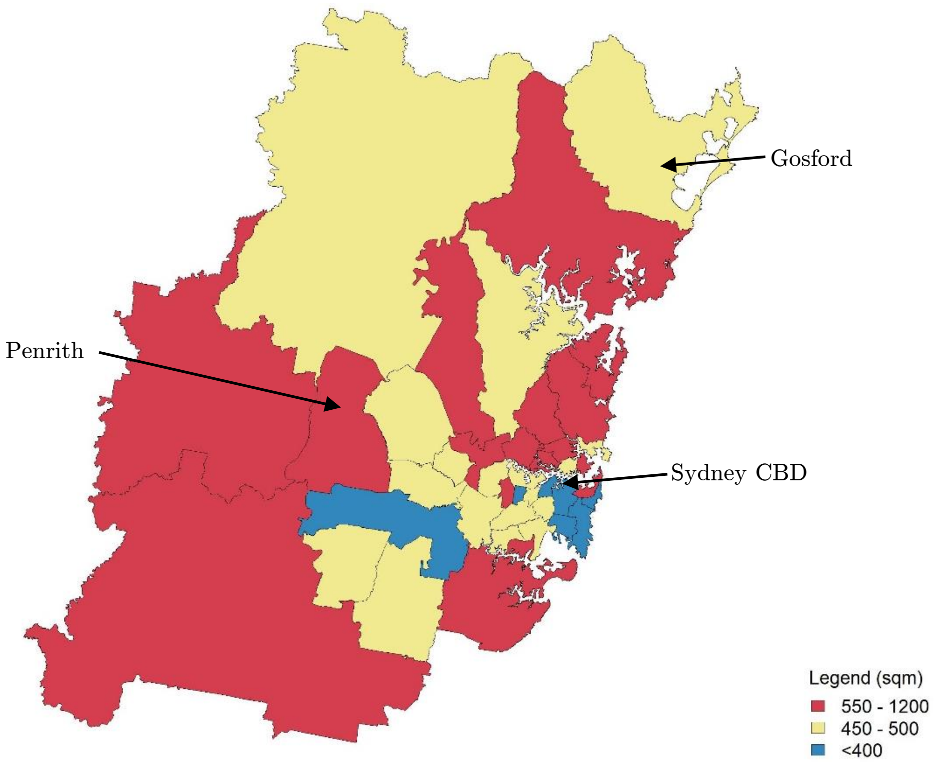

Figure 13: Minimum lot size by LGA

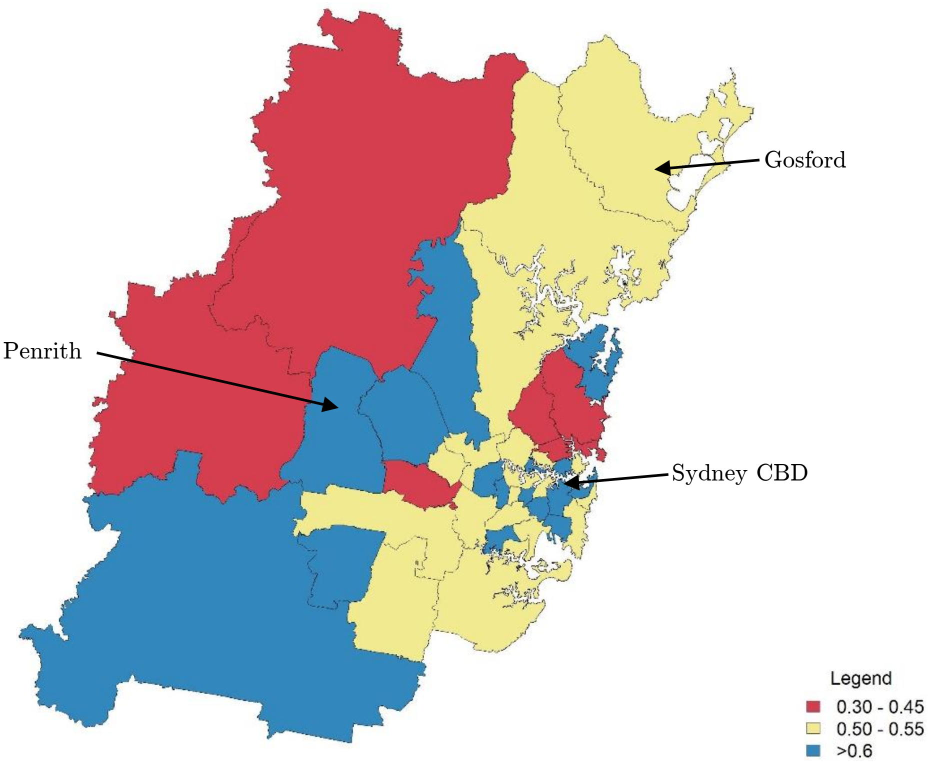

Figure 14: Maximum floor space ratio by LGA

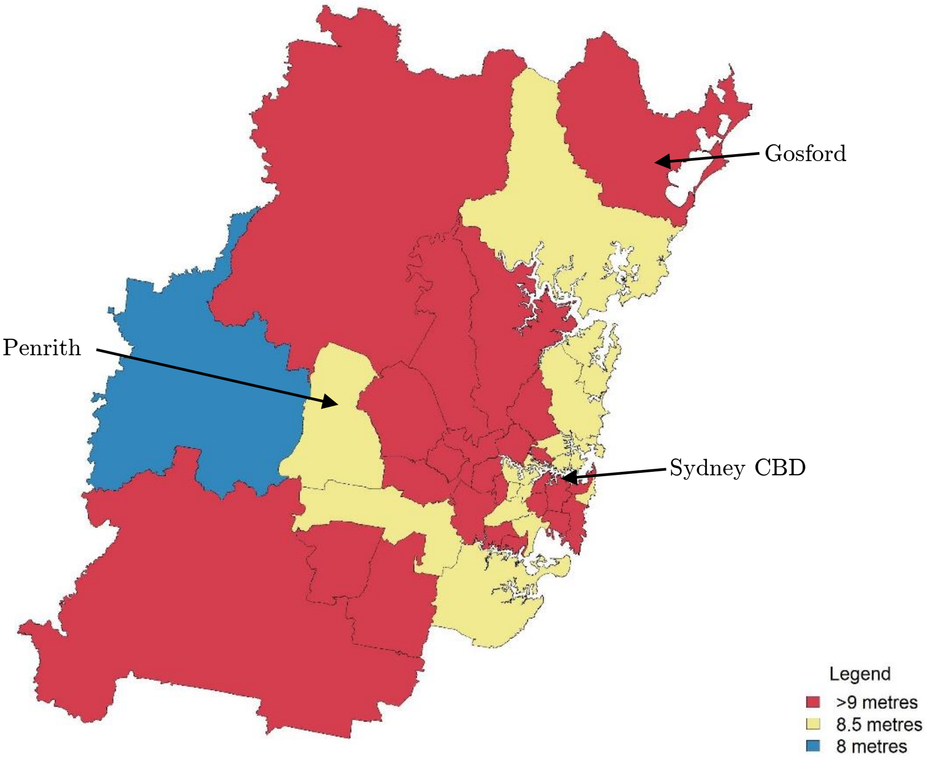

Figure 15: Maximum building height by LGA

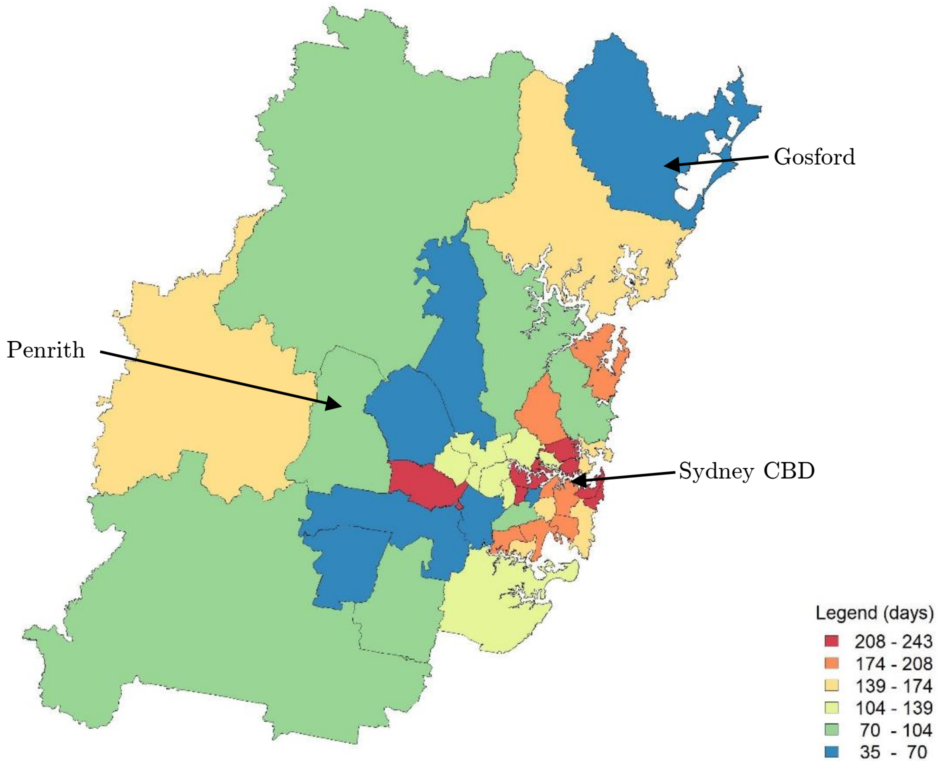

Figure 16: Mean gross days to approve a single new dwelling DA in 2015/16

5.5 Results

I run pooled OLS, time fixed effect and two-stage least square regressions to estimate the effect of zoning restrictions on the zoning effects obtained in Table 2 from 2012 to 2017. I use a log-log specification. Only the time fixed effect model shows all zoning restrictions as significant at the 10% level. The statistical insignificance of variables in other specifications likely reflects the small sample size of the data. Table 6 presents a summary of the regression output.

Dependent Variable: Zoning Effect	Pooling	Time FE	2SLS
Mean approval days	0.38***	0.28**	0.65
	(0.10)	(0.12)	(0.44)
Minimum lot size	0.29*	0.29*	0.29*
	(0.15)	(0.15)	(0.16)
Floor space ratio limit	-0.21	-0.23*	-0.13
	(0.14)	(0.14)	(0.16)
Constant	4.76	4.51	4.35
	(3.06)	(3.06)	(2.97)
Distance to CBD, income and share of dwellings over minimum lot size controls?	Yes	Yes	Yes
Time controls?	No	Yes	Yes
Instrumental variable?	No	No	Yes
T	6	6	6
n	43	43	43
F-stat in first stage	na	na	21.1
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$			

Table 6: Regression of estimated zoning effects obtained in Section 4 from 2012 to 2017 by LGA on zoning policies. Robust standard errors, clustered by LGA. Log-log specification. Full model in Appendix 8.4. Constant assumes 2012 as base year.

While not all variables are significant at the 10% level, the estimated coefficients in all three models are directionally identical and intuitive. For example, higher approval times and minimum lot sizes would indicate tighter zoning. The sign of the coefficients for these variables are positive. An increase in the floor space ratio would indicate looser zoning and the sign of the coefficient is negative. Notably, the coefficient for minimum lot size is consistent across all three models.

The coefficients for the 2SLS model are also generally not significant at the 10% level. I still present the results because the direction of the coefficients are unchanged from other models and imply economically important results. The reason the coefficients are not all significant likely reflects the small sample size of the data. It also reflects how the 2SLS process typically increases standard errors, likely a function of the relatively modest F-stat of 21.1 in the first stage regression.

While the 2SLS model is most robust to endogeneity concerns, the time FE model is the main model. This is because the 2SLS model may not be appropriate for a model with such a small sample size, while the pooling OLS does not capture important time varying effects.

The results of the regression should be interpreted as a log-log model. For example, in the time FE model, a 1% increase in mean approval days on average increases the effect of zoning on house prices by approximately 0.28%, ceteris paribus.

For ease of interpretation, Table 7 provides a linear interpretation of how a 1% tightening in zoning restrictions would impact the cost of supplying a house in 2017 across the three models. For minimum lot size, any effect on the measured share of dwellings over the minimum lot size is ignored.

	Soft restriction	Hard restrictions	
	Mean approval days	Minimum lot size	Floor space ratio
Pooling	$1,452***	$1,102*	$796
Time FE	$1,486**	$1,528*	$1,254*
2SLS	$3,444	$1,522*	$692
Simple average	$2,127	$1,384	$914
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01			

Table 7: Linear interpretation of how a 1% tightening in zoning restrictions impacts average house prices in 2017

Table 7 shows that across the three models, the largest difference in the zoning effect for a 1% tightening in zoning restrictions is due to mean approval days ($2,127), followed by minimum lot sizes ($1,384) and floor space ratios ($914). This analysis suggests minimum lot size and floor space ratios together have a similar impact on the effect of zoning on house prices as mean approval days.

However, as there is significantly more variation in mean approval days across LGAs than the hard zoning restrictions, a comparison of the 10th and 90th percentiles of the zoning restrictions variables would be more appropriate. Table 8 presents the 10th and 90th percentiles of the three zoning restriction variables.

	10th percentile	90th percentile
Mean approval days	55	177
Minimum lot size	400	700
Floor space ratio limit	1.00	0.45

Table 8: 10th and 90th percentiles of zoning restriction variables

A comparison of the effect of zoning on house prices with variables at the 10th and 90th percentile of zoning restriction variables shows mean approval days ($245,341), floor space ratios ($80,000) and minimum lot sizes ($71,532) are the largest contributor to high house prices.

	Zoning effect difference between 90th & 10th percentile			
	Pooling	Time FE	2SLS	Average
Mean approval days	$167,907	$172,566	$395,551	$245,341
Minimum lot size	$63,712	$88,309	$87,979	$80,000
Floor space ratio limit	$62,298	$97,873	$54,432	$71,534

Table 9: Difference between the estimated zoning effect at the 90th percentile & 10th percentile in 2017

As discussed in Section 5.3, the coefficient for mean approval days has likely been overestimated due to omitted variables. Data on many soft zoning restrictions, such as the enforcement of planning rules and the development appetite of a council, are unavailable. These variables are likely to be correlated with mean approval days and are confounded within the mean approval days coefficient, upwardly biasing estimates.

The results also suggest the effect of relaxing zoning restrictions on house prices is different depending on the restrictiveness of the variable chosen. For minimum lot size (Figure 17) and mean approval days (Figure 18), there is a greater reduction in the effect of zoning on house prices when they are least restrictive. This is intuitive because of the inherent non-linearities in the variables. For example, in a 600-day window, if approval times are 300, 200 and 100 days, then 2, 3 and 6 approvals can be made. Hence a fall from 200 to 100 has a greater impact on theoretical housing supply than a fall from 300 to 200.

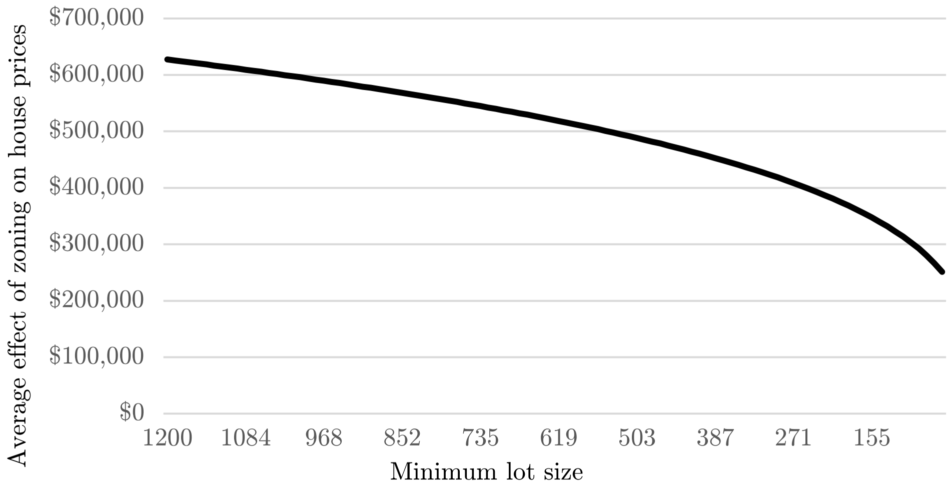

Figure 17: Effect of zoning on house prices as minimum lot sizes are relaxed. Simple average of the linear interpretation across the three models.

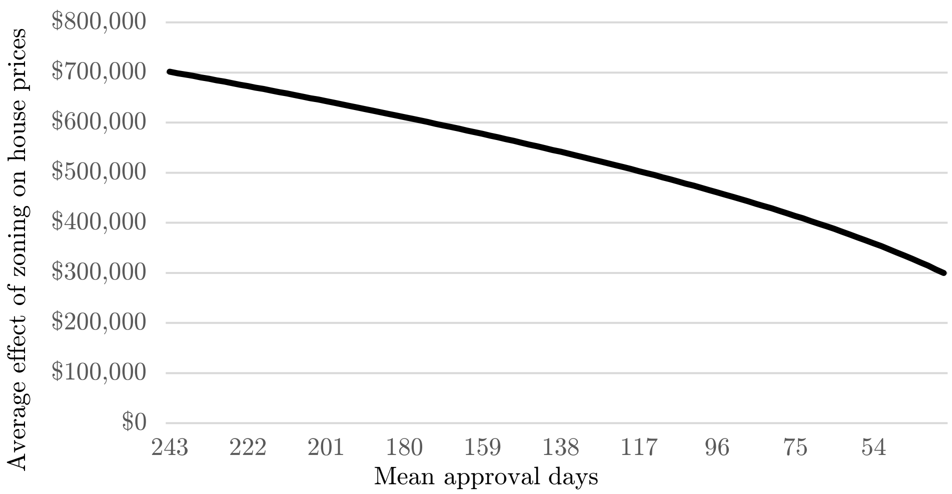

Figure 18: Effect of zoning on house prices as mean approval days are relaxed. Simple average of the linear interpretation across the three models.

In contrast, for floor space ratios (Figure 19), the greatest reduction in zoning effects can be achieved when floor space ratios are most restrictive. Hence, policymakers interested in reducing housing prices by increasing housing supply should consider how binding zoning restrictions are in each LGA and adapt policy responses for each LGA to maximise the effect of reducing zoning restrictions on house prices.

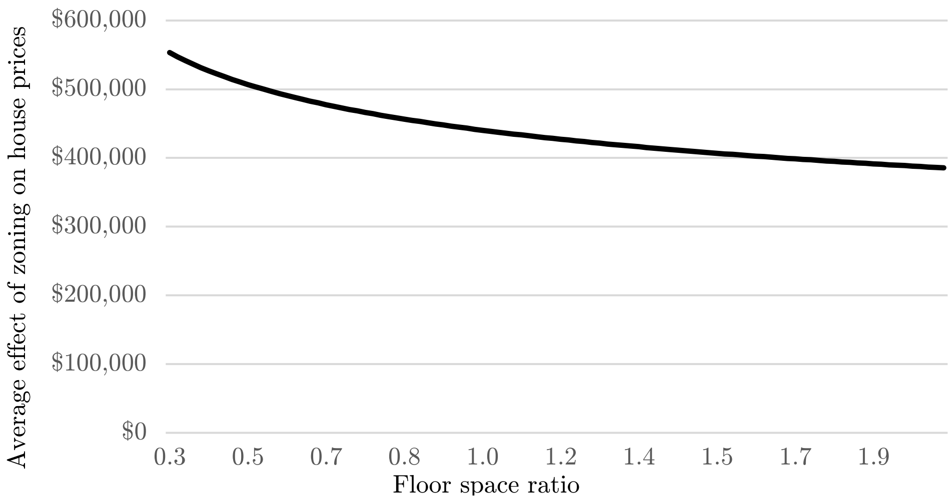

Figure 19: Effect of zoning on house prices as floor space ratios are relaxed. Simple average of the linear interpretation across the three models.

6 Conclusion

My thesis has shown that zoning restrictions contribute significantly to high house prices in Sydney. Despite zoning restrictions remaining largely constant, rising demand has meant the effect of zoning on house prices has increased substantially over time. I estimate that in 2018, zoning restrictions accounted for around 43% of the average house price.

My thesis has also analysed how the effect of zoning on house prices varies across Sydney due to differences in zoning restrictions. I show that moving from the 10^{th} to the 90^{th} percentile of approval times, minimum lot sizes and maximum floor space ratios adds $245,341, $80,000 and $71,534 to average house prices. The reason these zoning restrictions increase house prices is likely because they require homeowners to purchase more land than necessary to build a house and by delaying housing supply.

Policymakers interested in housing affordability need to balance the benefits and costs of zoning restrictions. Local governments often highlight the benefits of zoning restrictions, such as less congestion for existing residents and better local amenities. However, my thesis has shown that zoning restrictions also have significant costs in terms of housing affordability.

If zoning restrictions are not relaxed and demand for housing continues to grow in Sydney, then house prices are likely to rise in the future. Recent moves by policymakers to improve affordability have included increasing borrowing capacity as well as stamp duty concessions and discounted funding for first home buyers (Liberal Party of Australia, 2019). These policy decisions are likely to increase house prices because they increase demand without increasing supply, rendering them ineffective in improving affordability (Kehoe, 2019). Policymakers interested in improving housing affordability should instead consider changes to loosen zoning restrictions. Any change to zoning restrictions should also consider the existing level of zoning restrictions to maximise the effect on reducing house prices.

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8 Appendix

8.1 Squared Term in Regression of Land Price on Land Size

As a robustness check to the zoning model of housing introduced in Section 4.1, I add a square land size term into the regression of land price on land size. Across the average of the 43 LGAs, this reduces the constant coefficient (zoning effect) from \$514,271 in the simple linear regression to \$427,378. While this suggests the simple linear regression could overestimate the effect of zoning by around 20%, the results are still statistically and economically significant. Figure 20 and Figure 21 graph the output of the two separate models.

$$land\ price_i = \beta_0 + \beta_1 land\ size_i + \epsilon_i$$

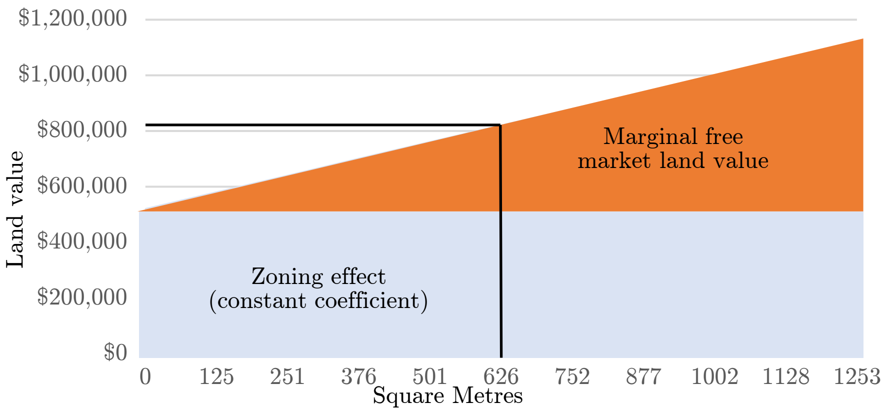

Figure 20: Graph of regression of land values on land size for Sydney in 2018

$$land\ price_i = \beta_0 + \beta_1 land\ size_i + \beta_2 land\ size_i^2 + \epsilon_i$$

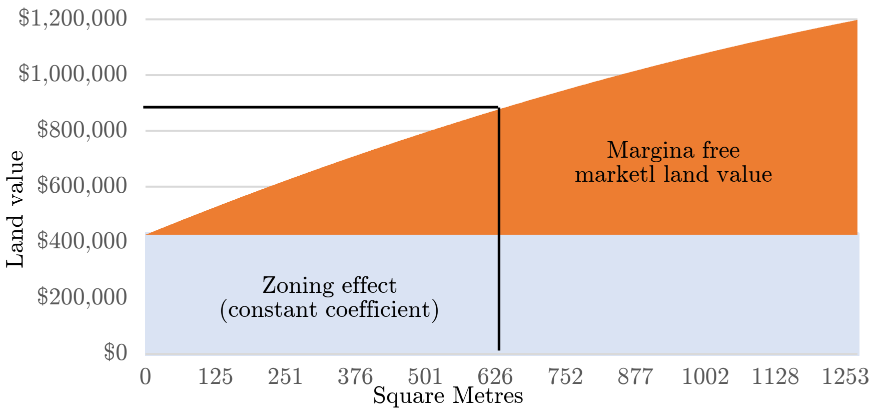

Figure 21: Graph of regression of land values on land size and squared land size for Sydney in 2018

LGA	Effect of zoning on house prices for the average lot size		
	Linear model	Squared model	Linear relative to squared
Ashfield	467807***	343098***	36.3%
Auburn	367849***	175173***	110.0%
Bankstown	325355***	129912***	150.4%
Blacktown	378007***	409640***	-7.7%
Blue Mountains	252799***	184245***	37.2%
Botany bay	741285***	372820***	98.8%
Burwood	571172***	464109***	23.1%
Camden	320465***	244502***	31.1%
Campbelltown	275557***	278072***	-0.9%
Canada Bay	978887***	952299***	2.8%
Canterbury	767371***	387518***	98.0%
City of Sydney	674536***	781663***	-13.7%
Fairfield	375157***	305730***	22.7%
Gosford	338127***	268834***	25.8%
Hawkesbury	317103***	244598***	29.6%
Holroyd	250253***	192049***	30.3%
Hornsby	702335***	468710***	49.8%
Hunters Hill	431991***	-175557	-346.1%
Hurstville	533265***	352233***	51.4%
Kogarah	725581***	457341***	58.7%
Ku-Ring-Gai	993626***	914314***	8.7%
Lane Cove	1057638***	989472***	6.9%
Leichhardt	660775***	736726***	-10.3%
Liverpool	309735***	196095***	58.0%
Manly	1235925***	1352873***	-8.6%
Marrickville	664333***	643966***	3.2%
Mosman	1139970***	404255***	182.0%
North Sydney	759186***	678919***	11.8%
Parramatta	378746***	246754***	53.5%
Penrith	290012***	269570***	7.6%
Pittwater	920817***	955469***	-3.6%
Randwick	889308***	832462***	6.8%
Rockdale	563186***	494541***	13.9%
Ryde	746827***	613405***	21.8%
Strathfield	374790***	-589779***	-163.5%
Sutherland	628255***	605217***	3.8%
The Hills Shire	476322***	163704***	191.0%
Warringah	1135505***	1344385***	-15.5%
Waverley	686300***	540592***	27.0%
Willoughby	1210027***	841337***	43.8%
Wollondilly	340627***	328346***	3.7%
Woollahra	849396***	726560***	16.9%
Wyong	244240***	207206***	17.9%
Sydney	514271	427378	20.3%

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Zoning effect by LGA in 2018 by model, robust standard errors

Table 10 presents the two different estimates of the effect of zoning on house prices by LGA. On average, the linear model has zoning effects that are 20.3% above the square model. Both models show that zoning is estimated to raise average house prices in Sydney by an economically large amount.

A theoretical explanation for the increased concavity of land prices with respect to land size in the model with square land size could reflect the fact that holding costs and fees for development approvals with large land sizes are higher than for small land sizes. This is because according to Land Tax Management Act 1956 No 26 (NSW) land tax in NSW is paid at progressive rates and LGAs typically charge progressive fees for development based on expected development costs. However, the large variation of fees faced by developers for similar projects within and across LGAs (Gurran, Ruming & Randolph, 2009) means there is little consistency in the size of average fees paid by the size of a development. Hence, it is difficult to find evidence that justifies a theoretical explanation for adding a square land size term.

I continue to use the linear model in my regression for three key reasons. Firstly, the simple linear regression is more parsimonious and has a stronger theoretical underpinning; without zoning restrictions land prices should be perfectly proportional as any concavity or convexity would allow for arbitrage profits. Secondly, the estimates from the squared model for some LGAs may be incorrect. The estimated effect of zoning on house prices in Strathfield council (-$589,779 in squared model vs. $374,790 in linear model) and Hunters Hills (-$175,557 in squared model vs. $431,991) seem implausibly low given their low distance to the CBD, high average incomes and restrictive council zoning policies. Finally, a visual comparison of Figure 20 and Figure 21 shows the curvature of land prices in the model with squared land size is not very significant. Hence, I continue to use the linear model in my regression.

8.2 Zoning Effect Variation Model Robustness Checks

I conduct robustness checks to the model for zoning effect variations, by using log-log, log-lin, lin-lin and lin-log specifications, adding an interaction term and exploring other sources of endogeneity. The model is largely robust to the addition of the interaction term and provides intuitive results across most specifications. However, as log-log most accurately reflects how zoning policies affect house prices, I continue to use the log-log specification for my main results.

Adding an Interaction Term

I add an interaction term between floor space ratio and minimum lot size as a robustness check. Table 11 presents summary results.

Dependent Variable: Zoning Effect	Pooling	Time FE	2SLS
Mean approval days	0.30***	0.19	0.58
	(0.10)	(0.13)	(0.53)
Minimum lot size	0.56**	0.60**	0.45
	(0.24)	(0.24)	(0.35)
Floor space ratio limit	-3.05*	-3.57**	-1.84
	(1.75)	(1.71)	(2.89)
Floor space ratio * minimum lot size	0.45	0.53*	0.27
	(0.28)	(0.27)	(0.45)
Constant	5.46*	5.32*	4.78*
	(2.93)	(2.93)	(2.56)
Distance to CBD, income and share of dwellings over minimum lot size controls?	Yes	Yes	Yes
Time controls?	No	Yes	Yes
Instrumental variable?	No	No	Yes
T	6	6	6
n	43	43	43
F-stat in first stage	na	na	25.7
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$			

Table 11: Regression of estimated zoning effects obtained in Section 4 from 2012 to 2017 by LGA on zoning policies. Robust standard errors, clustered by LGA. Constant assumes 2012 as base year.

The analysis is based on the following model:

$$
\begin{aligned}
\log(zoning\ effect_{it}) \\
&= \beta_0 + \beta_1 \log(approval\ time_{it}) + \beta_2 \log(min\ lot\ size_{it}) \\
&+ \beta_3 \log(max\ floor\ space\ ratio_{it}) \\
&+ \beta_4(\log(max\ floor\ space\ ratio_{it}) \times \log(min\ lot\ size_{it})) \\
&+ \beta_5 \log(controls_{it}) + c_t + \epsilon_{it}
\end{aligned}
$$

Table 11 shows the models are largely robust to the addition of the interaction term. However, for the main time FE model, mean approval days are no longer significant at the 10% level. Despite not all variables being significant at the 10% level across all the models, the signs of the variables are identical and remain directionally intuitive.

Adding an interaction term raises the estimated effect of minimum lot sizes and maximum floor space ratios, but lowers the estimated effect of mean approval days. This can be seen through a comparison of the effect of zoning on house prices with zoning restrictions at the 10th and 90th percentile. In Table 9, mean approval days, floor space ratios and minimum lot sizes add $245,341, $80,000 and $71,532 to house prices, while in Table 12, mean approval days, floor space ratios and minimum lot sizes add $203,564, $95,948 and $99,344 to house prices.

	Zoning effect difference between 90th & 10th percentile			
	Pooling	Time FE	2SLS	Average
Mean approval days	$136,429	$119,659	$354,605	$203,564
Minimum lot size	$77,137	$111,151	$99,557	$95,948
Floor space ratio limit	$84,913	$136,195	$76,925	$99,344

Table 12: Difference between the estimated zoning effect at the 90th percentile & 10th percentile in 2017. Models with interaction term.

Overall, there is little change to the economic interpretation of the results with an addition of the interaction term. Hence, for parsimony I continue to remove it from my main results.

Log-Log, Lin-Lin, Log-Lin and Lin-Log Specifications

The following tables show the results of log-log, lin-lin, log-lin and lin-log specifications.

Dependent Variable: Zoning Effect	log-log	lin-lin	log-lin	lin-log
Mean approval days	0.380***	1192**	0.000***	127821***
	(0.103)	(489)	(0.000)	(40519)
Minimum lot size	0.288*	200	0.000	144566***
	(0.152)	(125)	(0.000)	(55475)
Floor space ratio limit	-0.206	-93439*	-0.173	-115325**
	(0.137)	(49928)	(0.118)	(55400)
Constant	4.761	110643	12.291***	-3242373***
	(3.062)	(197885)	(0.480)	(1152504)
Controls?ˆ	Yes	Yes	Yes	Yes
Time controls?	No	No	No	No
Instrumental variable?	No	No	No	No
T	6	6	6	6
n	43	43	43	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01				

Table 13: Pooled OLS results under different model specifications. Robust standard errors, clustered by LGA. ˆ Distance to CBD, income and share of dwellings over minimum lot size controls. Constant assumes 2012 as base year.

Dependent Variable: Zoning Effect	log-log	lin-lin	log-lin	lin-log
Mean approval days	0.281**	632	0.000	81852*
	(0.121)	(581)	(0.000)	(48398)
Minimum lot size	0.289*	177	0.000	144697***
	(0.152)	(123)	(0.000)	(55106)
Floor space ratio limit	-0.234*	-105902**	-0.200*	-128416**
	(0.140)	(50840)	(0.120)	(56644)
Constant	4.511	73660	12.169***	-3340225***
	(3.060)	(205500)	(0.495)	(1153368)
Controls?ˆ	Yes	Yes	Yes	Yes
Time controls?	Yes	Yes	Yes	Yes
Instrumental variable?	No	No	No	No
T	6	6	6	6
n	43	43	43	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01				

Table 14: Time FE results under different model specifications. Robust standard errors, clustered by LGA. ˆ Distance to CBD, income and share of dwellings over minimum lot size controls. Constant assumes 2012 as base year.

Dependent Variable: Zoning Effect	log-log	lin-lin	log-lin	lin-log
Mean approval days	0.649	-203	0.000	140339
	(0.440)	(2395)	(0.001)	(191137)
Minimum lot size	0.288*	142	0.000	144531**
	(0.157)	(119)	(0.000)	(55914)
Floor space ratio limit	-0.130	-124479*	-0.191	-111761
	(0.162)	(71890)	(0.152)	(72586)
Constant	4.354	195283	12.107***	-3365062***
	(2.967)	(332317)	(0.727)	(1103785)
Controls?^	Yes	Yes	Yes	Yes
Time controls?	Yes	Yes	Yes	Yes
Instrumental variable?	Yes	Yes	Yes	Yes
T	6	6	6	6
n	43	43	43	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01				

Table 15: 2SLS results under different model specifications. Robust standard errors, clustered by LGA. ^ Distance to CBD, income and share of dwellings over minimum lot size controls. Constant assumes 2012 as base year.

I continue to prefer the log-log specification because it more accurately represents how zoning policies affect house prices. While the lin-log specification has the most significant variables, the interpretation of the model is difficult due to the very negative constant coefficient. A logarithmic transformation of the zoning effect is likely required to capture the fact that the same tightening in zoning should raise prices by more, in nominal terms, for highly valued land than for lowly valued land.

A log transformation for zoning restrictions also more accurately represents the restrictiveness of policies. For example, consider a council with total area of 600 square metres and minimum lot sizes of 100, 200 and 300 square metres. The linear difference between each minimum lot size is 100 square metres, but the plots of land that are available to be built are 6, 3 and 2 under the three different minimum lot size restrictions. Hence, the move from a 200 square metre to a 100 square metre minimum lot size increases house supply by more than a move from 300 square metres to 200 square metres. A log specification better captures this dynamic.

Regardless of the model chosen, the tables show the direction of the zoning restriction coefficients for the four different specifications across the pooled OLS, time FE and 2SLS models have the same economically intuitive sign. The only exception is the direction of the mean approval days variable in the lin-lin specified 2SLS model. Overall, the various specifications used generally lead to similar conclusions.

Variable	log-log	lin-lin	log-lin	lin-log	**Average**
Mean approval days	\$167,907	\$145,883	\$138,237	\$150,532	**\$150,640**
Minimum lot size	\$63,712	\$60,137	\$39,200	\$80,902	**\$60,988**
Floor space ratio limit	\$62,298	\$51,392	\$36,246	\$92,088	**\$60,506**

$* p < 0.1, ** p < 0.05, *** p < 0.01$

Table 16: Pooling OLS, difference in zoning effect from moving from 10th to 90th percentile by variable

Variable	log-log	lin-lin	log-lin	lin-log	**Average**
Mean approval days	\$172,566	\$77,354	\$111,863	\$96,396	**\$114,545**
Minimum lot size	\$88,309	\$53,040	\$45,986	\$80,975	**\$67,077**
Floor space ratio limit	\$97,873	\$58,246	\$58,093	\$102,541	**\$79,188**

$* p < 0.1, ** p < 0.05, *** p < 0.01$

Table 17: Time FE, difference in zoning effect from moving from 10th to 90th percentile by variable

Variable	log-log	lin-lin	log-lin	lin-log	**Average**
Mean approval days	\$395,551	-\$24,804	\$139,329	\$165,274	**\$168,838**
Minimum lot size	\$87,979	\$42,459	\$48,874	\$80,882	**\$65,049**
Floor space ratio limit	\$54,432	\$68,464	\$55,397	\$89,242	**\$66,884**

$* p < 0.1, ** p < 0.05, *** p < 0.01$

Table 18: 2SLS, difference in zoning effect from moving from 10th to 90th percentile by variable

Other endogeneity issues

While Section 5.2.3 addressed one source of endogeneity, there is another potential sources of endogeneity for the mean approval days variable. Rising house prices, for example, may encourage developers to seek more development approvals, which could plausibly lead to longer development approval times.

To examine if there is a relationship between the value of development approvals and approval times I run a time and individual fixed effect regression of approval times on the value of development approvals from 2009 to 2016. I use a log-log specification, but the significance of the results is unchanged in a lin-lin specification.

Dependent variable: mean approval days	FE Model
Value of development approvals	-0.06
	(0.05)
Time fixed effect?	Yes
Individual fixed effect?	Yes
T	7
n	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01	

Table 19: Regression of approval times from 2009 to 2016 by LGA on the value of development approvals. Standard errors clustered by LGA. Log-log specification.

Overall, there is little evidence to support the hypothesis that an increased value of development approvals leads to longer approval times. Table 19 shows that the coefficient for the value of development approvals is not significant at the 10% level. Adding one or two lags also does not change the statistical significance of the variable.

Summary of Robustness Checks

There are four main conclusions from my robustness checks. Firstly, many variables are not significant across the different models. While this could suggest issues with the robustness of my models, it instead likely reflects the relatively small sample size of my data, with only 43 LGAs across 6 time periods.

Secondly, regardless of the specification, the estimated effects of zoning restrictions are economically important across all models. Table 16, 17 and 18 show the average estimated effect of moving from the 10^{th} to the 90^{th} percentile of zoning restrictions across all the models ranges from increasing house prices by around $60,000 for minimum lot sizes and floor space ratios to more than $200,000 for mean approval days. These values are economically significant given the average price of a house in Sydney was $1.2 million in 2018. Hence, most specifications are still consistent with the conclusion that zoning restrictions have an economically important effect on house prices and that both soft and hard zoning restrictions play an important role in raising house prices.

Thirdly, while the results presented in Section 5.5 are fairly robust, the error bands on estimates of the effect of zoning restrictions on house prices are likely to be large. Adding an interaction term increases the estimates for minimum lot size and floor space ratio, while alternative lin-lin, log-lin and lin-log specifications generally find modestly smaller effects of zoning restrictions on house prices.

Finally, despite steps taken to address potential endogeneity concerns, the model still likely suffers from endogeneity. I have attempted to control for the endogeneity in the mean approval days variable, with Section 5.2.3 addressing issues related to political power. In the robustness checks, I also address potential endogeneity issues related to the level of development activity. However, the other two key zoning restrictions, minimum lot sizes and maximum floor space ratios, are likely to remain highly endogenous. Hence, the model's quantification of how specific zoning restrictions affect house prices should only be interpreted as correlations and not a causal framework.

8.3 Could Reducing Zoning Effects Increase Land Values?

Readers familiar with the Sydney property market are likely aware that the North Shore and Eastern Suburbs have the highest property prices in Sydney. Both regions are close to the CBD and their residents have some of the highest average incomes in the country (ATO, 2019).

Despite the similarities of the two regions, the effect of zoning on house prices is much greater in the North Shore than in the Eastern Suburbs. Table 20 shows this is because zoning controls in the North Shore are substantially tighter than in the Eastern Suburbs. For example, the average minimum lot size requirement in the North Shore is 656 square metres, compared to a much smaller 404 square metres in the Eastern Suburbs.

North Shore LGAs	Zoning Effect	Marginal Value of Land	Min. Lot Size	Max. Build Height	Floor Space Ratio
Manly	1243967	1000	500	8.5	0.45
Willoughby	1201694	712	550	8.5	0.4
Warringah	1177148	35	600	8.5	0.45
Ku-ring-gai	1050879	362	930	9.5	0.3
Mosman	998910	2433	700	8.5	0.5
Average	1134520	908	656	8.7	0.42

Eastern Suburb LGAs	Zoning Effect	Marginal Value of Land	Min. Lot Size	Max. Build Height	Floor Space Ratio
Randwick	889308	1274	400	9.5	0.5
Woollahra	849396	3431	675	9.5	0.9
City of Sydney	674536	2472	215	9.5	1.25
Waverley	686300	3465	325	9.5	0.5
Average	774885	2661	404	9.5	0.79

Table 20: Zoning variables for North Shore and Eastern Suburb LGAs.

Table 20 suggests that to reduce house prices, LGAs in the North Shore should ease zoning controls. However, while a relaxation of zoning controls should reduce the effect of zoning on house prices, it could increase the marginal value of land. It is plausible that a reduction in the minimum lot size would reduce the estimated effect of zoning on house prices, but as land can now be used more efficiently, the marginal value of every extra square metre of land increases.

I test the hypothesis that a lower zoning effect could increase marginal land values by running a time and individual fixed effects model to examine the relationship between zoning effects and marginal land values estimated in Section 4. I use a log-log specification.

Dependent Variable: Marginal Value of Land	FE Model
Zoning Effect	-0.12
	(0.16)
Time fixed effect?	Yes
Individual fixed effect?	Yes
T	7
n	43
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01	

Table 21: Regression of marginal land values obtained in Section 4 from 2012 to 2018 by LGA on zoning effects. Standard errors clustered by LGA. Log-log specification.

Table 21 presents the results of the regression. It suggests that a 1% increase in the effect of zoning on house prices on average decreases the marginal value of land by approximately 0.12%, ceteris paribus. However, the coefficient is not statistically different from 0 at the 10% level.

Nonetheless, the sign of the estimated coefficient is negative, which suggests that if zoning restrictions are relaxed and the zoning effect decreases, there may be a small positive offset to house prices from higher marginal land values.

A negative relationship also means that the impact of relaxing zoning on house prices could depend on land size. This is because the value of large lot sizes that can now be subdivided into smaller lots will likely increase relative to smaller lots. The distributional effects of such a change to households with existing housing assets could be significant, and while not explored in my thesis, could be an interesting topic for future research.

8.4 Full Regression Output

Variable	Pooling	Time FE	2SLS
Mean approval days	0.38***	0.28**	0.65
	(0.10)	(0.12)	(0.44)
Minimum lot size	0.28*	0.29*	0.29*
	(0.15)	(0.15)	(0.16)
Floor space ratio limit	-0.21	-0.23*	-0.13
	(0.14)	(0.14)	(0.16)
Share of lots over minimum lot size	0.26	0.24	0.30*
	(0.16)	(0.16)	(0.17)
Mean taxable income	0.52**	0.56**	0.41
	(0.25)	(0.25)	(0.38)
Distance to CBD	-0.12***	-0.13***	-0.10**
	(0.04)	(0.04)	(0.05)
2013 dummy		0.03**	0.00
		(0.02)	(0.04)
2014 dummy		0.18***	0.16***
		(0.02)	(0.03)
2015 dummy		0.42***	0.42***
		(0.02)	(0.04)
2016 dummy		0.52***	0.49***
		(0.03)	(0.04)
2017 dummy		0.64***	0.57***
		(0.03)	(0.07)
Constant	4.76	4.51	4.35
	(3.06)	(3.06)	(2.97)
Distance to CBD, income and share of dwellings over minimum lot size controls?	Yes	Yes	Yes
Time controls?	No	Yes	Yes
Instrumental variable?	No	No	Yes
T	6	6	6
n	43	43	43
F-stat in first stage	na	na	25.7
* p ‹ 0.1, ** p ‹ 0.05, *** p ‹ 0.01			

Table 22: Regression of estimated zoning effects obtained in Section 4 from 2012 to 2017 by LGA on zoning policies. Robust standard errors, clustered by LGA. Log-log specification. Constant assumes 2012 as base year.

8.5 Tax Revenue Implications of Zoning

As discussed throughout my thesis, the estimated effect of zoning on house prices does not measure how much house prices would fall by if zoning restrictions were removed. Estimating the change in house prices and welfare losses would need an analysis of general equilibrium effects, demand and supply curves as well as quantitative estimates of the positive externalities associated with zoning. I do not attempt to explore welfare losses from zoning in my thesis, but this could be an interesting topic for future research.

As a quick exercise, I assume that housing demand is perfectly inelastic and derive tax revenue implications under this strong assumption. If demand is assumed to be perfectly inelastic, then the removal of zoning would reduce average house prices in Sydney by $514,271. Figure 22 shows how a theoretical housing market with inelastic demand would behave with and without zoning.

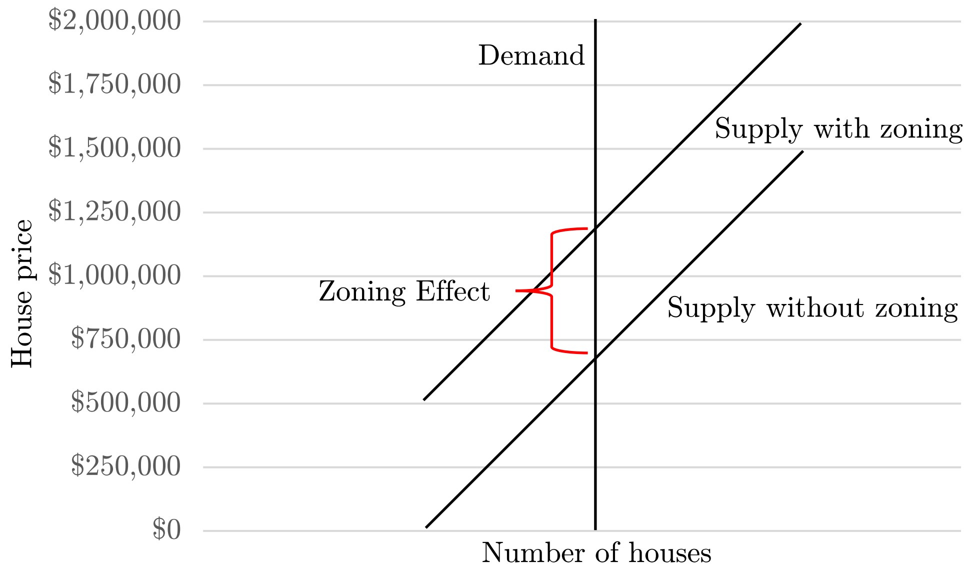

Figure 22: Housing market with inelastic demand and zoning restrictions

Property-related taxes are an important source of taxation revenue in NSW. In 2018/19, land taxes and property-related stamp duties raised $11.6bn in revenue, or more than 37% of total state tax revenues (NSW Treasury, 2019 & Author's calculations). In a market without zoning, if the housing turnover rate is assumed to be unchanged at its 2018-19 level of 5.1% (Revenue NSW, 2019 & Author's calculations), the marginal rate of stamp duty is assumed to be 5% and the average house sale price is $541,271 lower, then NSW stamp duty revenue would be $4.0bn lower.

For land tax, according to Land Tax Management Act 1956 No 26 (NSW), land tax thresholds are indexed to average land values. Therefore, the estimated revenue effect should be the fall in average land values. Table 1 shows the average land value in 2018 was $814,104. If demand is perfectly inelastic and construction is perfectly competitive, then a removal of zoning restrictions would see average land values fall by $541,271 (66% fall). Ignoring the three-year averaging of land values for land tax purposes, this would see a $2.5bn reduction in land tax revenue.

These simple estimates imply that without zoning, property-related tax revenue would fall by around $6.5bn; $4.0bn from lower stamp duty and $2.5bn from lower land tax. However, these estimates of the total tax revenue loss from a removal of zoning in NSW may not be accurate. It underestimates tax revenue loss by not considering reduced federal capital gains tax and local rates revenue, but overestimates the revenue loss by making the strong assumption of an unchanged housing turnover rate.