INTRA-METROPOLITAN HOUSING SUPPLY ELASTICITY IN AUSTRALIA: A SPATIAL ANALYSIS OF ADELAIDE

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ABSTRACT: This article estimates the supply elasticity of new housing for local government areas (LGAs) within Adelaide in South Australia by employing the urban growth model developed originally by Meyer and Somerville. In particular, we extend Gitelman and Otto's subsequent work in several ways. We employ narrower time intervals and consider different types of residential accommodation. Moreover, we include other geo-economic variables that potentially affect new supply, such as a spatially lagged dependent variable that assesses how supply conditions in one suburban region may subsequently influence supply in adjoining locations. Our findings suggest that the elasticity of new supply is up to 15 per cent over 10 quarters and thus sensitive to price changes, albeit lagged. Furthermore, we find that an LGA's land area and proximity to the coast are positively correlated with new housing supply, while its residents' average incomes and the level of building approval activity in neighbouring LGAs are negatively correlated with new supply. These findings have several potential implications for Metropolitan planning strategies.

KEY WORDS: house prices, supply elasticities, LGAs, causal factors, planning implications

1. INTRODUCTION

Until recently, there have been few analyses exploring the responsiveness of new housing supply to increases in demand in Australia. This is surprising, given the dramatic rise in the weighted average house prices in the country's eight capital cities of 77 per cent between September

2003 and March 2015 (ABS, 2015). Such increases have spurred a series of recent articles that examine general housing supply elasticity in Australia's metropolitan areas (McLaughlin, 2012), the impact of metropolitan-level growth policies on new supply (McLaughlin, 2011), and supply elasticity within a metropolitan area (Gitelman and Otto, 2012). The purpose of this paper is to extend McLaughlin's (2011 and 2012) analyses by estimating supply elasticity at the local government area (LGA) level, and to extend Gitelman and Otto's (2012) paper by estimating elasticity across narrower time intervals and for different types of residential accommodation.

While a set of solid literature on new housing supply elasticities is emerging, (Mayer and Somerville, 2000a and 2000b; Zabel and Patterson, 2006; Saiz, 2010; McLaughlin, 2011 and 2012; Gitelman and Otto, 2012), only Gitelman and Otto's analysis of Sydney examines local housing supply elasticity. As such, this paper seeks to expand their analysis by examining supply elasticity in another major Australian city – Adelaide, South Australia. We also expand on their analysis by including other geo-economic variables that may affect new supply, including a spatially lagged dependent variable which assesses how supply conditions in one suburban region may subsequently influence supply in adjoining locations. We employ the urban growth model of new housing supply developed by Mayer and Somerville (2000a and 2000b), and employed in Zabel and Patterson (2006) and McLaughlin (2011 and 2012), to estimate the elasticity of new housing supply within the Adelaide metropolitan area.

Following this introduction this article is structured as follows: section 2 reviews the current state of housing markets and land use policies in Australia; section 3 describes the empirical model, hypothesized outcomes, and data sources used in the analysis; section 4 presents the results of the models and discussion; and section 5 concludes with suggestions for future research.

2. CONTEXTUAL REVIEW OF HOUSING MARKETS AND LAND USE IN AUSTRALIA

Housing Supply and Demand in the Australian Context

Housing supply and demand is buffeted by a large and complexly integrated web of factors (shown in Table 1). All the factors shown are ultimately interconnected in some way, but their interactions will tend to be (i) asynchronous and lagged in varying degrees, (ii) non-linear, and (iii) circular and cumulative. These conditions are explored in depth in Taleb's

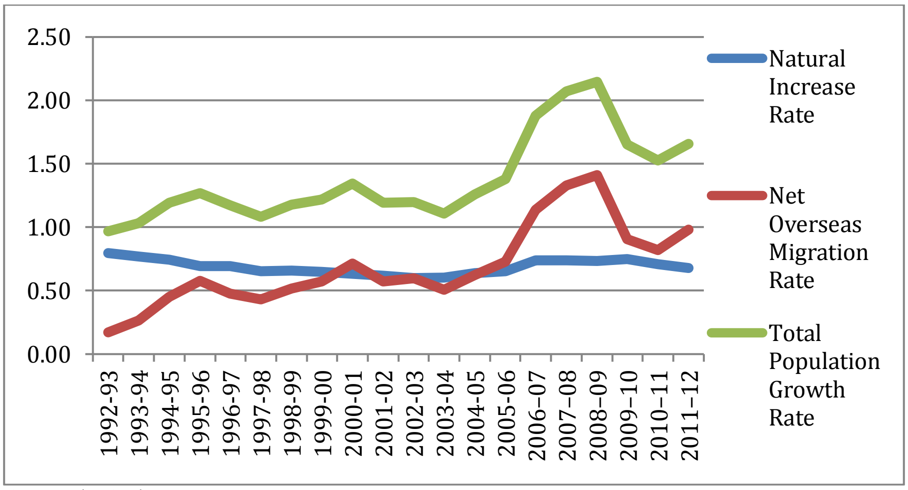
(2007, 2012) ground-breaking work on economic processes in complex and uncertain environments, and by Abelson (1997) and Abelson *et al.* (2004) in the specific context of Australian house prices. We concede that many of the variables listed in Table 1 are excluded from our analysis but this is because they operate, both simultaneously or lagged, over many different time frames and spatial scales, and reliable spatial data are unavailable for many elements. Moreover, the rates, directions or inherent stability of many variables may change independently over time. In Australia's case for example, population growth rates rose sharply during the period from 1998 to 2007, as shown in Figure 1. However, this was largely from two kinds of immigration: a rising tide of refugees from conflicts in Asia, the Middle East and Africa; and the scramble by business in a boom economy to secure skilled labour through 457 visas, which allow for the temporary hire of foreign labour. From 2008 until 2013, Australia was also affected by the global financial crisis, though not nearly as much as in other OECD countries and in different ways. Apart from a sharp drop in the Reserve Bank's cash rate in 2009, the rate soon reverted by 2011 to levels common between 2000 and 2005 as a result of a sound banking system, and modestly tight Reserve bank monetary policy. This and the mining boom then propelled Australia's currency markedly higher against its peers, while money was diverted simultaneously into the development of mine operations and related infrastructure. This, in turn, increased costs for home construction companies and would-be purchasers of residential real estate.

Australia's house prices stabilised at the end of the 2000s as households deleveraged because of an uncertain global outlook. However, the nation did not follow the United States and most of Europe into a house price melt-down as a result of a robust local economy and population expansion. Under these conditions many would-be homebuyers discovered, to everyone's surprise, that housing is indeed a substitutable good in the sense that young adults often found they could remain at home rather than venture into first-home ownership and become kippers ('kids in parents' pockets eroding retirement savings) or slops (singles living off parents)(Brown, 2011). Some of these complex interconnections are reported in recent work published by Australia's Reserve Bank; Windsor *et al.* (2013), Ellis (2013), Reed (2013) and Costello (2014).

Table 1. Factors Impacting Supply-Demand Interactions in the Housing Market-Place in Different Parts of Cities.

Category	Sub-Category
1 Macro-Economy	1.1 Reserve Bank discount rates
	1.2 Broader control of money supply
	1.3 Foreign Investment Review Board strategies / decisions on inflows of foreign capital
	1.4 Fiscal balance
	1.5 Productivity trends and impacts on disposable income
	1.6 Balances in economic power between:
	public & private sectors
	labour & capital
	social groups (e.g. retirees, baby boomers, generation X & Y)
	1.7 Unemployment rates
2 Socio-Demographic	2.1 Current population growth rate and age/sex composition
	2.2 Rate of new household formation
	2.3 Social structure of hosueholds and demand / supply implications
	2.4 Substitutability of housing types (e.g. young adults staying at home longer, delaying marriage)
	2.5 Lifestyle preferences - accepted and preferred
3 Economic Structures	3.1 Proportional contribution of different goods to the economy and services
	3.2 Locational requirements of different production sectors
	3.3 Geographical distribution of jobs
	3.4 Implications for journeys to work assuming (a) current distribution of households and (b) potential relocation of households to better match workplace locations
4 Infrastructure Supply (electricity, gas, water, sewerage, ICT, transport)	4.1 Adequacy of existing infrastructure to facilitate re-development and / or renewal of the current urban fabric
	4.2 Extent to which the supply of new infrastruture is running ahead of likely demand from developers, and its impact on supply of new greenfields housing
	4.3 The effect of pricing levels and structures (e.g. 2-part or 3-part pricing) on the timing and quality of construction of new infrastructure
	4.4 The extent to which governments are prepared to subsidise infrastructure
5 Planning Decision-Making	5.1 The extent to which planning decision-making is restrictive or welcoming in terms of (a) design innovation, (b) social / age composition of neighbourhoods, and (c) innovation in building construction technology?
	5.2 The sensitivity of planning decision-making to new fashions in urban living
	5.3 How speed of planning decision-making
	5.4 Impact of the cost of operating this decision-making on house prices
6 Building and Construction	6.1 The capacity of the building and construction industry to:
	read the supply / demand situation as a whole or in different locations?
	amass the necessary capital
	take risks on the early timing of construction, design and construction innovation
7 Technology More Generally	7.1 Technology of all kinds (e.g. medical, ICT, materials, transport and energy, decision-making, financial) will over-lay many of the above factors

Source: The Authors



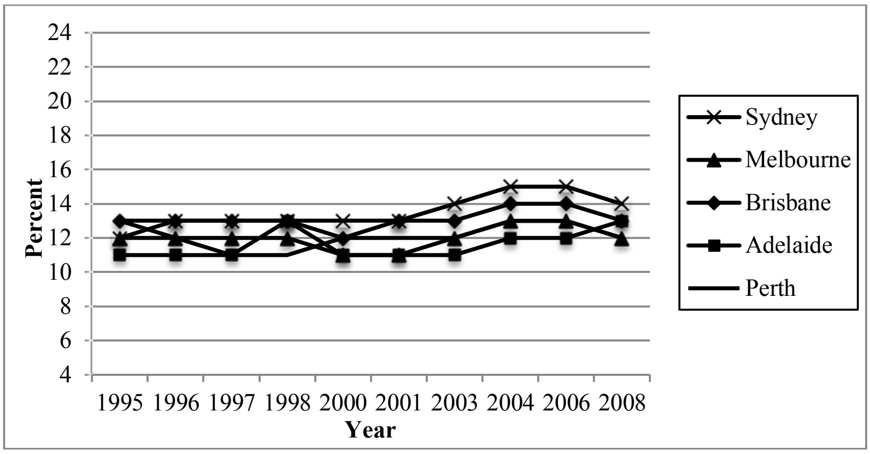
Source: the Authors

Figure 1. Australia's Population Growth Rate 1992-2012.

To make matters more confusing, we should also note that the foregoing complexities will likely vary spatially according to (i) physical environment (climate, terrain, vegetation, water); (ii) relative geographical accessibility; and (iii) local population density or demography. In other words, place matters considerably. Thus, the relative importance of individual variables, the strength of their interactions, and time lapse between cause and effect will tend to vary from one location to another. However, even if geography is taken into account, many of the interactions between factors influencing housing supply and demand are unlikely be forecast with any degree of accuracy, even in the short-term.

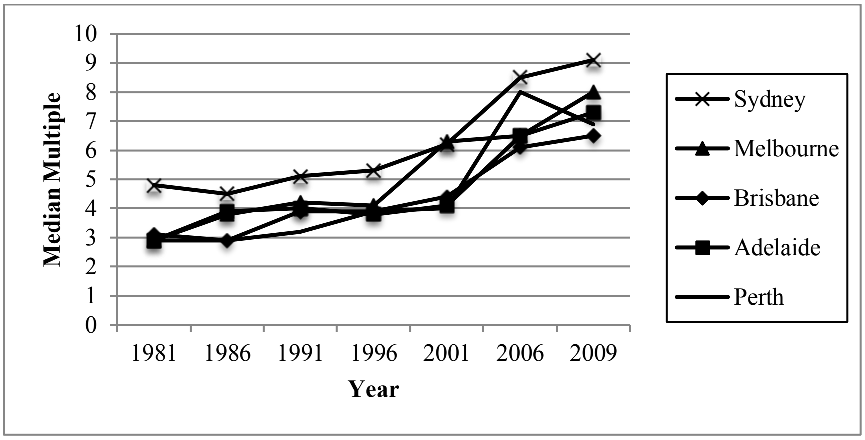
Housing Affordability in Australia

House prices in Australian cities have climbed rapidly over the past decade, and several recent reports claim Australian housing markets are some of the least affordable in the world (The Economist, 2010; Demographia, 2015). Demographia (2010; 2015) assesses affordability in terms of the ratio of median house prices to median income, an approach we adopt here. Despite these reports, readily available data shows conflicting stories about whether the country has indeed grown less affordable since the turn of the century. On one hand, Figure 2 shows that household expenditures on housing costs have remained relatively stable over the past 13 years. On the other hand, Figure 3 shows that median house prices have rapidly expanded relative to median income in all Australian cities over the 27 years to 2009, although rates vary over time and place.



Source: McLaughlin (2012).

Figure 2. Housing Costs as a Proportion of Income. Note: Housing costs comprise housing-related mortgage payments; rates (general and water); and rent payments.



Source: Adapted from Deomographia (2010).

Figure 3. Housing Affordability: Ratio of Median House Prices to Median Household Income in Australian Capital Cities.

Gan and Hill (2009), find that average loan length has increased from 20 years in 1990 to 30 years in 2007, and Lea (2010) finds that the proportion of interest-only loans has almost doubled from 15 per cent in 2005-2006 to 27 per cent in 2008-2009. These findings suggest that innovation in the mortgage industry might indeed downwardly bias the ABS data used in Figure 2. This is because innovations in mortgage finance can stabilize monthly payments even in the midst of increasing house prices.

But what might explain the decrease of affordability portrayed in Figure 3? Several studies and reports have emerged that suggest the cause may be due to supply constraints (Richards, 2009; Demographia, 2010; Real Estate Institute of Australia 2010; Property Council of Australia, 2010; McLaughlin, 2011). However, both Stapledon (2010) and the National Housing Supply Council (2011) add additional layers of complexity, with the former suggesting that house price escalation may be due to increased land costs and the latter noting the effects of sometimes lengthy development approval processes for both land and buildings, as shown in Table 2.

Table 2. Supply Stages and timeline for residential land development in Australia.

Stage of Supply Pipeline	Description	Timeline (years) Normal	Complicated
Stage 1	Future urban designation	3	4
Stage 2	Specific use zoning	2	3
Stage 3	Structure planning	2	3
Stage 4	Development/subdivision approval	1	2
Stage 5	Civil works and issue of title	1	2
Stage 6	Building approval and completion	1	1

Source: National Housing Supply Council's 2nd State of Supply Report

Furthermore, much urban economic literature on growth management and land use policies suggests that restrictions on the supply of urban land must increase the price of housing across the board. If developers are unable to substitute capital for land efficiently – as is the case when land supply restrictions are enforced but density restrictions are kept - or if the price elasticity of demand for land is quite low, then both prices per square meter and observed house sales prices themselves will increase. To counteract this effect, metropolitan planning efforts in Australian cities have explicitly focused on achieving infill development targets. Table 3 summarizes these targets as stated in each city's metropolitan plan. These infill targets range from a low of 50 per cent in Melbourne to a high of 70 per cent in Sydney and Adelaide.

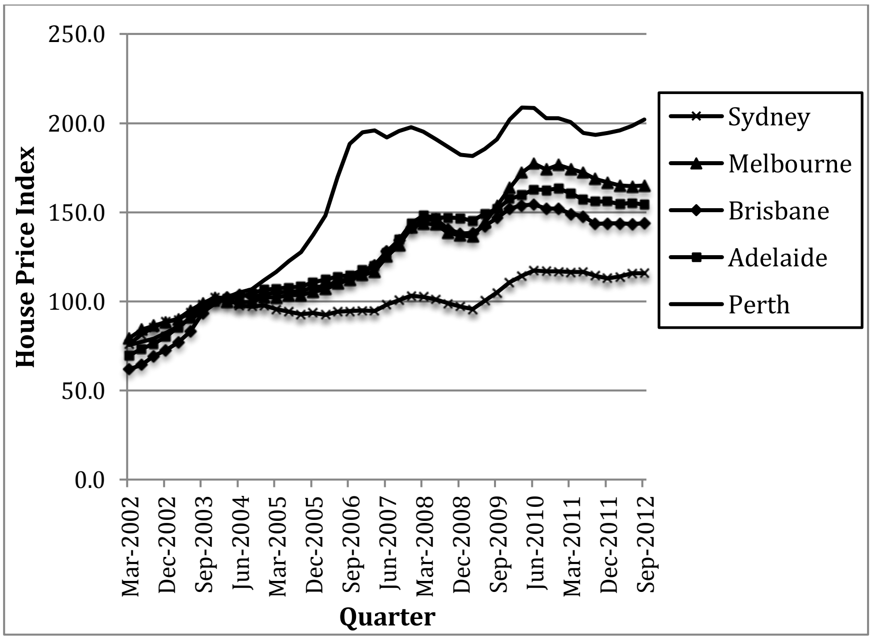
The Adelaide metropolitan area represents an interesting case study from both a policy and geographic perspective. Since its European founding in the early 1800s, the State of South Australia has been perceived as one of the more progressive Australian states, and has a long tradition of state-level land use planning for its capital city - Adelaide. For example, South Australia made most use of the federally funded land-banking program introduced in the 1970s, acquiring nearly half of the developable land surrounding the metropolitan area (Troy, 1978). Most recently, the state adopted an urban growth strategy for the Adelaide metropolitan area in 2002 that restricts outward growth. Along with this boundary, the government of South Australia also adopted a series of infill policies to help increase the supply of medium and high-density housing.

Table 3. Infill Targets for Australian Capital Cities.

City	Document Name	Timeframe	Dwellings	Percent
Sydney	City of Cities: A Plan for Sydney's Future	2005 - 2031	640,000	60 - 70
Melbourne	Melbourne 2030: A Planning Update - Melbourne @ 5 million	2009 - 2030	600,000	50
Brisbane	South East Queensland (SEQ) Regional Plan	2009 - 2031	754,000	53
Perth	Directions 2031: A Spatial Framework for Perth and Peel	2009 - 2031	328,000	55
Adelaide	The 30-Year Plan for Greater Adelaide	2010 - 2040	258,000	50 - 70

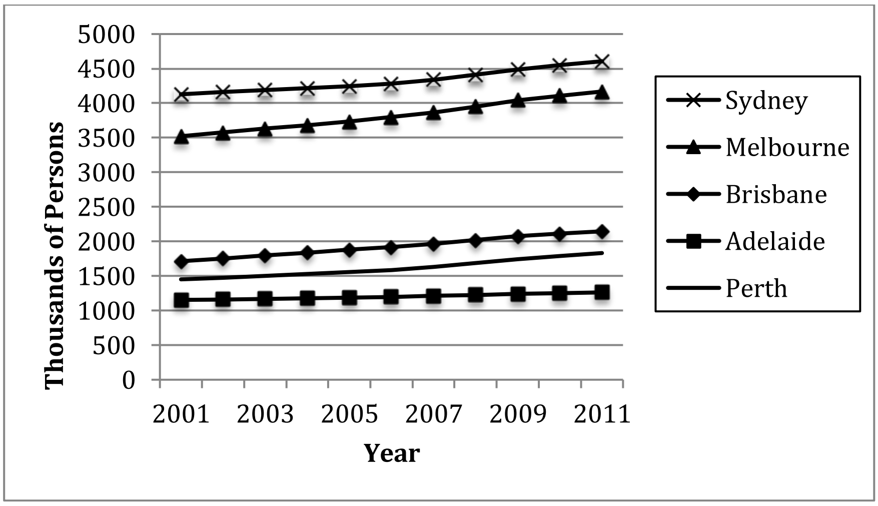
Source: National housing supply council's 2nd state of supply report.

Despite these efforts to promote new housing supply, housing prices in Adelaide continue to be disproportionately high. Figure 4 shows the Australian Bureau of Statistics' (ABS) official housing price index for capital cities. In 2009, relative house price growth in Adelaide was second only to Perth, whose population was then rapidly growing. And even between 2010 and 2012 the index out-paced Brisbane and Sydney. This is surprising, given Adelaide's population size and growth is the lowest amongst the five major capital cities (see Figure 5) and low population growth is often thought to restrain house price increases. Furthermore, Figure 6 shows that Adelaide's gross state product (GSP) per capita is also the lowest of the give major capital cities, showing only modest growth between 2000 and 2012. So what might be the cause of such disproportionate house price growth?



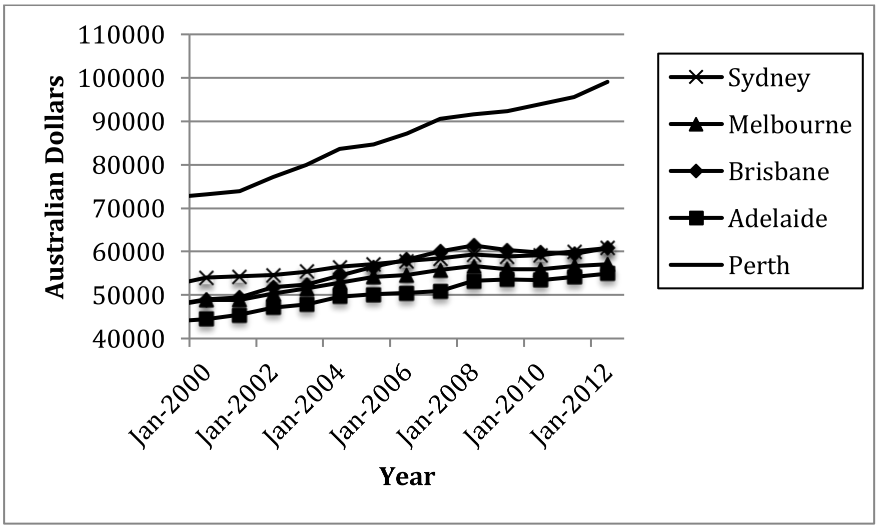
Source: ABS (2012).

Figure 4. House Price Index.



Source: ABS (2012).

Figure 5. Population by City.



Source: ABS (2012).

Figure 6. GSP Per Capita.

The following section describes an empirical model designed to test local housing supply elasticity, using controls for geo-economic factors and a quality-constant measure of housing prices. Our study period begins just after the enactment of Adelaide's urban growth boundary so that we may test for spatial variation in housing supply elasticity across the metropolitan area. We elaborate further below.

3. DEVELOPMENT OF EMPIRICAL MODELS

The most recent, and arguably most robust, empirical model of new housing supply is that developed by Mayer and Somerville (2000a). They base their model on urban growth theory and stock-flow models developed by Capozza and Helseley (1989), and DiPasquale and Wheaton (1994), respectively. Essentially, their model posits that new housing starts represent new additions to the housing stock, and as such, are a function of *changes* in house prices, rather than a function of price *levels*. To date, only a handful of studies have applied the Mayer-Somerville model to metropolitan markets. The first was Mayer and Somerville (2000b) themselves who adapted their model (which originally used national-level data) to analyze land use regulations and housing supply for 44 metropolitan markets in the US. They found that a one per cent increase in house prices led to a 15 per cent increase in new housing starts over 5 quarters. However, the Mayer-Somerville model used in two other studies yields supply elasticities that vary drastically by region. Zabel and Patterson (2006) and Hanak (2008) find supply elasticity in Californian cities range from only one to five per cent over two years using annual data. In one of the first international applications of the model, McLaughlin (2011 and 2012) finds that supply elasticity in Australian cities are approximately four to six per cent over five quarters for single-family houses and 10 – 15 per cent over 9 quarters for multifamily units.

In addition to these works, recent empirical evidence from Saiz (2010) suggests that in the United States, both stringent land use regulations and natural geography affect the supply elasticity of new housing. He finds that the inverse-supply elasticity of new housing is, on-average, 1.54 between 1970 and 2000 in US metropolitan areas, but that elasticity ranges from 0.60 in Miami to 5.45 in Wichita. Additionally, his findings indicate a strong and positive relationship between restrictive land use regulations and natural geographic constraints on land supply, and suggest that these two factors help explain high housing prices in areas with stringent regulations, steep topography, and large bodies of water, such as San Diego, New York, Boston, and Los Angeles. Most recently, Gitelman and Otto (2012) estimate local housing supply elasticity for LGAs within the Sydney metropolitan area. They find that new housing supply is relatively inelastic over the period of their study, and range from 0.33 to 0.55. Furthermore, they find some evidence that increases in the time for development approval negatively impacts new supply.

The shortcomings of these various studies are twofold: First, they either exclusively use data at the inter-metropolitan level, as in the work of Mayer and Somerville and McLaughlin, or, secondly, they use the change in total housing units and median prices, of which the latter is susceptible to bias because the quality of the housing stock can change over time, as in both the Saiz and Gitelman and Otto articles. This is perhaps due to the limited availability of data on prices of housing units and approvals in the US.

However, there is reason to suspect *a priori* that elasticity of new housing supply could be different at the intra-metropolitan level. This is for several reasons. First, the provision of new housing is likely more difficult and time consuming in areas with less land, both because of increased competition and complexities inherently associated with the development process. Second, local resistance to the negative externalities of denser development may vary within a metropolitan area. Such externalities may include traffic congestion, public service provision, and decreased land values of adjacent residential neighborhoods (Fischel, 2001; Ihlanfeldt and Burge, 2006), and may be more likely to arise in wealthier areas.

To test for such effects, we use the traditional Mayer-Somerville model to estimate local housing supply elasticity for LGAs within the Adelaide metropolitan area. While local housing markets in Australia's capital cities may extend beyond LGA boundaries into sub-regions of the metro area, we explicitly choose to analyze approvals at the LGA level because this is the scale at which new housing supply is approved. LGAs essentially represent City Council boundaries, so analysis at this scale is appropriate for planning policy recommendations. The modifiable areal unit problem identified by Openshaw (1984) has limited relevance in this instance. While previous studies using the Mayer-Somerville model (Mayer and Somerville, 2000b; Zabel and Patterson, 2006; Hanak, 2008; and McLaughlin, 2011) examine elasticity lags up to two years prior, we allow for the possibility of longer-run price adjustments by using lags of 12 quarters to test for both short-run and medium-run supply elasticity. In Australia, a lag of up to 3 years for acquisition of new building approvals is not uncommon (National Housing Supply Council, 2011; McLaughlin, 2012). Thus, our base model for estimating housing supply elasticity at the LGA level appears as:

$$(1) \quad S_{i,t} = \alpha + \gamma_1 \boldsymbol{Q}_t + \gamma_2 \boldsymbol{L}_t + \beta_1 \Delta P_{i,t} + \beta_{12} \Delta P_{i,t-12} + \lambda_1 X + \varepsilon_{i,t}$$

where i is an index of LGAs in the Adelaide metropolitan area, t is a balanced index of quarters spanning 2001-2010, $S_{i,t}$ is the number of new building approvals for all dwellings, Q and L are vectors of dummy variables for each quarter and sub-region within Adelaide, respectively (omitting the appropriate number of quarters and the central region of Adelaide), $\Delta P_{i,t \dots t-12}$ is the current and lagged price change from 1 – 12 quarters for each LGA and for all dwellings, X is a series of exogenous factors, including land area, average income, construction costs, and the RBA cash rate, γ , β , λ are estimable coefficients, and $\varepsilon_{i,t}$ is a standard error. While endogeneity between the current period price change and current period building approvals is possible, this is highly unlikely. This is because approvals do not typically yield new supply on the market until several quarters or years later. Mayer and Somerville (2000a) explore this relationship using instrumental variables, and find little difference in the resulting coefficients. Thus we include current period price changes in our models.

We estimate equation (1) using data on dwelling approvals and price changes for single-families. When interpreting the results, summing the significant beta coefficients allows us to determine if time-lagged supply adjustments to equilibrium also vary over time. In doing this, we follow the procedure adopted by Mayer and Somerville (2000a and 2000b) as the standard procedure for calculating true quarterly price elasticities.

We include a location-specific dummy term to control for unobservable, time invariant factors that vary between four sub regions within the Adelaide metropolitan area – inner coastal, outer coastal, inner hills, and outer hills. Such factors might include natural topography (greater in the hills region), climate (warmer in the inner locations), political sentiment towards development (less positive in the hills), infrastructure investment (greater in the outer regions), geographic proximity to raw materials (greater in the outer regions), local industrial structure of the development sector (ambiguous), and labor costs (ambiguous).

However, equation (1) does not take into account the possible effect of spatial dependence. It has been well noted in spatial econometric literature that the level of development activity in a jurisdiction can depend upon current activity in its neighbours (Brueckner, 1998; Ding, 2001). Thus, we also estimate an empirical model that takes into account building approval activity in neighboring LGAs. To do so, we include a spatial lag of building permits and specify the weights matrix using a contiguity specification. This model appears as:

$$(2) S_{i,t} = \alpha + \gamma_1 \boldsymbol{Q}_t + \gamma_2 \boldsymbol{L}_t + \theta W S_{i,t} + \beta_1 \Delta P_{i,t} + \cdots \beta_{12} \Delta P_{i,t-12} + \lambda_1 X + \varepsilon_{i,t}$$

Here, W is the spatial weights matrix, θ is an estimable coefficient for the spatially lagged dependent variable, and the remaining terms are similarly defined as in equation (1).

Last, in specifications (1) and (2) we assume homogeneity of the beta coefficients across all sub regions. While other studies that use the Mayer-Somerville model also assume homogenous supply elasticity across units, there is no reason *a priori* to assume this is so. Housing markets are typically local, rather than regional in nature, so the idiosyncrasies associated with individual submarkets could possibly lead to rather different magnitudes and lags of supply elasticity within regions. As such, we also test for difference in the elasticity of the beta coefficients by sub region by including additional models that use interaction terms between the price variable and each sub region dummy. Such a model appears as:

$$(3)\ S_{i,t} = \alpha + \gamma_1 \boldsymbol{Q}_t + \gamma_2 \boldsymbol{L}_t + \theta_1 W S_{i,t} + \beta_1 \Delta P_{i,t} + \cdots \beta_{12} \Delta P_{i,t-12} + \theta_2 (\boldsymbol{L} \Delta P_{i,t} + \cdots \boldsymbol{L} \Delta P_{i,t-12}) + \lambda_1 X + \varepsilon_{i,t}$$

where θ_2 is a vector of coefficients for the interaction between sub region dummy and price change. All other variables are identified as in equations (1) and (2).

Data Sources and Estimation Procedures

We acquired data from a variety of sources. For housing approvals, we used the ABS regional database on quarterly economic activity. For constant-area LGAs in Adelaide, this data extends back to the third quarter of 2001. For construction costs, we used the ABS quarterly producer-price index for materials used in house building. For interest rates, we used the Reserve Bank of Australia's (RBA) target cash rate that was set at the beginning of the quarter.

Another variable we construct for each neighborhood/year record is a constant-quality house price index value. This value is obtained by using the information on the two most recent sales transactions of each single-family home to estimate standard repeat sales models separately for each neighborhood using the following model:

(4) $$\ln\left(\frac{P_{i,t}}{P_{i,t-n}}\right) = \sum_{k=1}^{T} \beta_k D_{i,k} + \varepsilon_{i,t,t-n}$$

where, $P_{i,t}$ is the most recent selling price of property i at time t; $P_{i,t-n}$ is the previous selling price of property i at time $t - n$; β_k is the regression coefficient on $D_{i,k}$; T is the last time period in the sample; k is an index over the time periods; $D_{i,k}$ is a dummy variable which equals -1 at the time of the initial sale, $+1$ at the time of the second sale, and 0 otherwise; and $\varepsilon_{i,t,t-n}$ is the regression error term. To calculate the LGA specific house price index, we calculate a specific house price index for each LGA using the exponential to base e of the slope coefficient β_t and multiplying by 100.

For prices, construction costs, and interest rates, we follow Mayer and Somerville's (2000b) lead by calculating changes as the log difference between quarters, and we also log the number of housing approvals for each quarter. This log-log specification allows us to interpret the coefficients as true supply elasticities, where a per cent change in the dependent variable is associated with a per cent change in housing approvals. We use lagged changes in construction costs because such costs may also be endogenous to price changes: increasing interest rates may reduce new supply, but new supply may place upward demand on raw materials of housing and thus drive up construction costs. Interest rates may also be endogenous to new supply. While increases in interest rates make borrowing more costly for developers and thus can decrease new supply, low housing supply elasticity may drive up prices and lead to increases in interest rates by the Reserve Bank. Omitting the current quarter observation of these variables helps avoid these potential sources of endogeneity.

And last, we employ tests for the presence of both heteroskedasticity and autocorrelation, as is common when using panel data. For the former, we use the Wooldridge F-test (Wooldridge, 2002), and for the latter, we use the Likelihood-Ratio Test (Cameron and Trivedi, 2009). Results of these tests show heteroskedasticity and serial correlation are present in each model. Thus, to estimate equations (1), (2), and (3) we follow similar techniques used in Mayer and Somerville (2000b) and McLaughlin (2011) and employ Feasible Generalized Least Squares estimators (FGLS). We introduce the necessary corrections for heteroskedasticity (H) and panel-specific autocorrelation of the first order (PSAR1) using STATA's *xtgls* command. While Zabel and Patterson (2006) argue the presence of temporal autocorrelation is a sign of model misspecification, and suggest using lagged building approvals in place of lagged prices is preferable, doing so in our model would prevent estimation of true price elasticities. Thus, we choose instead to include price lags and test and correct for serial correlation using FGLS procedures.

The FGLS technique is preferred over fixed and random effects models when panels are long and narrow (Wooldridge, 2001; Cameron and Trivedi, 2009). As our data consists of 19 LGAs over 37 quarters, we thus feel the FGLS procedure is most appropriate.

4. RESULTS

Table 4 presents the results from equations (1) and (2). For simplicity of presentation, quarterly dummies are omitted. The left-hand columns of Table 4 show the results for the equation (1). The regression coefficients of price changes are significantly positive at the less than .05 per cent level in quarters t-4 through t-10. The sum of these significant price change coefficients is approximately 15.7. This suggests a one per cent increase in the price index for single-family homes leads to a 15.7 per cent increase in new building approvals between one and two and a half years later. These results are similar to those found by McLaughlin (2011 and 2012) at the capital city level. Furthermore, our results also show that average LGA income is negatively correlated and land area is positively correlated with new building approvals. The associated coefficients are -2.20 and 0.16, respectively. Last, the sub-region specific indicators suggest that all sub regions permit more building approvals than the city center, but that the positive coefficients are lowest in the hills region (Outer: 0.81 and Inner: 1.01) and highest in the coastal plains (Outer: 1.75 and Inner: 1.84). The coefficients of construction costs and interest rates are not significant.

Table 4. Regression Results for Base and Spatial Models.

	Base Model				Spatial Model			
Variable	Coef.	Std. Err.	z	P>z	Coef.	Std. Err.	z	P>z
Δprice, t-1	0.29	0.79	0.36	0.72	0.31	0.78	0.40	0.69
Δprice, t-2	0.93	0.77	1.20	0.23	0.91	0.76	1.19	0.23
Δprice, t-3	1.18	0.91	1.30	0.19	1.11	0.89	1.24	0.21
Δprice, t-4	**1.96**	**0.91**	**2.16**	**0.03**	**1.94**	**0.89**	**2.17**	**0.03**
Δprice, t-5	**2.12**	**0.94**	**2.25**	**0.02**	**2.15**	**0.93**	**2.32**	**0.02**
Δprice, t-6	**2.85**	**0.92**	**3.08**	**0.00**	**2.91**	**0.91**	**3.19**	**0.00**
Δprice, t-7	**2.65**	**0.92**	**2.90**	**0.00**	**2.73**	**0.90**	**3.02**	**0.00**
Δprice, t-8	**2.39**	**0.89**	**2.67**	**0.01**	**2.54**	**0.88**	**2.87**	**0.00**
Δprice, t-9	**1.69**	**0.83**	**2.04**	**0.04**	**1.83**	**0.83**	**2.22**	**0.03**
Δprice, t-10	**2.02**	**0.80**	**2.54**	**0.01**	**2.26**	**0.79**	**2.84**	**0.00**
Δprice, t-11	0.62	0.67	0.92	0.36	0.85	0.67	1.26	0.21
Δprice, t-12	0.91	0.66	1.38	0.17	1.03	0.66	1.56	0.12
Income	**-2.20**	**0.31**	**-7.06**	**0.00**	**-2.54**	**0.33**	**-7.70**	**0.00**
Land	**0.16**	**0.03**	**5.05**	**0.00**	**0.19**	**0.03**	**5.78**	**0.00**
ΔConst. Costs	15.59	100.51	0.16	0.88	34.41	103.55	0.33	0.74
ΔCash Rate	1.66	6.27	0.26	0.79	2.94	6.37	0.46	0.64
Inner Coastal	**1.84**	**0.11**	**16.85**	**0.00**	**1.69**	**0.12**	**14.70**	**0.00**
Outer Coastal	**1.75**	**0.12**	**14.96**	**0.00**	**1.61**	**0.12**	**13.25**	**0.00**
Inner Hills	**1.01**	**0.09**	**11.09**	**0.00**	**0.85**	**0.10**	**8.75**	**0.00**
Outer Hills	**0.81**	**0.12**	**6.60**	**0.00**	**0.82**	**0.12**	**6.78**	**0.00**
W*S (spatial lag)	-	-	-	-	**-0.24**	**0.06**	**-3.75**	**0.00**
Observations	393				393			
Prob>chi^2	0.00				0.00			

Notes: Dependent variable is the natural log of quarterly housing approvals (S), all independent variables are logged. Coefficients on quarterly dummies are not shown, but are available from the authors upon request. Bold text indicates significance at the < 5% confidence level.
Source: the Authors.

The right hand side section of Table 4 shows the results for equation (2). The regression coefficients of price changes are also significantly positive at less than the 0.05 per cent level in quarters t-4 through t-10, and the magnitude of elasticity is approximately 15.5 per cent. Again, this suggests a one per cent increase in the multifamily price index leads to a 15.5 per cent increase in new approvals between one and two and a half years later. LGA income, land area, and sub region dummies all have similar significance and magnitudes to equation (1). Perhaps most interesting is the negative and significant coefficient on the spatially lagged dependent variable W*S in the spatial model. While the coefficient is quite small, it does suggest that a one per cent increase in a neighboring LGA's building approvals leads to a 0.24 per cent decrease in an LGA's own building approvals. The regression coefficients of construction costs and interest rates are not significant

Table 5 shows regression results from the interaction model represented by equation (3). The effect of adding price change interactions for each regional sub-group of LGAs into the interaction model results in the coefficients of all but one lagged price change variable becoming insignificant. No interaction variables are significant, and the only significant price change variable is for the t-6 time period (with a coefficient of approximately 4). Turning to the other variables, income and land area are significantly related to new home construction negative and positive respectively, with coefficients similar to equations (1) and (2). Sub regions dummies are also similar in significance and magnitude to equations (1) and (2), although the outer hills dummy is not significant.

Table 5. Regression Results – Interaction Model

Variable	Coef	Std. Err	z	P>z	Variable	Coef	Std. Err.	z	P>z
$\Delta price_{t-1}$	-0.33	1.76	-0.19	0.85	$OC{*}\Delta p_{t-3}$	1.99	2.52	0.79	0.43
$\Delta price_{t-2}$	2.11	1.82	1.16	0.25	$OC{*}\Delta p_{t-4}$	-0.68	2.35	-0.29	0.77
$\Delta price_{t-3}$	-0.10	2.13	-0.05	0.96	$OC{*}\Delta p_{t-5}$	2.86	2.48	1.16	0.25
$\Delta price_{t-4}$	2.49	1.99	1.25	0.21	$OC{*}\Delta p_{t-6}$	-1.50	2.40	-0.62	0.53
$\Delta price_{t-5}$	0.31	2.19	0.14	0.89	$OC{*}\Delta p_{t-7}$	1.15	2.59	0.44	0.66
$\Delta price_{t-6}$	**4.64**	**2.17**	**2.14**	**0.03**	$OC{*}\Delta p_{t-8}$	1.68	2.66	0.63	0.53
$\Delta price_{t-7}$	1.91	2.31	0.83	0.41	$OC{*}\Delta p_{t-9}$	1.35	2.74	0.49	0.62
$\Delta price_{t-8}$	1.51	2.31	0.65	0.51	$OC{*}\Delta p_{t-10}$	-0.06	2.55	-0.02	0.98
$\Delta price_{t-9}$	1.44	2.31	0.62	0.53	$OC{*}\Delta p_{t-11}$	-1.27	2.51	-0.51	0.61
$\Delta price_{t-10}$	3.47	2.13	1.63	0.10	$OC{*}\Delta p_{t-12}$	-0.60	2.28	-0.26	0.79
$\Delta price_{t-11}$	2.44	2.17	1.12	0.26	$IH{*}\Delta p_{t-1}$	0.14	2.27	0.06	0.95
$\Delta price_{t-12}$	2.10	1.99	1.06	0.29	$IH{*}\Delta p_{t-2}$	-1.77	2.33	-0.76	0.45
Income	**-2.66**	**0.34**	**-7.91**	**0.00**	$IH{*}\Delta p_{t-3}$	0.15	2.58	0.06	0.96
Land	**0.18**	**0.03**	**5.45**	**0.00**	$IH{*}\Delta p_{t-4}$	-0.27	2.40	-0.11	0.91
ΔConst. Costs	-52.58	128.32	-0.41	0.68	$IH{*}\Delta p_{t-5}$	2.01	2.56	0.79	0.43
ΔCash Rate	-1.55	5.91	-0.26	0.79	$IH{*}\Delta p_{t-6}$	-1.03	2.44	-0.42	0.67
Inner Coastal (IC)	**1.40**	**0.29**	**4.77**	**0.00**	$IH{*}\Delta p_{t-7}$	1.27	2.56	0.50	0.62
Outer Coastal OC)	**1.43**	**0.28**	**5.03**	**0.00**	$IH{*}\Delta p_{t-8}$	1.90	2.58	0.74	0.46
Inner Hills (IH)	**0.78**	**0.29**	**2.65**	**0.01**	$IH{*}\Delta p_{t-9}$	0.90	2.62	0.34	0.73
Outer Hills (OH)	0.24	0.39	0.61	0.55	$IH{*}\Delta p_{t-10}$	-0.24	2.44	-0.10	0.92

Notes: Dependent variable is the natural log of quarterly housing approvals, all independent variables are logged. Coefficients on quarterly dummies are not shown, but are available from the authors upon request. Bold text indicates significance at the < 5% confidence level. Source the Authors.

Table 5. (Continued) Regression Results – Interaction Model.

W*S	**-0.24**	**0.06**	**-3.82**	**0.00**	IH*Δp_{t-11}	-1.38	2.38	-0.58	0.56
IC*Δp_{t-1}	1.37	2.85	0.48	0.63	IH*Δp_{t-12}	-0.43	2.19	-0.20	0.84
IC*Δp_{t-2}	-1.41	3.13	-0.45	0.65	OH*Δp_{t-1}	4.89	4.91	1.00	0.32
IC*Δp_{t-3}	2.64	3.52	0.75	0.45	OH*Δp_{t-2}	0.25	4.73	0.05	0.96
IC*Δp_{t-4}	1.48	3.35	0.44	0.66	OH*Δp_{t-3}	4.00	5.61	0.71	0.48
IC*Δp_{t-5}	3.53	3.16	1.12	0.26	OH*Δp_{t-4}	-1.09	5.82	-0.19	0.85
IC*Δp_{t-6}	-0.57	3.02	-0.19	0.85	OH*Δp_{t-5}	5.77	5.95	0.97	0.33
IC*Δp_{t-7}	2.78	3.08	0.90	0.37	OH*Δp_{t-6}	-1.33	5.91	-0.22	0.82
IC*Δp_{t-8}	2.82	3.05	0.93	0.35	OH*Δp_{t-7}	6.78	6.05	1.12	0.26
IC*Δp_{t-9}	1.27	2.89	0.44	0.66	OH*Δp_{t-8}	2.81	5.68	0.49	0.62
IC*Δp_{t-10}	-1.58	2.72	-0.58	0.56	OH*Δp_{t-9}	5.84	5.72	1.02	0.31
IC*Δp_{t-11}	-1.34	2.61	-0.51	0.61	OH*Δp_{t-10}	-0.59	5.06	-0.12	0.91
IC*Δp_{t-12}	-1.32	2.28	-0.58	0.56	OH*Δp_{t-11}	0.40	4.55	0.09	0.93
OC*Δp_{t-1}	0.99	2.12	0.47	0.64	OH*Δp_{t-12}	-4.36	4.03	-1.08	0.28
OC*Δp_{t-2}	-1.57	2.16	-0.73	0.47					
Observations	393								
Prob>chi^2	0.00								

Notes: Dependent variable is the natural log of quarterly housing approvals, all independent variables are logged. Coefficients on quarterly dummies are not shown, but are available from the authors upon request. Bold text indicates significance at the < 5% confidence level. Source the Authors.

5. CONCLUSION

These results tell an interesting, if somewhat mixed, story of variations in housing supply elasticity within a metropolitan area. Overall housing supply elasticity appears to be quite large, with a one per cent increase in prices leading to an approximately 15 per cent increase in supply between one and two and half years later. While this magnitude is relatively large compared to the estimates of McLaughlin (2011 and 2012) and Gitelman and Otto (2012) for other Australian cities, we do find that several other important factors may play a role in increasing the spatial balance of new housing supply in Adelaide.

First, we find that for every one per cent increase in an LGA's average income the number of building approvals in an LGA decreases by over 2 per cent. This finding may suggest that wealthier LGAs in Adelaide may be successfully stifling new development in order to protect themselves from the negative externalities associated with new residential growth. Second, a one per cent increase in an LGA's land area is associated with a 0.16 per cent increase in new building approvals. Although this magnitude is quite small, it does suggest that land supply does play a factor in the ability of local governments to provide new housing supply. Third, it appears that the positive effect of LGAs in the coastal plain on the number of new building approvals is twice that of LGAs in the hills region. This may be for two reasons: (1) land in the coastal plains is flatter and easier to build on than land in the hills, and (2) much of the land in the hills region is protected open space (especially in the Adelaide Hills LGA). Last, it appears that spatial dependence of new building approvals negatively impacts new housing supply. We find that for a one per cent increase in building approvals in a neighboring LGA, new housing supply decreases by almost a quarter of a per cent. This could be for two reasons: (1) building approvals in adjacent LGAs may be satisfying sub regional housing demand; (2) LGAs may be reacting negatively to neighboring development activity by reducing new development in their own jurisdiction; or (3) developers may shop around for LGAs with the least burdensome development application process and/or they develop expertise and local knowledge of the approval process, and thus tend to focus their efforts on specific areas.

Our results suggest that policy intervention at the state level may be needed to discourage local-level not-in-my-backyard (NIMBY) resistance to new development, and thereby help to limit the rate of increase in house prices. Specifically, such policies may be needed in more affluent LGAs, where local residents may be better educated, organized, and funded to resist new housing developments. In addition, more research is also needed to determine if our finding of negative spatial dependence is a result of demand satisfaction by neighboring jurisdictions, or whether LGAs are 'reacting' negatively to development in adjacent municipalities by enforcing tighter restrictions on new residential growth.

Last, metropolitan plans might also be needed to help increase the supply of brownfield – or redevelopable – land. Such efforts might include land assembly, development application/site plan assistance, and local community consultation. This issue and many of the other themes developed in this article could lead to a comprehensive research agenda into the means by which federal, state and governments could seek to rein in Australia's house price spiral, which is reducing home-ownership rates and raising social and economic inequality.

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