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Metropolitan Growth Policies and New Housing Supply: Evidence from Australia's Capital Cities

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METROPOLITAN GROWTH POLICIES AND NEW HOUSING SUPPLY: EVIDENCE FROM AUSTRALIA'S CAPITAL CITIES

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ABSTRACT: This paper empirically examines the relationship between house price change, metropolitan growth policies, and new housing supply in Australia's five major capital cities. Our hypothesis suggests capital cities with tighter regulations on new development will have fewer housing starts and price elasticities than those in less-regulated markets. The empirical procedure used in this paper utilises the Urban Growth Model of Housing Supply developed in Mayer and Somerville (2000a and 2000b) and employed in Zabel and Patterson (2006) by using quarterly data on housing approvals and house prices from 1996-2010. Data on metropolitan growth policies in Australia is borrowed from Hamnett and Kellett (2007). Preliminary findings indicate that new housing supply in Australian capital cities is elastic to housing price changes, as a one per cent increase in prices leads to an approximately 4-6 per cent increase in housing approvals over five quarters. While this indicates a properly functioning housing market, the estimated elasticity is about a third of other developed countries, such as the United States. Furthermore, the use of established growth policies, such as urban growth boundaries and urban consolidation, appears to have a greater impact on new housing approvals than adoption of new-style growth policies, such as development corporations and infrastructure levies. However, both types of policies decrease new housing supply.

1. INTRODUCTION

Much scholarly work on Australian housing markets centres on housing price trends and their determinants (Abelson, 1994; Maher, 1994; Bourassa and Hendershot, 1995; Murphy and Harley, 2003; Berry and Dalton, 2004; Abelson, Joyeux, Milunovich, and Chung, 2005), while relatively little work examines supply-side dynamics (Williams, 2000; Yates and Wulff, 2000; Yates, 2001; Wood, 2003; Berry, 2003). Furthermore, few studies empirically examine supply-side responses to increases in housing demand (Yates and Wulff, 2000). This is surprising, given that recent theoretical and empirical evidence suggests low housing supply elasticity may play an important role in the emergence of market bubbles and decreased housing affordability (Berry and Dalton, 2004; Glaeser, 2006; Glaser, Gyourko, and Saiz, 2008).

Low housing supply elasticity could result from a number of factors. In Australia, two primary culprits are oft-blamed: land market intervention, and developer land banking. The former is usually targeted by representatives of the housing industry (Day, 2006), while the latter targeted by opponents of neo-liberalism (Gleeson and Coiacetto, 2007; Beer, Kierans, and Pieters, 2007). Land market interventions are said to lower supply elasticity by restricting the pace and intensity of new development, while private land banking is blamed for reducing elasticity through monopolistic private ownership of large amounts of developable land.

In response to the perceived problems of private land banking and "economic surplus" of the development industry, the Whitlam Government established the Land Commission Program (LCP) in the early 1970s, and state governments in Australia formed public land corporations for the purpose of regulating the acquisition and release of land supply (Stretton, 1970; Troy, 1979; Gleeson and Coiacettto, 2007). Approximately twenty years later, urban consolidation and other metropolitan growth policies were hallowed across the country as solutions to problems of environmental and social sustainability. Both efforts involved removing large amounts of developable land around Australia's capital cities by different means: public land commissions achieved this by purchasing land from the private market, while metropolitan-wide policies preserved land through the use of various land regulations, such as urban growth boundaries, urban service limits, and non-urban zoning. Much criticism concerning large increases in Australian house prices have been directed towards these two efforts. However, there is little empirical evidence to verify housing price effects of such programs. This is perhaps enhanced by the complex nature of housing prices themselves.

This paper takes an alternative approach to testing this argument by empirically examining the cumulative impacts of metropolitan growth policies on new housing supply. Specifically, we address three interrelated questions:

(1) What is the general supply elasticity of new housing in Australia over the past 15 years?
(2) Has utilisation of strong metropolitan growth policies affected the supply of new housing units? and
(3) Do impacts of such policies vary between older 'established" policies vs. newer "innovative" policies?

The following section reviews past and recent trends in housing studies and conditions in Australia, and lays out the advantages of using the urban growth model of housing supply for evaluations of metropolitan planning policies. Section 3 describes a theoretical and empirical model of new housing supply based on the urban growth model; section 4 discusses results from the empirical analysis; and section 5 concludes with policy recommendations and caveats.

2. THE AUSTRALIAN HOUSING MARKET

Over the past 40 years, housing issues in Australia have been a central focus of academics, politicians, industry players, and the general public alike. Much of this focus has centred on the interplay of government and urban planning policies, neo-liberalism, and housing affordability. Specifically, the major debate on housing affordability festers between government interventionists and neo-liberals. On the left, proponents of government intervention argue the housing market, left to its own device, will lead to over-speculation, market instability, and generally unaffordable housing via the monopolistic tendencies of land and housing developers. On the right, neo-liberals argue urban planning policies reduce affordability by excessive restrictions on the supply of developable land through land market intervention, public land agencies, and high taxation. Both arguments have theoretical merit, although little empirical evidence exists to vindicate either perspective. This lack of evidence is the primary motivation for this study.

Urban economic theory suggests that, *ceteris paribus*, a reduction in the supply of developable land does not unambiguously lead to higher housing prices. This should be the same for any supply reduction, regardless of whether it originates from public agencies or monopolistic land speculators. However, a reduction in the supply of developable land must lead to higher land prices. And although land and housing prices are certainly correlated, an increase in land prices does not necessarily lead to higher housing prices. This is because land and capital are substitutable: when faced with higher land costs and a downward sloping demand curve, developers should theoretically use less land per housing unit and built more housing units per hectare of land. This substitution should occur at a rate that offsets the increase in land price. Thus, the end result of a supply-induced increase in land prices should be smaller housing units, but not necessarily more expensive housing units. This is the desired mechanism of urban consolidation efforts: to increase sustainable development and preserve open space by limiting the supply of developable land, while allowing developers and other government programs to increase the density of the built environment and housing choice, respectively.

However in a socio-political landscape, existing residents are often opposed to increases in density within their communities. As such, local development plans and zoning codes typically reflect local not-in-my-back-yard (NIMBY) attitudes through the use of density and minimum lot size restrictions. As a result, the goals of increasing housing affordability and sustainability through urban consolidation policies can be at odds with local desires of urban form. Thus, what often results from initial efforts of urban consolidation are heavily regulated land markets with tight density restrictions on new development, both from state government reductions of new green field sites and local council density restrictions on existing brown field sites. In such a scenario, developers are prevented from making an efficient land/capital substitution, and the end result must be an increase in both land and housing prices.

To complicate matters, comprehensive planning of land and housing markets can result in housing price increases from two independent market effects: a decrease in supply, due to restrictive zoning and development plans, but also from demand increases, which arises from improvements in the quality of the built environment. As a result, analyses of planning policies and house prices must take into account these separate effects. Failing to do so could misattribute the specific effects of a given policy. While quantifying the stock of housing supply is relatively straightforward, quantification of improvements in the quality of the built environment is quite difficult. Only a handful of studies address the prospective welfare gains from comprehensive planning schemes (Cheshire and Sheppard, 2002 and 2005), and even fewer empirical studies have attempted to estimate demand-side price effects (Egbu, Olomolaiye, and Gameson, 2007; Ihlanfeldt, 2009).

Despite this empirical challenge, academic analyses of house prices (Abelson and Chung, 2005), housing policies (Berry and Dalton, 2004), and their determinants (Abelson, Joyeux, Milunovich, and Chung, 2005) remain popular in Australian academic literature. This comes as no surprise, since recent house price appreciation in Australia has topped the list of developed countries (The Economist, 2003; Abelson and Chung, 2005). Even in the face of housing bubble concerns in the earl-mid 2000s (Berry and Dalton, 2004), house price indices continued to climb for all Australian cities. Furthermore, the robustness of the Australian housing market continued during the onset of the global financial crisis.

Figures 1 and 2 show the Residex quarterly housing price index for the five major capital cities from 1993-2010 for homes and units, respectively. The picture for both detached homes and apartment units are similar: price appreciation was relatively smooth to the late 1990s, but rapid increases took hold in Sydney and Melbourne, followed by Brisbane in the early 2000s and soon after in Adelaide and Perth. While these figures show rapid increases, they do not take into account increases in income and inflation. Figures 3 and 4 better captures this, as they show increases in the price index relative to increases in weekly wages from the previous quarter, for houses and units, respectively. These figures show a less pronounced price increase compared to Figure 1 and 2. Even so, the price growth of housing relative to income increased dramatically from the late 1990s to the mid 2000s, followed by another sharp increase from 2006-2007. Income increases gained significant ground on house prices only for two brief periods in the late 2000s. A simple comparison of house prices changes with average weekly wage changes between 1994-2010 best shows this discrepancy. For Adelaide, income grew by 72% while house prices grew by 259%; income in Brisbane grew by 96% and house prices by 250%; income in Melbourne increased by 72% and house prices by 294%; income in Perth rose by 102% and house prices by 323%; and income in Sydney grew 77% and house prices by 208%. Clearly, more than just increases in disposable income are driving house price appreciation.

But what other factors might be driving these large price escalations? This has been a matter of debate in the academic literature, and scholarly evidence ranges from descriptive and speculative (Berry and Dalton, 2004), to inferential and inconclusive (Abelson *et al*, 2005). The speculative evidence suggests a number of causes for price appreciation, such as: declines in interest rates, increases in speculative residential investment, changes in land use regulation, tax subsidies for homeownership, and long term economic and demographic growth (Berry and Dalton, 2004; Abelson and Chung, 2005). The inferential evidence gives clues to which of these factors has played the most significant role (Abelson *et al*, 2005). For house price changes between 1970 and 2003, the largest impact was from changes in mortgage rates, where one point decrease in quarterly interest rates has historically increased house prices by 5.4 per cent. Income also plays a significant role, with a one per cent change in per capita income leading to a 1.7 per cent increase in prices. Most pertinent to the empirical approach in our study is the impact of housing supply. Abelson *et al.* (2005) estimate that a one per cent increase in the Australian housing stock leads to a 3.6 per cent decrease in housing prices. This finding suggests that the

Figure 1. House Price Index for Homes, 1993-2010

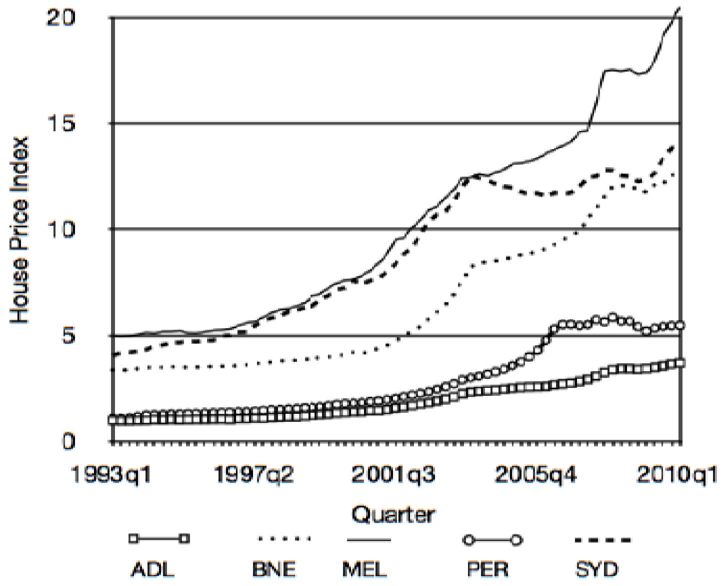


Figure 2. House Price Index for Units, 1993-2010

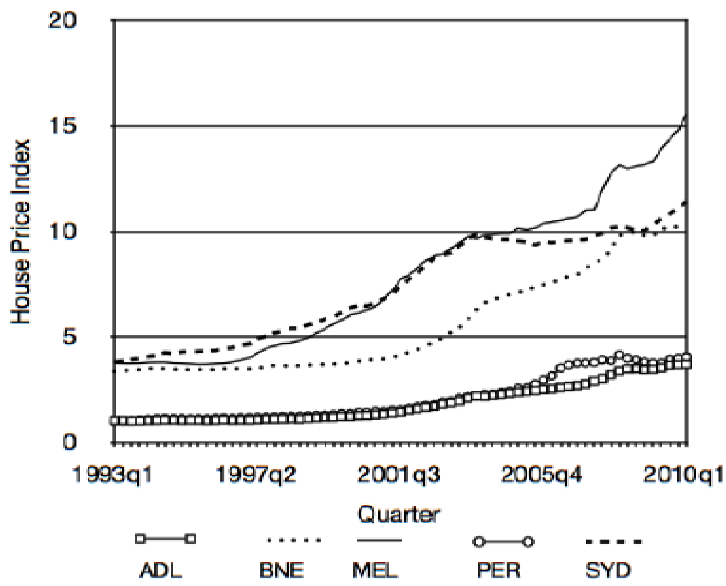


Figure 3. HPI-Income Ratio for Homes, 1994-2010

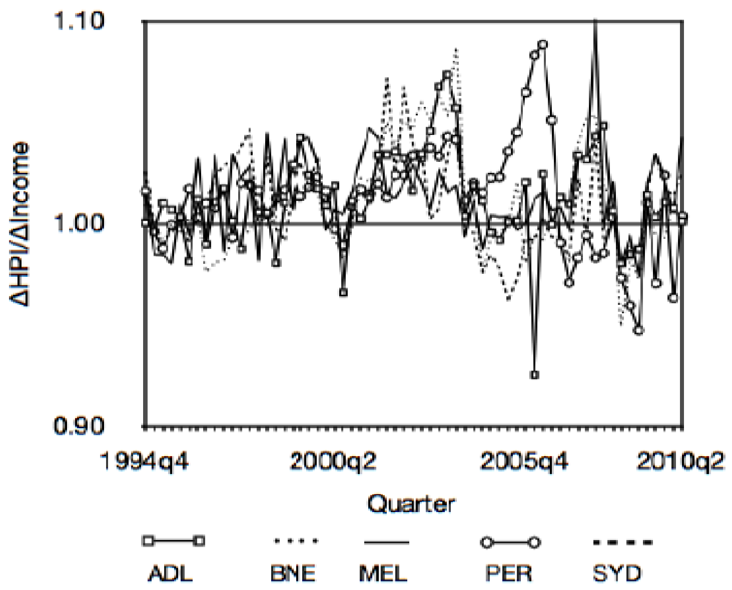
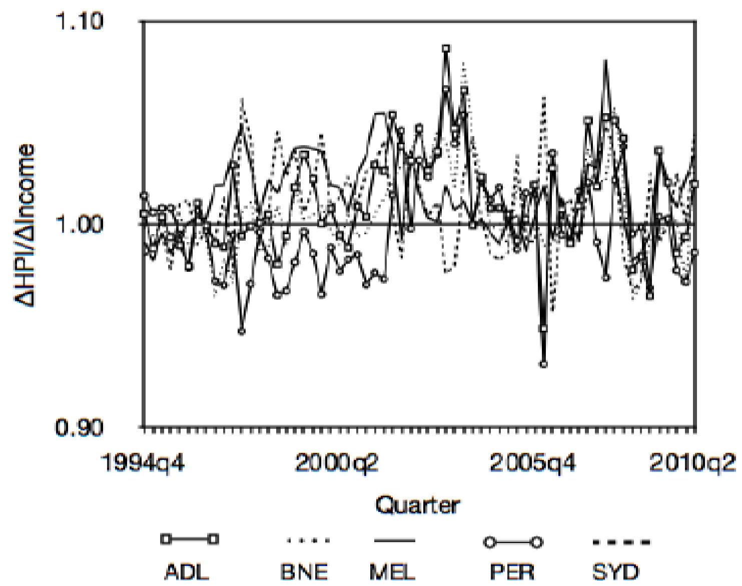


Figure 4. HPI-Income Ratio for Units, 1994-2010



addition of new housing supply could play a significant role in moderating escalating house prices. Furthermore, supply factors could play an even greater role today, as the estimates of Abelson *et al*. (2005) were computed from data only up to 2003 – well before the most recent run-up in housing prices.

While studies of Australian housing *prices* are quite abundant, empirical analyses of *supply* are practically non-existent. This is by no means limited to the Australian context, as few scholarly efforts have addressed the theoretical or empirical determinants of new housing supply. The few existing studies primarily focus on determinants of the size of the housing stock, such as population, income, and household size, while very few empirically estimate supply-side elasticities. Moreover, an empirical model of new housing starts was only recently developed (Mayer and Somerville, 2000a) and tested empirically (Mayer and Somerville, 2000b; Zabel and Patterson, 2006). But no known use of this model has been employed to the Australian case.

The advantages of using empirical models of housing supply elasticities are threefold. First, as described above, planning policies can influence prices by reducing supply and increasing demand. Bifurcating these two effects empirically is a difficult, if not impossible task. Using supply elasticities avoids this problem. Second, estimating new supply is not as vulnerable to measurement error as measuring housing prices. This is because house price indicators can vary tremendously depending on method of measurement: median and average prices can shift depending on the quality and quantity of homes sold during any period, and the quality of home sales data can vary drastically between sources because there is no standard definition of what constitutes housing prices (Abelson and Chung, 2005; Abelson and Joyeux, 2007). Alternatively, data on new housing approvals (which represents new supply) consists of straightforward counts on the number of new permits in a given area, and is reliably available from the ABS on a monthly basis. As such, we choose to estimate the impacts of metropolitan planning policies on new housing supply, rather than prices.

3. THEORETICAL AND EMPIRICAL MODEL OF HOUSING SUPPLY

3.1 A Theoretical Narrative of New Housing Supply

For purposes of this paper, the Mayer and Somerville (2000b) model of new housing supply is ideal as its conceptual underpinnings are based in urban growth theory. Urban growth theory postulates that the determinants of urban growth are best measured by *changes*, as opposed to levels, of such factors. In other words, the existing state of the universe is best predicted by *shifts* in the previous state of the universe, rather than the previous universe itself. For new housing supply, this is characterised by housing price *changes* as a superior predictor of new housing units compared to housing price *levels*. The following paragraphs describe the theoretical intuition.

Imagine a large city that is neither growing nor shrinking, but rather exists in a steady-state with no major changes to population, income, or transportation costs. In this hypothetical city, housing prices reflect the overall wealth of city, the number of people bidding for different housing types, and the costs of commuting. As it is a large city with higher than average income and number of residents, housing and land prices are relatively high compared to other areas but no new units are being demanded. Housing starts thus approach zero in such a city.

Now imagine a small city where housing prices are much lower than the large city. Suppose a one-time increase in population occurs only in the small city. Demand for housing increases. Since housing is a complex durable good, new supply does not occur instantaneously (or even quickly) because of inherent lags in construction processes and planning approvals. In the short-run, house prices increase temporarily as new households bid up the price for land and housing. Developers take note of housing price increases and respond by building more units. Once enough new supply is provided to satisfy demand, house prices should fall close to pre-growth levels (though land prices will be slightly higher on a per metre basis to reflect an increase in scarcity).

In each of these scenarios, housing price levels would not correctly predict increases in new supply. This is because a city can be large and expensive but also slow growing, as in the first scenario, and have relative few housing starts, while a small and inexpensive but fast growing town could have many starts. Price *changes* (increases), on the other hand, occur wherever demand shifts (increases), regardless of existing price levels. As such, models of new housing supply should be theoretically more robust when using price changes in place of price levels.

In addition, a number of other geo-economic and institutional factors can affect the provision of new housing. Geographical and geological variations in the landscape can drastically alter construction costs. Cities in close proximity to shipping ports and/or large sources of raw materials will have lower constructions costs because of readily available inputs for new development, while areas with dramatic topographical features or unstable soils have higher constructions costs because of increased complexities in the building process.

Furthermore, policies of governments and financial institutions can affect new housing supply. And although many of these policies are designed to influence housing demand, such as interest rates and homeowner tax breaks, several also affect the provision of new housing units. For example, increases in interest rates make financing new development projects more costly, and thus likely to reduce new residential supply. Local and state development plans also reduce the supply of new residential units by using regulations that reduce the intensity of new development, such as maximum density limits and minimum lot sizes. Additionally, most new development cannot occur without proper approval from local councils. Approval hearings can introduce delays and uncertainty into the development process, thereby making development riskier and less likely to occur (Mayer and Somerville, 2000b).

Thus, to avoid estimation bias, all of these aforementioned factors must be controlled for in empirical models of housing supply. The following subsection intimately details such a model, which is derived from Mayer and Somerville (2000a and 2000b) and Zabel and Patterson (2006).

3.2 The Mayer-Somerville Empirical Model of New Housing Supply

In many theoretical models of urban growth, new development occurs instantaneously. However, as mentioned above, there are various reasons why this is not an accurate reflection of the development process. Construction delays, development approvals, and geo-economic anomalies may create a lag between demand shocks and supply response. When lags exist, larger increases in demand lead to greater short-run increases in both land and housing prices. As a result, it is important to account for not only price changes in current periods, but also price changes in previous periods.

The intuition is that developers, seeking to maximise profits, observe price increases in the housing market, and respond by providing new supply over the course of several time periods as they obtain building permits and mobilise resources for construction. In empirical models of housing elasticities, it is important to include an adequate number of time period lags to properly capture the delayed impacts of price changes. Evidence from Mayer and Somerville (2000a and 2000b) suggests that in the US, these lag periods range from three to five quarters. However, legal, economic, and institutional conditions are different in Australia. Although there are no known estimates of residential supply lags in Australia, Abelson *et al.* (2005) estimates Australian housing market prices adjust to equilibrium in approximately four quarters. As this estimate is similar to the lag period in Mayer and Somerville, we employ the more conservative structure of five quarters to allow for the possibility of longer adjustments to prices.

In our model, the price change for each proceeding five quarters is included as an explanatory variable of new housing supply. Specifically, we use the log of the ratio of the house price index at time t relative to time t-1 to measure price change. This is analogous to the change in log prices, and allows interpretation as per cent house price change. We exclude the current quarter price change to avoid problems of endogeneity bias. If included, bias would arise because house prices and new housing supply are codetermined during a given time period: changes in new supply affect price, but changes in price also affect new supply. Excluding current quarter prices helps circumvent this problem, and is standard practice in models of housing supply, such as Mayer and Somerville (2000b) and Zabel and Patterson (2006).

Furthermore, appropriate measurements of prices are an equally important matter. While many analyses of Australian housing markets use median or average housing prices, potential bias can occur with these measurements. This is because the distribution of homes sold at any moment is not constant. As such, prices are best measured using a quality-constant housing price index. Several such indices exist in Australia, and are produced from a variety of sources such as the Australian Bureau of Statistics (ABS), RP Data, and Residex Pty. Each of these indices use variations of the repeat sales approach, which consist of calculations based on price appreciations of individual homes sales. A detailed description of the repeat sales approach can be found in Case and Shiller (1987). We choose to use Residex's publicly available index for capital cities, as their measure spans the entire universe of sales in a given quarter and is calculated using a unique non-revisionary approach that does not require adjustments over time. The Residex HPI is then transformed to our housing price change variable by calculating the percent change in HPI from the previous quarter.

In addition to housing prices, construction costs are also needed to control for inter-spatial and inter-temporal variations in the costs of raw construction materials. We obtain these figures from ABS's Producer Price Index (PPI) series for materials used in house building. This index is available quarterly for each capital city back to 1966. For interest rates, we use the Australian Reserve Bank cash rate that was in place at the end of the quarter. And finally, to measure new housing supply, we employ data on quarterly housing approvals also obtained from the ABS for each capital city. Descriptive statistics for housing approvals, as well as changes in construction costs, the HPI, and growth policy strength, are shown in Table 1.

Table 1. Descriptive Statistics

City	Quarterly HPI Growth Rate		(1)	(2)	(3)	(4)	(5)	(6)
	Mean	SD						
Adelaide	1.02	0.02	1290	138.78	5.36	12	9	3
Brisbane	1.02	0.02	2624	132.43	5.36	16	7	9
Melbourne	1.02	0.02	5212	131.12	5.36	19	11	8
Perth	1.02	0.03	3066	130.33	5.36	9	9	0
Sydney	1.02	0.02	2628	139.05	5.36	24	11	13

(1) Mean Quarterly New Housing Approvals
(2) Mean Quarterly Construction Cost Index
(3) Mean Quarterly Cash Rate
(4) Metropolitan Policy Strength
(5) Established Policy Strength
(6) Innovative Policy Strength

Source: HPI is available from Residex Pty; Housing approvals and construction costs from the ABS; cash rate from the RBA; and metropolitan growth policies from Hamnett and Kellett (2007).

Furthermore, it is certainly plausible (and likely) that a number of other factors, both measurable and unmeasurable, could affect housing supply elasticities. Excluding these factors could introduce omitted variable bias, and the effects of our included variables could possibly exhibit spurious relationships with the excluded factors. However, many of these factors are not likely to change much over space or time, such as macroeconomic or national political climate (constant over space) or geographical anomalies (constant over time). As such, we choose to examine housing supply over 60 quarters (years 1996-2010) to take advantage of panel data procedures. Panel data techniques, such as population averaged OLS, random effects, and generalised-least-squares (GLS), employ a series of adjustments to control for the impacts of any omitted variables that are constant over space or time. Such techniques are described in detail in Wooldridge (2001) and Cameron and Travedi (2009). As our analysis is most similar to Mayer and Somerville (2000b), we choose to closely follow their estimation procedures, which is described in the following subsection.

3.3 Formal Model Specifications

As mentioned in the introduction, this paper seeks to answer three key questions: (1) What is the general supply elasticity of new housing units in Australia over the past 15 years? (2) Do strong adopters of metropolitan growth policies affect the provision of new housing units? and (3) Does the effect differ between established growth policies and newer, supply oriented policies? The empirical model used here takes three different specifications to address these questions. The model specification used to address question 1 is the most parsimonious of the three, and is nested within the other two models. It appears as:

$$S_{i,t} = \alpha + \gamma_t + \beta_1 \Delta P_{i,t-1} \ldots \beta_5 \Delta P_{i,t-5} + \beta_6 C_{i,t} + \beta_7 I_{i,t} + \beta_8 pop_{i,87} + \varepsilon_{i,t} \quad (1)$$

where $S_{i,t}$ is the quarterly number of new housing approvals, α is the constant, γ_t is the quarterly dummy, $\Delta P_{i,t-q}$ is the quarterly ratio of the house price index (HPI) to the previous period (HPI_t/HPI_{t-1}) where q=5, $C_{i,t}$ is the quarterly construction cost index, $I_{i,t}$ is quarterly RBA cash rate, $pop_{i,87}$ is the population for city i in 1987 to control for city size, and $\varepsilon_{i,t}$ is the error term.

To test for the cumulative impacts of urban metropolitan growth policies, we employ data from Hamnett and Kellett's (2007) classification of metropolitan planning tools employed in Australia's five largest capital cities. Their classification scheme ranks capital cities on the both the presence and strength of two classifications of growth policies: "Established Strategies," which include policies such as urban growth boundaries and public land agencies, as well as "Recent Innovations," such as infrastructure levies and fast-track planning systems. A summary of their classification is reproduced in Table 2.

For the purposes of this analysis, we build a series of simple calculations of regulatory stringency at the metropolitan level based on these two classifications. The first measures the cumulative strength of metropolitan growth policy adoption. This measure, labelled MP, is based on the sum of adoption strength identified in Hamnett and Kellett, where No Policy = 0, Weak Policy = 1, Moderate Policy = 2, and Strong Policy = 3.

For example, Adelaide scores a 12 for adoption strength, while Sydney scores 24. While the interpretation and scale is not linear (i.e., a score of 24 is not necessarily twice as strong as 12), we do believe it is a simple yet meaningful step in measuring the rigidity of land and housing markets in Australia. The cumulative model appears as:

$$S_{i,t} = \alpha + \gamma_t + \beta_1 \Delta P_{i,t-1} \ldots \beta_5 \Delta P_{i,t-5} + \beta_6 C_{i,t} + \beta_7 I_{i,t} + \beta_8 pop_{i,87} + \beta_9 MP_{i,t} + \varepsilon_{i,t} \quad (2)$$

where MP is included as an explanatory variable of new housing approvals.

Our third test of metropolitan growth policies seeks to determine whether the impacts of "established" growth policies differ from newer "innovative" policies. Hamnett and Kellett (2007, p. 279) describe "innovative" policies as extensions of established policies that build upon past lessons in efforts to increase supply:

> "The preliminary review of current metropolitan planning strategies ... suggests that it is premature to judge their likely outcomes but the trend appears increasingly to favour supply based policies, enthusiastically backed up by the development industry, which in its turn is expected to fund the infrastructure required for metropolitan growth."

Table 2. Adoption Strength of Metropolitan Growth Policies in Australia

	Ade-laide	Bris-bane	Mel-bourne	Perth	Syd-ney
Established Policies (EP)					
Activity centres	XX	XXX	XXX	XXX	XXX
Corridor planning	XX	XX	XXX	XXX	XX
Public land agency role	X	O	X	X	XX
Urban consolidation	XX	XX	XX	XX	XXX
Urban growth boundaries	XX	O	XX	O	X
Innovative Policies (IP)					
Development Corporation	O	O	O	O	XX
Expand land supply	O	XX	XXX	O	XX
Fast track planning systems	O	XX	XXX	O	XXX
Infrastructure levies	O	XX	O	O	XXX
New co-ordinating authorities	O	O	XX	O	XXX
Overarching strategic plan	XXX	XXX	O	O	O

O = No policy in place; X = Weak policy; XX = Moderate policy; XXX = Strong policy
Source: Hamnett and Kellett (2007).

So from an empirical perspective, stronger adoption of newer, "innovative" policies should be associated with increases in housing supply. We measure the strength of adoption of both established and innovative metropolitan growth policies in a manner similar to our measurement of *MP*. To accomplish this, we bifurcate *MP* into two separate measures: *EP*, which measures established policies, and *IP*, which measures innovative policies. For example, this gives Melbourne an *EP* score of 11 and an *IP* score of 8. Substituting *EP* and *IP* for MP in equation 2 yields:

$$S_{i,t} = \alpha + \gamma_t + \beta_1 \Delta P_{i,t-1} \ldots \beta_5 \Delta P_{i,t-5} + \beta_6 C_{i,t} + \beta_7 I_{i,t} + \beta_8 pop_{i,87} + \beta_9 EP_{i,t} + \beta_{10} IP_{i,t} + \varepsilon_{i,t} \qquad (3)$$

We estimate all three equations using a semi-log structure by calculating the natural logarithm of both housing approvals and the ratio of price changes. This allows interpretation of the price change coefficients as true elasticities, where a per cent change in housing prices leads to a per cent change in housing approvals. All other variables are included using their original, unlogged values.

3.4 Estimation Procedures

As the data and model structure used in this paper is similar to Mayer and Somerville (2000a and 2000b) and Zabel and Patterson (2006), we adopt similar estimation procedures. We estimate equations (1) to (3) using three separate techniques: Pooled Feasible Generalised Least Squares (PFGLS), Feasible Generalised Least Squares with heteroskedasticity and autoregressive adjusted error terms (FGLS-HAR1), and Feasible Generalised Least Squares with heteroskedasticity and panel-specific autoregressive adjusted error terms (FGLS - HPSAR1).

While fixed effects and random effect models are popular procedures for analysis of panel data, we avoid these estimators for two reasons. First, fixed effects require the explanatory variables be heterogenous over time. Since our models include a time-constant measure of metropolitan growth policies and population, use of the fixed-effects model prohibits estimation of the MP, EP, and IP variables. Second, the random effects procedure is inappropriate when using panel data with relatively few cases and many time periods. As our data contains only five cities over 60 quarters, we follow the recommendations of Wooldridge (2001) and Cameron and Travedi (2009) for long, narrow panel data and employ FGLS estimators.

The FGLS-HAR1 and FGLS-HPSAR1 estimators are preferred because they correct for heteroskedasticity and first-order serial correlation. Heteroskedasticity and autocorrelation can arise when the error terms of panel data are non-constant over space and time, respectively. While presence of heteroskedasticity and autocorrelation does not necessarily bias the coefficient estimates, the standard errors can be skewed. To account for this, we use the FGLS-HAR1 procedure, which uses a heteroskedastic and autoregressive error structure. Furthermore, use of panel data is also susceptible to serial correlation of the error terms within panels (in our case, each capital city). This occurs when error terms from one time period are correlated with future or past time periods but vary in structure for each city. As such, we estimate the FGLS-HPSAR1 specification, which uses heteroskedastic and panel-specific autocorrelation adjustments for each capital city's error term.

4. RESULTS AND DISCUSSION

4.1 Results

Tables 3 to 5 present the regression results. Table 3 contains the results for equation 1, which includes regression of log housing approvals on 5 quarter lags of house price changes, constructions costs, and the current quarter ABS cash rate. Quarterly dummies are suppressed for simplicity of presentation, and are available from the author upon request. Column 1 contains the results from the PFGLS model, column 2 the FGLS-HAR1 model, and column 3 the FGLS-HPSAR1 model.

In the PFGLS model, the first 4 price changes are significant at below the .01 level, and suggest that a one per cent change in housing prices leads to a 5.8 per cent increase in housing approvals over the next 4 quarters. Construction costs and population are insignificant, while the cash rate is significant and negative at below the .10 level and suggests a one point increase in the cash rate decreases new housing approvals by 31 per cent. Estimates from the FGLS-HAR1 model are similar but more robust, with 1 per cent increase in prices exhibiting a 4 per cent increase in approvals. Construction costs, the RBA cash rate, and metropolitan population are all significant at below the .01 level: a one point increase in the construction cost index and cash rate is associated with a 4 per cent and 53 per cent decrease in new approvals, respectively, and a larger population is associated with higher levels of new housing approvals. Results from the FGLS-HPSAR1 specification are almost identical.

Table 3. Housing Approval Regression Results: Equation 1

Estimates	**PFGLS**	**FGLS-HAR1**	**FGLS-HPSAR1**
ln(Δ$Price_{t-1}$)	***1.318***	*0.637*	*0.648*
	(2.64)	*(1.77)*	*(1.80)*
ln(Δ$Price_{t-2}$)	***1.279***	*0.798*	*0.801*
	(2.46)	*(1.90)*	*(1.89)*
ln(Δ$Price_{t-3}$)	***1.158***	**0.902**	**0.956**
	(2.61)	**(2.15)**	**(2.26)**
ln(Δ$Price_{t-4}$)	**2.082**	**0.955**	**0.976**
	(2.22)	**(2.29)**	**(2.32)**
ln(Δ$Price_{t-5}$)	1.965	**0.751**	**0.761**
	(1.54)	**(2.03)**	**(2.07)**
Construction Costs	-0.022	***-0.042***	***-0.043***
	(1.31)	***(7.07)***	***(7.13)***
Cash Rate	*-0.307*	***-0.528***	***-0.544***
	(1.86)	***(7.57)***	***(7.70)***
Population	0.000	***0.000***	***0.000***
	(1.47)	***(6.46)***	***(7.84)***
Observations	285	285	285
Prob > chi^2	0.001	0.000	0.000
AR(1) *Rho*	-	0.869	-

Notes: Dependent variable is the natural log of quarterly housing approvals. Coefficients on quarterly dummies not shown – full results are available upon request from the author; absolute values of z-scores are shown in parentheses below coefficients. Italicized, bold, and bold italicized represent significance at the .10, .05, and .01 levels, respectively.

Table 4. Housing Approval Regression Results: Equation 2

Estimates	**PFGLS**	**FGLS-HAR1**	**FGLS-HPSAR1**
ln(Δ$Price_{t-1}$)	***1.318***	*0.660*	**0.701**
	(2.63)	*(1.92)*	**(2.10)**
ln(Δ$Price_{t-2}$)	**1.278**	**0.843**	**0.765**
	(2.47)	**(2.12)**	**(1.97)**
ln(Δ$Price_{t-3}$)	***1.158***	**0.844**	**0.869**
	(2.62)	**(2.13)**	**(2.25)**
ln(Δ$Price_{t-4}$)	**2.081**	**0.898**	**0.906**
	(2.22)	**(2.27)**	**(2.35)**
ln(Δ$Price_{t-5}$)	1.964	*0.646*	*0.621*
	(1.54)	*(1.84)*	*(1.83)*
Construction Costs	-0.022	***-0.031***	***-0.032***
	(1.30)	***(5.11)***	***(5.30)***
Cash Rate	*-0.307*	***-0.414***	***-0.432***
	(1.85)	***(5.93)***	***(6.18)***
Population	***0.000***	***0.000***	***0.000***
	(3.10)	***(7.84)***	***(7.13)***
Metropolitan Policies (*MP*)	***-0.165***	***-0.158***	***-0.155***
	(3.31)	***(6.17)***	***(5.37)***
Observations	285	285	285
Prob > chi^2	0.001	0.000	0.000
AR(1) *Rho*	-	0.863	-

Notes: Dependent variable is the natural log of quarterly housing approvals. Coefficients on quarterly dummies not shown – full results are available upon request from the author; absolute values of z-scores are shown in parentheses below coefficients. Italicized, bold, and bold italicized represent significance at the .10, .05, and .01 levels, respectively.

Equation 2 includes all variables from equation 1 plus the *MP* variable, which is the measure of metropolitan growth policy adoption strength; see Table 4. In the PFGLS specification, a one per cent change in prices leads to a 5.8 per cent increase in housing approvals over the following 4 quarters. Construction costs are again insignificant, while a one per cent increase in the RBA cash rate significantly decreases new approvals by 30 per cent. Cities with large populations permit significantly more new units than smaller cities. The *MP* variable is significantly negative, which suggests stronger adopters of metropolitan growth policies have less housing approvals than weak adopters. The effect is quite pronounced, as a one point shift in the adoption strength scale decreases new housing approvals by 16 per cent.

Results from the FGLS-HAR1 model are also similar, and suggest a one per cent increase in prices leads to a 3.9 per cent increase in new housing approvals, a one point increase in the construction costs index and cash rate decreases new approvals by 3 per cent and 41 per cent, respectively, and larger cities permit significantly more units than smaller cities. Additionally, a one point increase in *MP* is also associated with a 16 per cent decrease in new approvals. In the FGLS-HPSAR1 specification, the impacts of price changes, construction costs, the cash rate, population, and *MP* are virtually identical to those in the FGLS-HAR1 specification.

Table 5 reports results for equation 3. It includes all variables from equation 1 plus the *EP* and *IP* variables that measure the strength of established policy adoption and innovative policy adoption respectively. In the PFGLS specification, a one per cent increase in prices is associated with a 4.51 per cent increase in new housing approvals. Construction costs are insignificant, while a one point increase in the cash rate decreases new construction by 31 per cent, and larger cities approve significantly more units than smaller cities. Both *EP* and *IP* significantly decrease new housing supply, as a one unit increase in the strength of policy adoption is associated with 23 per cent and 18 per cent fewer housing approvals.

Moving on to the FGLS-HAR1 model, a one per cent increase in prices is associated with a 4 per cent increase in housing approvals. A one point increase in construction costs and the cash rate significantly decrease new housing approvals by 3 per cent and 40 per cent, respectively. As in other specifications, larger cities permit significantly more units than smaller cities. Again, strong adopters of both *EP* and *IP* approve significantly less housing units, as a one unit increase in *EP* or *IP* is associated with 24 per cent and 18 per cent fewer approvals. As with estimation of equations (1) and (2), the FGLS-HPSAR1 specification yields comparable results to the FGLS-HAR1 model.

4.2 Discussion

Overall, the results paint a clearer picture of housing supply elasticities and metropolitan growth policies in Australia than previously available. In contrast to studies by Abelson *et al*. (2005) and Berger-Thompson and Ellis (2004), we find housing supply is indeed elastic. Our estimates suggest supply elasticity in Australia is approximately 3.9 to 5.8 over 5 quarters. While this indicates an elastic housing market, there are few empirical benchmarks to compare these results. Existing estimates of housing supply elasticities using the Mayer-Somerville model are from the US, where supply elasticity is much greater and in the order of 18 per cent for nationally aggregated data, while Mayer and Somerville (2000b) find elasticity to be around 15 per cent for metropolitan areas. The results from our model are more closely aligned to Zabel and Patterson's (2006) estimates for California cities, where a 1 per cent increase in housing prices leads to a 3.1 per cent increase in new housing permits over 8 quarters.

Table 5. Housing Approval Regression Results: Equation 3

Estimates	**PFGLS**	**FGLS-HAR1**	**FGLS-HPSAR1**
ln(Δ$Price_{t-1}$)	**1.322** **(2.56)**	**0.681** **(1.97)**	**0.746** **(2.23)**
ln(Δ$Price_{t-2}$)	**1.281** **(2.42)**	**0.911** **(2.29)**	**0.941** **(2.43)**
ln(Δ$Price_{t-3}$)	***1.158*** ***(2.62)***	**0.857** **(2.16)**	**0.875** **(2.27)**
ln(Δ$Price_{t-4}$)	**2.081** **(2.22)**	**0.907** **(2.29)**	**0.922** **(2.39)**
ln(Δ$Price_{t-5}$)	1.962 (1.54)	*0.648* *(1.84)*	*0.621* *(1.82)*
Construction Costs	-0.022 (1.28)	***-0.027*** ***(4.37)***	***-0.020*** ***(3.16)***
Cash Rate	*-0.306* *(1.82)*	***-0.377*** ***(5.21)***	***-0.305*** ***(4.07)***
Population	***0.000*** ***(3.69)***	***0.000*** ***(7.67)***	***0.000*** ***(8.56)***
Established Policies (*EP*)	**-0.230** **(2.00)**	***-0.248*** ***(4.85)***	***-0.331*** ***(6.59)***
Innovative Policies (*IP*)	***-0.184*** ***(4.21)***	***-0.183*** ***(6.49)***	***-0.214*** ***(6.87)***
Observations	285	285	285
Prob > chi^2	0.001	0.000	0.000
AR(1) *Rho*	-	0.859	-

Notes: Dependent variable is the natural log of quarterly housing approvals. Coefficients on quarterly dummies not shown – full results are available upon request from the author; absolute values of z-scores are shown in parentheses below coefficients. Italicized, bold, and bold italicized represent significance at the .10, .05, and .01 levels, respectively.

Furthermore, interest rates have a rather large impact on new housing approvals. A typical RBA cash rate increase of 0.25 per cent would lead to a 7.5-10.75 per cent decrease in new housing approvals. Note that this effect is in addition to the decrease in housing demand that results from individual mortgage payments increases, which is captured by the price change variables.

Of importance in this paper are the estimated effects of metropolitan growth policies. The results show that a one unit increase in the strength of metropolitan growth policies reduces new supply by approximately 16 per cent. These findings are not dissimilar from Mayer and Somerville's (2000b) estimates of growth management policy adoption in the US, where an additional growth management policy decreases new housing permits by approximately 7 per cent. Furthermore, the impact of metropolitan growth policy adoption seems to be about 30 per cent greater for established growth policies, rather than new innovative policies. Both types of growth policies decrease new housing approvals, with established and innovative policies lowering new supply by 25 per cent and 18 per cent, respectively. While both negative, the greater magnitude effect of established policies does support Hamnett and Kellett's (2007) claim that the newer "innovative" policies were supply oriented. Still, the cumulative impact of such policies is correlated with fewer new housing approvals.

5. CONCLUSION

This paper presents a theoretical and empirical model of housing supply in Australia, and uses quarterly data for the five primary capital cities to estimate supply elasticity and effects of metropolitan growth policies on new housing approvals from 1996-2010. In contrast to other housing supply studies in Australia, the UK, and US, we find that housing supply is indeed elastic, although elasticities in Australia appear to be on the order of 70-80 per cent less than similar studies conducted in the US, and adjustment periods approximately 0-2 quarters longer.

We also find significant effects from strong implementation of metropolitan growth policies. Cumulatively, it appears that stronger adopters of such policies approve less new houses than weaker adopters, controlling for changes in prices, construction costs, interest rates, and population. Furthermore, it appears that the effects are about 30 per cent greater for "established" growth policies, such as urban growth boundaries and urban consolidation, than for newer innovations like land supply monitoring and strategic planning. While these measures of growth policies are rudimentary at best, they are an intriguing first glimpse at the empirical effects of strong land use regulation in Australia.

So what do these results imply about the Australian housing market? Is Australia's recent and substantial rise in housing prices resultant of supply restrictions? While not absolute, our findings indicate that price increases may stem from more than just changes in economic fundamentals. This is supported by the relatively low supply elasticity compared to the US housing market. While Mayer and Somerville (2000b) also find that supply adjusts to price changes after 5 quarters, the magnitude is three to five times the supply response rate in Australia. This could be due to a combination of factors. First, land developers could be restricting supply in monopolistic tendencies to drive up prices. While little empirical evidence exists on the matter, this has been championed as a major justification for the use of public land agencies to improve supply and increase affordability. On the other hand, not all development occurs at the urban fringe, where developers typically land bank. It also occurs on redeveloped land, within urban areas. Rather, supply restrictions could result from local NIMBYist resistance and local council downzoning of existing land. This factor is equally as plausible, as recent metropolitan growth policies have focused on encouraging infill development within existing urban centres. Our results also support the latter possibility, as we find stronger adopters of metropolitan growth policies provide less new housing than weaker adopters. More intensive local backlash could arise in metropolitan areas that encourage infill projects, as is exemplified by the emergence of NIMBY groups like Save our Suburbs in Melbourne.

As with any empirical analysis, there are a number of caveats that arise from the results. First, we judge the supply elasticity estimates to be low compared to the US. This benchmark comes from the only other known country where the Mayer-Somerville model has been applied. Without a third benchmark, it is difficult to determine if supply elasticities in Australia are exceptionally small, or wether elasticities in the US are exceptionally large. Judging by the most recent oversupply of housing in the US, the latter is quite plausible. Second, our measures of metropolitan growth policies are rudimentary at best. The actual unit of measurement – strength, as evaluated by Hamnett and Kellett – has no numerical meaning. Therefore, we cannot confidently estimate the precise magnitude of adopting stronger growth policies, nor are our findings applicable to the impact of specific policies themselves. And third, our analysis is conducted at the metropolitan level, and therefore ignores the heterogeneity of local council planning policies that may be endogenous to the growth process. For instance, stronger adopters of new metropolitan planning innovations may do so in response to a lack of housing supply incurred by restrictive local councils. Since our measure of such policies is time invariant, we could be misattributing the effect to innovative policies when indeed they may simply have been enacted because of existing low housing supply.

In response, we lay out a number of items in need of future research. In order to better evaluate supply elasticities, there needs to be more international research on housing supply using the stock-flow adjustment approach so that better relative comparisons can be made. Second, more detailed analyses of metropolitan growth policies, their goals, and implementation dates is needed so that changes in policy adoption can be used as natural experiments. This way, growth policies can be evaluated over time and space. And last, a comprehensive analysis of local council planning policies and outcomes are needed to properly control for potential endogenous effects of metropolitan policies. Despite these caveats, our results do suggest that low elasticity – whatever their cause – may have played a role in Australia's house price escalation over the past 15 years.

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