

# Supply Elasticity in the Sydney Housing Market\*

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## Abstract

This paper presents estimates of the supply elasticity for residential property in metropolitan Sydney over the period 1991 to 2006. Our results suggest that supply is inelastic – less than unity – for all types of housing; although the supply elasticity is relatively larger for strata properties (apartments and flats) than for non-strata properties (separate and semi-detached houses, terraces and town-houses). We also find evidence of a significant fall in supply elasticity between 1991-1996 and 2001-2006. It appears that housing supply in Sydney has become less elastic over time. When a proxy for the government regulation – the median time taken by a Local Council to decide on a development application – is included in the supply curve, it is found to have a negative effect on the supply of residential property. However split-sample estimates suggest this effect is largely confined to the 1991-96 period.

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## 1 Introduction

How responsive is the supply of new housing in Australia to increases in demand? A relatively common answer to this question is – not very (Richards, 2009; Kennedy, 2010). Richards (2009) argues:

“.....there have been a number of factors on the supply side that have combined to keep the supply of new housing below where it would have been in a more responsive environment. As a result, we have had the combination of higher prices and lower supply than might otherwise have occurred.”

Despite the prevalence of such views about the unresponsiveness of supply, there is an absence of formal empirical evidence on the magnitude of the elasticity of supply for housing in Australia. What evidence that is used to support the view of low supply elasticity tends to be relatively informal. For example, Caplin, Joye, Butt, Glaeser and Kuczynski (2003) report a time-series plot (Figure 83) of smoothed house prices and building approvals for Sydney, which indicates a marked divergence in the trends of these two series from the beginning of the 1990s.

A number of authors have argued that the price of housing in Australia – particularly in urban areas such as Sydney – is artificially high, due in part to government policies that restrict the availability of new land for housing (Caplin, Joye, Butt, Glaeser and Kuczynski, 2003; Moran, 2007). Moran points to State government control of the supply of land for new housing as an important influence on the level of Australian house prices. He claims this is most notably the case in Sydney, which is subject to both the most restrictive planning regime and the highest land costs in Australia.<sup>1</sup> These policies are driven by a desire for urban consolidation; that is to restrict the geographic size of cities by limiting the amount of land on the outskirts that can be used for housing. New housing developments are encouraged within a city’s existing boundaries and in the form of higher density developments. However as Caplin *et al* argue, new high density developments in existing suburbs often face opposition from existing residents and their preferences may be reflected in local government decision-making.

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<sup>1</sup> Not everyone agrees with this view. McNamara (2009) suggests that there is a divergence between the location of land suitable for new construction and where people desire to live. In his view high house prices therefore reflect buyer preferences and a natural (not artificial) scarcity of desirable land for housing.

There is a large literature for the United States (US) on the effect of government regulation on house prices (Katz and Rosen, 1987; Glaeser, Gyourko and Saks, 2005a; 2005b; Brueckner, 2007). In a series of papers, Glaeser and co-authors have argued that US house prices are heavily influenced by local zoning and land-use restrictions, rather than by a shortage of land. Glaeser, Gyourko and Saks (2005b) analyze the large regional and city-wide differences in US house prices, as well as the large differences in the housing supply response across regions and cities. They show that while housing supply is almost perfectly elastic in some regions of the US, it is virtually inelastic in other (particularly coastal) cities. The inelastic housing supply in a number of US cities is found to be due to government regulation and not a scarcity of available land.

Existing empirical studies of Australian house prices have tended to focus on estimating the effects of demand shifters such as income, population or interest rates on the level or growth rate of housing prices (Bourassa and Hendershott, 1995; Bodman and Crosby, 2004; Otto, 2007; Abelson, Joyeux, Milunovich and Chung, 2005). Less attention has been paid to supply-side influences on house prices; although both Bourassa and Hendershott, and Bodman and Crosby include a measure of building costs in their models. In a recent study Fry, Martin and Voukelatos (2010) develop a structural VAR model for the Australian economy, in which they identify housing demand and supply shocks. One interesting finding of this study is that what Fry, Martin and Voukelatos identify as housing supply shocks have very little effect on house prices, which tends to provide some support for the existing emphasis on demand-side variables.

Despite considerable speculation about the nature of housing supply in Australia, there is currently no formal econometric evidence on the supply elasticity. A key object of this paper is to provide some empirical estimates of the elasticity of housing supply. In the remainder of the paper we develop an econometric model for housing supply and provide estimates of the supply elasticity for residential housing in the Sydney housing market.

## **2 Studies on Housing Supply**

In the absence of any estimates of housing supply elasticity for Australia it is useful to consider some of the international evidence on this parameter. Swank, Kakes and Tieman (2002) report estimates of economy-wide elasticities of new housing supply for several countries including: Netherlands (0.3), United Kingdom (0.5), Denmark (0.7), France

(1.1), Germany (2.1), and US (1.4). However given the focus of this study is on housing supply in Sydney, the estimates by Green, Malpezzi and Mayo (2005) and Saiz (2008) for US cities provide a more useful benchmark. Green, Malpezzi and Mayo report estimates of the elasticity of housing supply for forty-five cities (strictly Metropolitan Statistical Areas) in the US. They identify considerable variation across cities, with estimates of the supply elasticity ranging from zero to around 30. Cities with the largest supply elasticities include Dallas, Tampa-St. Petersburg and Phoenix, while those with the most inelastic supply include Miami, Honolulu, New Orleans and San Francisco. In their study Green, Malpezzi and Mayo regress their estimated supply elasticities on a number of explanatory variables, most notably population density and an index of regulation for each city. They find both higher population densities and more stringent regulatory environments are associated with lower supply elasticities.

Broadly similar results are obtained by Saiz (2008) using a more structural econometric approach. Supply elasticities are reported for 95 US cities and range from about 0.6 to 5 – somewhat narrower than that found by Green, Malpezzi and Mayo. Los Angeles, Miami and San Francisco have the lowest elasticities, while Indianapolis, Fort Wayne and Wichita have the highest. Saiz finds that the variation in supply elasticities across cities is well explained by regulatory and physical environment constraints.

A standard approach to studying housing supply is to use a  $q$ -theory framework, which leads to a model of new investment in housing or of the flow of new houses (Poterba, 1984; Topel and Rosen, 1981; Grimes and Aitken, 2006). The approach in this paper differs from most previous studies in that we use the stock of housing as our dependent variable, rather than a measure of the flow of new houses. Our measure of the supply of housing is based on an estimate of the actual number of dwellings in Local Government Areas (LGAs) in metropolitan Sydney. The figures are from the Australian Census and we have observations on a five-yearly basis for the years 1991, 1996, 2001 and 2006. In our view use of the housing stock gets us closer to an estimate of the long-run supply curve for housing and the long-run elasticity of supply. Moreover, the relatively long span between our data observations implies that it is reasonable to ignore the role of dynamics and estimate a purely static model.

One obvious limitation with using the number of dwellings is that we are ignoring any quality changes in the existing stock of houses. As an (extreme) example suppose that between 2001 and 2006 all free-standing houses in Sydney had an additional storey (or level) added. This would tend to raise the price of all houses and increase the supply of housing, if the supply of housing is measured by the number of rooms or by floor areas, but not in terms of the actual number of houses. Intuitively this might tend to bias our estimate of the supply elasticity downwards relative to what would be obtained using data on floor area. While we recognize this potential limitation, we are unable to account for quality changes in the existing stock of housing due to the lack of data on renovations at the LGA level.<sup>2</sup>

### 3 Econometric Framework

#### 3.1 Model

The supply curve for residential housing that forms the basis for the econometric analysis has the following general form;

$$\ln H_{i,t} = \beta_{i,t} \ln P_{i,t} + \text{controls}_{i,t} + \text{regulation}_{i,t} + a_i + u_{i,t} \quad (1)$$

where  $i$  indexes location and  $t$  indexes time.  $H$  measures the stock of residential housing and  $P$  is a measure of the real (or relative) price of housing. The error term for the model  $u_{i,t}$  is assumed to be uncorrelated over time, but may exhibit conditional heteroskedasticity. The variable  $a_i$  represents unobserved effects across geographical locations, which are invariant across time.<sup>3</sup> We view the *controls* as representing variables (other than own price) that would usually enter a housing supply curve and includes the prices of factor inputs used in the production of houses as well as some indicator of productivity in housing construction. In this current study we have no data on such variables so any effects will be included in the error term of the estimated model and may be a source of omitted variable bias.

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<sup>2</sup> Abelson and Chung (2004) estimate that expenditure on alterations and additions equals about 1 per cent of the value of the housing stock in most years.

<sup>3</sup> Ideally the model would also include a time-effect dummy for each census year. However we find that inclusion of the time dummies tends to capture the time-variation in house prices, with the result that we cannot obtain sensible estimates of the supply elasticity. Figure 1 illustrates the basic nature of the problem.

The *regulation* variable can be thought of as capturing the effects of all forms of government regulation on the housing supply curve. For the US indexes of housing supply regulations have been developed for various cities or localities (Gyourko, Saiz, and Summers, 2008). However in this study the basic locality unit is a LGA in Sydney so we require an indicator of regulation that varies across local councils. One variable that is available is a measure of the median time taken by a LGA to determine a development application. Development applications (DAs) are required before any new housing can be built and for any renovation or extension of existing housing. A number of factors are likely to influence differences in median times for determining DAs (over time and across LGAs) including: (i) the efficiency of local councils and their staff; (ii) differences in the preferences of voters across LGAs for new housing developments; (iii) systematic differences in the complexity of housing projects across LGAs; and (iv) the complexity of the planning rules. Whatever the reason, we expect that the marginal effect on the housing stock of an increase in the length of time taken to consider a DA will be negative.

In specifying equation (1) the supply elasticity  $\beta_{i,t}$  is allowed to vary with location and time. There is clearly a limit as to how much heterogeneity we can allow for in  $\beta_{i,t}$ , however we are interested in examining whether the supply elasticity varies across areas of Sydney and also whether it has changed over time. In particular we consider whether housing supply has become less elastic over time in Sydney. If this is the case then one explanation could be the effects of increased government regulation of new housing.

Associated with the above supply curve is an (implicit) demand curve. It is implicit because we do not seek to estimate the demand curve in this study. However since we use instrumental variables to estimate the parameters of (1) it is useful to be explicit about the form of the demand curve. We assume a demand curve of the form;

$$\ln P_{i,t} = \theta_{i,t} \ln H_{i,t} + \delta_Y \ln Y_{i,t} + \delta_P \ln Pop_{i,t} + \delta_R R_t + \delta_r r_t + a_i + v_{i,t} \quad (2)$$

where  $Y$  is real income,  $Pop$  is population,  $R$  is the nominal interest rate (for period  $t$ ) and  $r$  is the real interest rate. The specification for the demand and supply curves implies that there are potentially four instruments that can be used to estimate the supply elasticity  $\beta$ .

The validity of real income, population, real and nominal interest rates as instruments requires these variables to be weakly exogenous, i.e.  $E(\ln Y_{i,t} u_{i,t}) = 0$  etc.

### 3.2 Data

The data series used to estimate the supply curve are for the city of Sydney and are disaggregated to the level of the 43 LGAs that comprise the Sydney Statistical Division. Measures of housing stocks, income and population for each LGA are obtained from Census data for 1991, 1996, 2001 and 2006. Measures of property prices are median values and are obtained from the NSW Department of Housing's *Sales Reports*.

Each census reports data for the number of private dwellings by LGA. Private dwellings are classified into three main categories: separate house; semi-detached, row or terrace house, townhouse; and flat, unit or apartment.<sup>4</sup> The census reports both total dwellings and occupied dwellings. The results we report in this paper are based on the use of total dwellings as a measure housing supply (although there are no important differences in our results if we use occupied dwellings).

The LGAs in Sydney can be grouped into three rings: Inner, Middle and Outer.<sup>5</sup> In Table 1 we report some data on the number of and the growth rate of dwellings in each of the three rings. The data indicate that in 2006 there were about 1.6 million residential properties in Sydney. Over the period from 1991-2006 the total stock of properties increased by about 27 percent. One feature of the statistics in Table 1 is the relatively stronger growth in strata properties than in non-strata properties. This is evident across all three regions of Sydney, although the relative strength it is most striking in the Inner and Middle Rings. Across the entire Sydney region, what we classify as non-strata residences, comprise about 73 percent of the total housing stock in 2006. This figure has declined from 77 percent in 1991. The proportions of strata and non-strata properties differ across areas of Sydney – strata properties account for about 57 percent of the housing stock in the Inner Ring, but only about 12 percent in the Outer Ring.

Data for property prices is available on a quarterly basis, with the earliest observations being for the March quarter 1991. For each LGA the *Sales Reports* records median sales prices by housing title – strata and non-strata – and also for total sales. In

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<sup>4</sup> There are two additional categories – other dwellings and dwelling not stated – that are small and therefore excluded from our analysis.

<sup>5</sup> The LGAs in each ring are listed in Table 1A of the Appendix.

matching-up the housing quantity and price data, we assume that flats, units and apartments have strata titles and then treat the census classifications of separate houses, semi-detached, row or terrace houses and townhouses as non-strata titles. Finally to get a price observation that corresponds to each of the census years we average the quarterly price observations for the calendar year 1991 and then for the financial years 1995-96, 2000-01 and 2005-06. As an example of our data, Table 2 presents price and quantity data for the LGA of Randwick.

The other variables used in the empirical analysis are income, population, the nominal interest rate, the real interest rate and the consumer price index (CPI) for Sydney.<sup>6</sup> Both income and population are obtained from the Census; with income is measured as median family weekly income for each LGA, while population for each LGA is measured as total persons less overseas visitors. The nominal interest rate is the 10-year Australian government bond rate, while the real rate is that on the 10-year Australian government indexed bond. As with property prices we average the quarterly interest rate observations for the calendar year 1991 and then for the financial years 1995-96, 2000-01 and 2005-06. Measures of median property prices and the income variable are deflated by the CPI for the relevant period to obtain real values.

#### **4 Empirical Results**

Initially we estimate a baseline version of equation (1) with price as the only explanatory variable. Given the relative simplicity of this model a scatter-plot can be used to provide some intuition about how estimates of the supply elasticity are obtained from the data. Figure 1 presents a scatter-plot of the data observations on the stock of residential properties and median prices for three LGAs; Ashfield, Auburn and Baulkham Hills. For consistency with equation (1) we measure the logarithm of  $H$  on the vertical axis and the logarithm of  $P$  on the horizontal axis. An ordinary least squares (OLS) regression line is reported for each LGA. The slope of this line is an estimate of the supply elasticity for each LGA<sup>7</sup>. When data for all 43 LGAs is used to estimate (1); the inclusion of LGA-specific fixed-effect  $a_i$  means that the intercept term of the supply curve

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<sup>6</sup> All data series used in this study can be found at <http://members.optusnet.com.au/~g.otto/>.

<sup>7</sup> Since estimation of (1) uses instrumental variables rather than OLS the intuition provided by Figure 1 is only approximately correct. However in principle the actual values of  $\ln P$  could be replaced by the fitted values from a regression of  $\ln P$  on some instruments.

is allowed to vary by LGA, while the estimator of  $\beta$  will tend to average over the individual supply elasticities for each LGA. The scatter-plot indicates why we are unable to include time-effect dummies in the model since they will tend to capture the positive trend in  $\ln H$  and  $\ln P$ , and that is essentially what is used to estimate the supply elasticity.

#### 4.1 Reduced-Form Model for Property Prices

Equations (1) and the (2) can be solved to obtain reduced-form equations for  $\ln P$  and  $\ln H$ . In the absence of any exogenous variables entering the supply curve, we can write the reduced-form equation for property prices as,

$$\ln P_{i,t} = \pi_Y \ln Y_{i,t} + \pi_P \ln Pop_{i,t} + \pi_R R_t + \pi_r r_t + \tilde{a}_i + e_{i,t} \quad (3)$$

where the parameters in (3) measure the effect of each of the exogenous variables on the logarithm of property prices. Table 3 reports estimates of (3) obtained using data for all residential properties and also for data on strata and non-strata properties separately. The results indicate that Sydney property prices are positively related to real income, negatively related to the real interest rate and positively related to the nominal interest rate.<sup>8</sup> The elasticity of property prices with respect to real income is in the range 0.20 to 0.30. The reduced-form estimates imply that the real interest rate has a relatively large marginal effect on Sydney property prices. Over a five year interval, a 100 basis point fall in the real interest rate is associated with about a 20 percent rise in real property prices. A somewhat surprising result from the reduced-form estimates is the absence of a significant effect of population on the level of house prices in Sydney.<sup>9</sup>

#### 4.2 Estimates of the Supply Curve for Residential Property

We report estimates of the baseline housing supply curve in Table 4, obtained using both a fixed-effects estimator (based on dummy variables) and a first-difference estimator. In both cases estimates of the supply elasticity are obtained using an appropriate instrumental variable (IV) procedure.<sup>10</sup>

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<sup>8</sup> Note that  $R = r + \pi^e$ , so from the estimates in Table 3 we have two effects from the real interest rate  $-\hat{\pi}_r r$  and  $\hat{\pi}_R (r + \pi^e)$ . Collecting terms gives  $-(\hat{\pi}_r - \hat{\pi}_R)r$  and  $\hat{\pi}_R \pi^e$ , where the latter term allows for a separate effect on property prices from expected inflation (other than just through the real interest rate).

<sup>9</sup> This conclusion is not changed by excluding income from the model, which suggests the result is not due to multi-collinearity.

<sup>10</sup> In the case of the first-difference model all of the instruments are differenced.

It is evident from Table 4 that the differences in the elasticity estimates obtained from the fixed-effects (FE) and the first-difference (FD) procedures are relatively small and not of any real economic importance. The largest difference is for strata properties, where the FE estimate is 0.64 and the FD estimate is 0.57.

If we focus on the results for the FE procedure, the supply elasticity for all residential property is estimated to be about 0.36 for the period 1991-2006. When the data are disaggregated into strata and non-strata categories, we find unsurprisingly, that the supply of strata properties is more responsive to price than non-strata properties. The estimated supply elasticity for strata properties (0.64) is over three times larger than for non-strata properties (0.19). A similar result is obtained from the FD estimator.

The estimates in Table 4 point to a relatively inelastic supply response for residential property in Sydney. Comparing our estimates for Sydney with those reported by Green, Malpezzi and Mayo (2005) for US cities; indicates that Sydney would fall in a group of only six US cities that have supply elasticities less than unity.<sup>11</sup>

What do we make of these findings? Are they credible? The specification of the supply curve is certainly very simple, with price the only stochastic variable. So we might have good reason to be concerned that estimates are biased due to model misspecification. From a purely statistical perspective it is the case that the over-identifying restrictions imposed in estimating the model are rejected by the J-test (Hansen, 1982). However there are two observations that might allow us to down-play these results. In calculating the J-statistics we have allowed for heteroskedasticity but not for serial correlation. If we compute the J-statistics using a heteroskedasticity and serial correlation robust procedure they tend to have larger p-values and hence provide less evidence against the model. Secondly the large values of the IQ statistics suggest that instrument quality is very good, i.e. our instruments are very good predictors of property prices. In fact, one might wonder whether the results would differ if we didn't instrument property prices. Table 5 reports the supply elasticities for the FE and FD models using property prices as its own instrument. These OLS estimates are smaller than the IV ones, although the differences are relatively minor for non-strata properties, they are somewhat larger for strata properties (e.g. 0.41 versus 0.57 for the FD model).

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<sup>11</sup> The six cities are Miami, Honolulu, New Orleans, San Francisco, San Jose and Toledo.

One reason why our results are hard to evaluate is that economic theory does not place very tight restrictions on the magnitude of the supply elasticity. Any value in the range zero to infinity is theoretically plausible. However one way to increase the degree of confidence in our results from the model is to see if it produces reasonable results, in circumstances where we have stronger prior expectations about the value of the supply elasticity. If we disaggregate our data by geographic location, then we expect the supply elasticity for housing to be higher in LGAs that are located further away from the centre of Sydney. This expectation is based on the idea that as we move away from the centre, the population and housing density of LGAs will fall and land for new housing should become relatively more abundant.

#### *4.3 Differences across LGAs*

The 43 LGAs in Sydney are geographically classified into three groups – Inner Ring (11 LGAs), Middle Ring (15 LGAs) and Outer Ring (17 LGAs). Table 6 reports supply elasticity estimates for each group, by various property type. The pattern of the estimates seems intuitively plausible. In general the estimates of the supply elasticity are larger as we move from the centre of Sydney towards its outskirts.

Looking at all types of property, the Inner Ring has a supply elasticity of 0.26 (0.24 for the FD estimator), compared with an estimate of 0.43 (or FD estimate of 0.35) for the Outer Ring. As might be expected the supply curve for non-strata properties is very inelastic in the Inner Ring (and also apparently for the Middle Ring), but considerably more elastic in the Outer Ring. The one somewhat surprising finding from this analysis by areas is that the highest elasticity for strata property is for the Middle Ring, rather than for the Outer Ring.

Since the estimates of the supply elasticity reported in Table 6 are generally consistent with our prior expectations we turn to the issue of whether there has been a change in the housing supply elasticity over time.

#### *4.4 Has Housing Supply in Sydney Become Less Elastic?*

House prices in Sydney were flat (in nominal terms) in the first half of the 1990s and then began to rise after about 1996. The extent to which housing supply considerations were responsible for this rise is an open question. However one piece of evidence may be obtained by testing if there is any evidence of a structural change in the supply curve. In

particular what we are interested in examining is whether the housing supply curve has become more inelastic in the period 2001-2006 than it was in the period 1991-1996. To undertake a formal tests of whether there has a been a change in the supply elasticity we use the fixed-effects model and allow the fixed-effects (as well as the supply elasticity) to differ across time periods;

$$\ln H_{i,t}^s = \beta \ln P_{i,t} + \beta_{0106}(\ln P_{i,t} \times D_{0106}) + a_i + a_i \times D_{0106} + v_{it} \quad (4)$$

where  $D_{0106}$  is a dummy variable that is zero for the years 1991 and 1996 and one for the years 2001 and 2006. Our specific interest is in whether there is a statistically significant change in the supply elasticity and whether  $\beta_{0106} < 0$ .

Estimates of the above model for strata, non-strata and all property types are reported in Table 7. For all three cases the estimate of  $\beta_{0106}$  is negative and statistically significant. These results provide some evidence of a significant fall in the elasticity of housing supply in Sydney between 1991-96 and 2001-06. Table 8 reports the actual estimates of the supply elasticity for both of these periods. For strata property there is a marked decline in the supply elasticity estimate from 2.56 to 0.61. Although some caution needs to given to the estimate for the 1991-96 period as it has a relatively large standard error (compared to the other estimates). For non-strata properties the estimated elasticity declines from 0.31 to 0.18. A similar pattern is observed for all property. One feature that is evident from Table 8 is that the supply elasticity estimates for each type of property that are obtained for the full sample (1991-2006) are very similar to those obtained in the later sample (2001-2006). It would appear that much of the information for the full sample estimates is coming from the second half of the data sample.

The estimates in Tables 7 and 8 suggest is that at least part of the explanation for the increase in Sydney housing prices between 1991-96 and 2001-06 is attributable to a reduction in the elasticity of the supply curve for housing. What caused this decline? One possibility is that it reflects the impact of an increase in government regulation.

## **5. Effects of Government Regulation on Supply**

In this section we attempt to provide some evidence on whether government zoning regulations and restrictions have had any effect on the supply curve for housing. A key difficulty is in finding a sensible measure of government regulations. Work has been

done in the US to develop indexes (Gyourko, Saiz and Summers, 2008) but not for Australia. One possible proxy for restrictions on housing supply that is available on an annual basis at the LGA level is median time for determining Development Applications (DAs). These data are published by the NSW Department of Local Government on a financial year basis from 1994-95 to 2005-06. Table 9 shows figures for the LGA of Randwick.

We use the figures for the years 95-96, 01-02 and 05-06 as corresponding to the census data for 1996, 2001 and 2006. Since we do not have data for 90-91, the best we can do for the 1991 census year is to use data for 94-95. We estimate the following FE model by IV,

$$\ln H_{i,t}^s = \beta \ln P_{i,t} + \gamma \ln DA_{i,t} + a_i + v_{it} \quad (5)$$

where  $DA$  is treated as an exogenous variable and is measured in weeks. Estimates of equation (5) are reported in Table 10. It is evident that an increase in the number weeks required for  $DA$  determination has a statistically significant negative effect on housing supply. The estimate of  $\gamma$  for strata properties indicates an elasticity of about -0.1, while for non-strata properties the elasticity is -0.07. It is also notable that the inclusion of  $DA$  in the model produces relatively little change in the estimates of the supply elasticities. In all cases there is a slight fall in the size of the supply elasticity.

While it is evident that an increase in the time required for determining a  $DA$  has a negative effect on housing supply, it is useful to examine the magnitude of the effect in terms of actual properties forgone. In 2006 the median  $DA$  response time for Randwick was 33.5 days (or 4.78 weeks). A 10 percent increase in this time to 5.36 weeks is estimated to reduce the supply of strata properties by 1.04 percent. Using the 2006 figure for the number of strata properties in Randwick of 28,008, this amounts to a fall of 289 properties. While this may seem like a modest figure, it is worth noting that between 2001 and 2006 the increase in the number of strata properties in Randwick was only 1,150.

Finally it is interesting to see if the effects from  $DA$  have changed over time. While data limitations make formal structural change tests unreliable, Table 11 reports estimates of equation (5) for the two sample periods 1991-96 and 2001-06. The results suggest that the effects of the  $DA$  variable are only in evidence during the 1991-96 period and that there is no significant effect of  $DA$  on the supply curve in the period 2001-06. It appears

that the DA process has ceased to be an important disincentive to the supply of residential properties in the period 2001-06. An explanation for this result is that in that over the latter period, local councils became more efficient at processing development applications. Some support for this view is provided in Figure 2, which shows the change in the DA variable between 1991-96 and 2001-06. For most LGAs, the median response time to process a DA has fallen – in some cases by a number of weeks.

The results in Table 11 also indicate evidence of a decline in supply elasticity between 1991-96 and 2001-06, even after some attempt has been made to control for the effects of government regulation.

## **6. Conclusions**

The results in this paper indicate that the aggregate housing supply curve for Sydney is relatively inelastic. Estimates of the supply elasticity for housing in Sydney are similar to those obtained for coastal US cities like Miami, Honolulu, New Orleans and San Francisco. There are some differences in supply elasticity with the type of housing and with locations across Sydney. Across Sydney as a whole, the supply of strata properties is about three times more elastic than non-strata properties. Other things equal, this suggests that demand driven increases in property prices are likely to continue changing the mix of housing within Sydney, towards a more flats and apartments. Looking at supply elasticity across various areas of Sydney we find that housing supply is more elastic towards the outer regions of Sydney.

When we compare estimates for the periods 1991-96 and 2001-2006 we find relatively strong evidence that the elasticity of housing supply has declined over time. The decline in supply elasticity arises even when we include a proxy for government regulation – time taken to decide on a development application – in the supply curve. In fact our results suggest that the negative effect of government regulations on the supply curve only arises in the 1991-96 period. Of course it is possible that our proxy does a poor job at capturing the types of government policies that are widely seen to restrict housing supply. Alternatively perhaps there are other factors that made housing supply in Sydney less responsive to price over time.

What are the limitations of the study? We have a modest sample size, particularly when we seek to disaggregate by areas of Sydney or look at changes over time. In

addition the specification of the supply curve is relatively simple. One extension to our work that could potentially address both of these issues is to include data for LGAs outside of Sydney. This would increase the number of cross-section units in the study and also allow for additional variables to enter the supply curve.

**Table 1: Growth in the Number of Dwellings in the Inner, Middle and Outer Rings**

<b>Inner Ring</b>			
	<b>Strata</b>	<b>Non-Strata</b>	<b>Total</b>
1991	135,713	134,069	269,782
1996	146,878 (8.2)	134,141 (0.1)	281,019 (4.2)
2001	174,443 (18.8)	138,371 (3.2)	312,814 (11.3)
2006	194,356 (11.4)	145,488 (5.1)	339,844 (8.6)
<b>Middle Ring</b>			
	<b>Strata</b>	<b>Non-Strata</b>	<b>Total</b>
1991	93,405	291,111	384,516
1996	102,473 (9.7)	292,661 (0.5)	395,134 (2.8)
2001	120,375 (17.5)	304,309 (4.0)	424,684 (7.5)
2006	139,576 (16.0)	313,367 (3.0)	452,943 (6.7)
<b>Outer Ring</b>			
	<b>Strata</b>	<b>Non-Strata</b>	<b>Total</b>
1991	64,077	565,527	629,604
1996	74,259 (15.9)	622,825 (10.1)	697,084 (10.7)
2001	85,896 (15.7)	694,314 (11.5)	780,210 (11.9)
2006	99,150 (15.4)	738,045 (6.3)	837,195 (7.3)
<b>Sydney</b>			
	<b>Strata</b>	<b>Non-Strata</b>	<b>Total</b>
1991	293,196	990,706	1,283,902
1996	323,610 (10.4)	1,049,627 (5.9)	1,373,237 (7.0)
2001	380,714 (17.6)	1,136,994 (8.3)	1,517,708 (10.5)
2006	433,082 (13.8)	1,196,900 (5.3)	1,629,982 (7.4)
<b>Percentage Growth (1991-06)</b>			
Inner	43.21	8.52	25.97
Middle	49.43	7.65	17.80
Outer	54.74	30.51	32.97
Sydney	47.71	20.81	26.96

Notes: Numbers in brackets are percentage growth rates.

**Table 2: Number of Dwellings and Median Sales Prices for Randwick**

	1991	1996	2001	2006
<i>Occupied Dwellings</i>				
Strata	21,716	23,219	24,737	25,533
Non-Strata	21,080	21,359	22,025	23,028
<i>Total Dwellings</i>				
Strata	23,486	24,946	26,938	28,088
Non-Strata	22,252	22,376	23,237	24,498
<i>Median Prices (\$000)</i>				
Strata	166.2	213.5	333.1	450.0
Non-Strata	243.2	342.5	606.0	885.9

Notes: Median prices for 1991 are the averages of quarterly price observations for the calendar year 1991, while 1996, 2001 and 2006 correspond to the average of quarterly price observations for the financial years 1995-96, 2000-01 and 2005-06.

**Table 3: Estimates of Reduced-Form Model for Property Prices**

	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\ln P_{i,t} = \pi_Y \ln Y_{i,t} + \pi_P \ln Pop_{i,t} + \pi_R R_t + \pi_r r_t + \tilde{a}_i + e_{i,t}$			
$\pi_Y$	0.243 (2.25)	0.305 (3.41)	0.198 (1.85)
$\pi_P$	-0.076 (-0.62)	-0.144 (-1.43)	0.021 (0.16)
$\pi_R$	0.041 (3.01)	0.040 (3.98)	0.042 (3.37)
$\pi_r$	-0.240 (-9.57)	-0.299 (-18.01)	-0.249 (-10.20)
Fixed Effects ( $\tilde{a}_i$ )	yes	yes	yes
Joint Sig. (p-value)	0.00	0.00	0.00
$\bar{R}^2$	0.925	0.976	0.943
DW	2.41	1.96	2.32

Notes: The numbers in brackets are heteroskedasticity-robust t-statistics (White, 1980).

**Table 4: IV Estimates of the Supply Curve for Residential Property**

$\ln H_{i,t}^s = \beta \ln P_{i,t} + a_i + v_{it}$			
	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\beta_{FE}$	0.643 (0.06)	0.191 (0.02)	0.362 (0.03)
Fixed Effects ( $a_i$ )	yes	yes	yes
Joint Sig (p-value)	0.00	0.00	0.00
<i>DW</i>	1.91	1.81	1.70
<i>J</i> (p-value)	0.00(3)	0.03(3)	0.00(3)
<i>IQ</i> (F-stat)	203.7	611.4	248.3

$\Delta \ln H_{i,t}^s = \beta \Delta \ln P_{i,t} + \Delta v_{it}$			
	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\beta_{FD}$	0.566 (0.07)	0.182 (0.02)	0.329 (0.03)
<i>DW</i>	1.69	0.96	1.46
<i>J</i> (p-value)	0.01(3)	0.05(3)	0.01(3)
<i>IQ</i> (F-stat)	70.4	272.3	106.6

Notes: Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980). *J* is the p-value for Hansen's (1982) test statistic for over-identification. *IQ* is the F-statistic for the slope coefficients of the reduced-form regression of the explanatory variable on the instruments. From Stock and Yogo (2002), Table 1, the 5 percent critical value for the null of weak instruments is 11.12.

**Table 5: OLS Estimates of Supply Elasticity**

	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\beta_{FE}$	0.533 (0.05)	0.180 (0.02)	0.324 (0.03)
$\beta_{FD}$	0.407 (0.05)	0.161 (0.02)	0.261 (0.02)

Notes: The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980).

**Table 6: Supply Elasticity in Different Areas of Sydney**

<i>Region</i>	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
<b>Inner Ring</b>			
<i>Fixed Effect</i>	0.35 (0.05)	0.08 (0.01)	0.26 (0.04)
<i>First-Difference</i>	0.35 (0.08)	0.08 (0.01)	0.24 (0.05)
<b>Middle Ring</b>			
<i>Fixed Effect</i>	0.84 (0.09)	0.10 (0.01)	0.31 (0.03)
<i>First-Difference</i>	0.83 (0.09)	0.10 (0.01)	0.30 (0.04)
<b>Outer Ring</b>			
<i>Fixed Effect</i>	0.66 (0.12)	0.38 (0.04)	0.43 (0.04)
<i>First-Difference</i>	0.48 (0.14)	0.32 (0.04)	0.35 (0.04)

Notes: Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980).

**Table 7: Structural Change in the Supply Curve**

$$\ln H_{i,t}^s = \beta \ln P_{i,t} + \beta_{0106} (\ln P_{i,t} \times D_{0106}) + a_i + a_i \times D_{0106} + v_{it}$$

	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\beta$	2.912 (1.10)	0.330 (0.08)	1.637 (0.46)
$\beta_{0106}$	-2.316 (1.11)	-0.152 (0.08)	-1.323 (0.47)
<i>DW</i>	3.02	3.17	2.96
<i>J</i> (p-value)	0.00(2)	0.01(2)	0.00(2)

Notes: Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980). *J* is the p-value for Hansen's (1982) test statistic for over-identification.  $D_{0106}$  is a dummy variable that is zero in 1991 and 1996 and one in 2001 and 2006.

**Table 8: Supply Elasticity in Different Periods**

<i>Period</i>	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
1991-96	2.56 (0.96)	0.31 (0.07)	1.60 (0.43)
2001-06	0.61 (0.10)	0.18 (0.01)	0.32 (0.03)
1991-06	0.64 (0.06)	0.19 (0.02)	0.36 (0.03)

Notes: Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980).

**Table 9: Median Response Time of Randwick Council to Development Applications**

	1994-95	1995-96	2000-01	2005-06
Days	92	103	53	33.5

**Table 10: Effect of Median Time to Respond to a Development Application**

$\ln H_{i,t}^s = \beta \ln P_{i,t} + \gamma \ln DA_{i,t} + a_i + v_{it}$			
	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
$\beta$	0.593 (0.06)	0.167 (0.02)	0.334 (0.02)
$\gamma$	-0.104 (0.04)	-0.070 (0.02)	-0.059 (0.02)
Fixed Effects ( $a_i$ )	yes	yes	yes
Joint Sig. (p-value)	0.00	0.00	0.00
<i>DW</i>	1.95	1.83	1.76
<i>J</i> (p-value)	0.00(3)	0.04(3)	0.00(3)
<i>IQ</i> (F-stat)	257.9	930.8	239.8

Notes: Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980). *J* is the p-value for Hansen's (1982) test statistic for over-identification. *DA* is measured in weeks.

**Table 11: Estimates of Supply Curve Parameters for Different Periods**

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$$\ln H_{i,t}^s = \beta \ln P_{i,t} + \gamma \ln DA_{i,t} + a_i + v_{it}$$

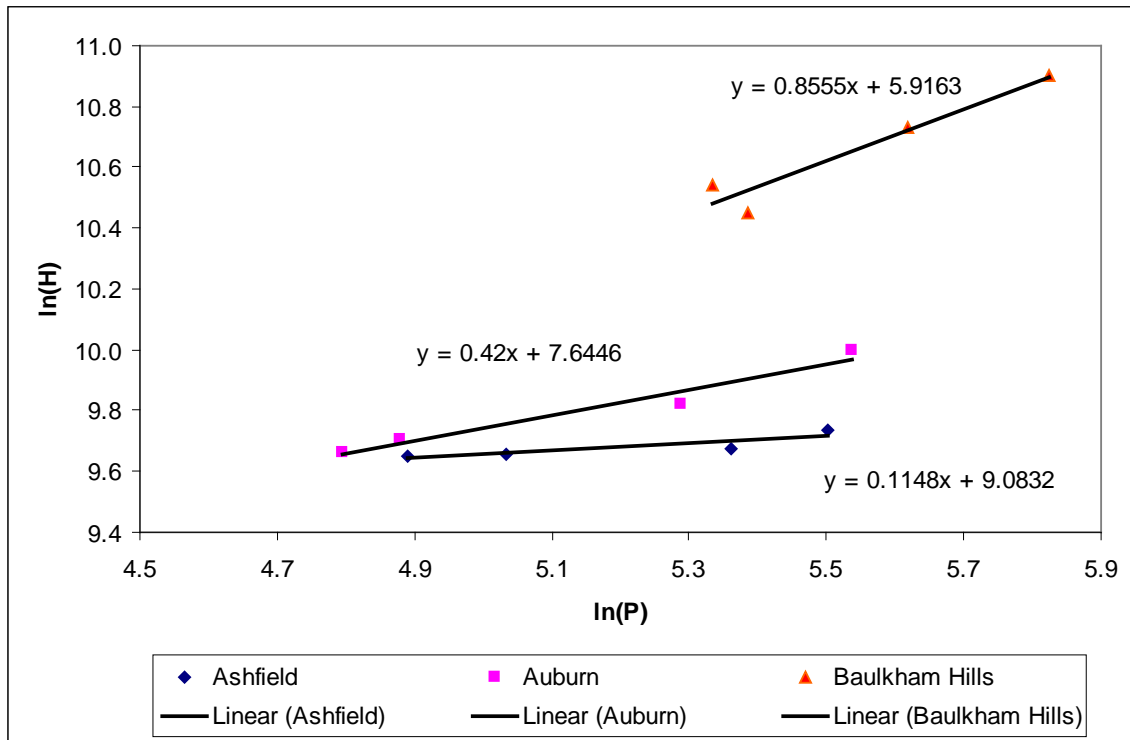
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<i>Period</i>	<i>Strata</i>	<i>Non-Strata</i>	<i>All Property</i>
1991-96			
$\beta$	2.36 (1.21)	0.39 (0.09)	3.05 (1.21)
$\gamma$	-0.22 (0.19)	-0.12 (0.04)	-0.71 (0.36)
2001-06			
$\beta$	0.61 (0.10)	0.17 (0.01)	0.31 (0.03)
$\gamma$	0.00 (0.05)	-0.02 (0.01)	-0.01 (0.02)

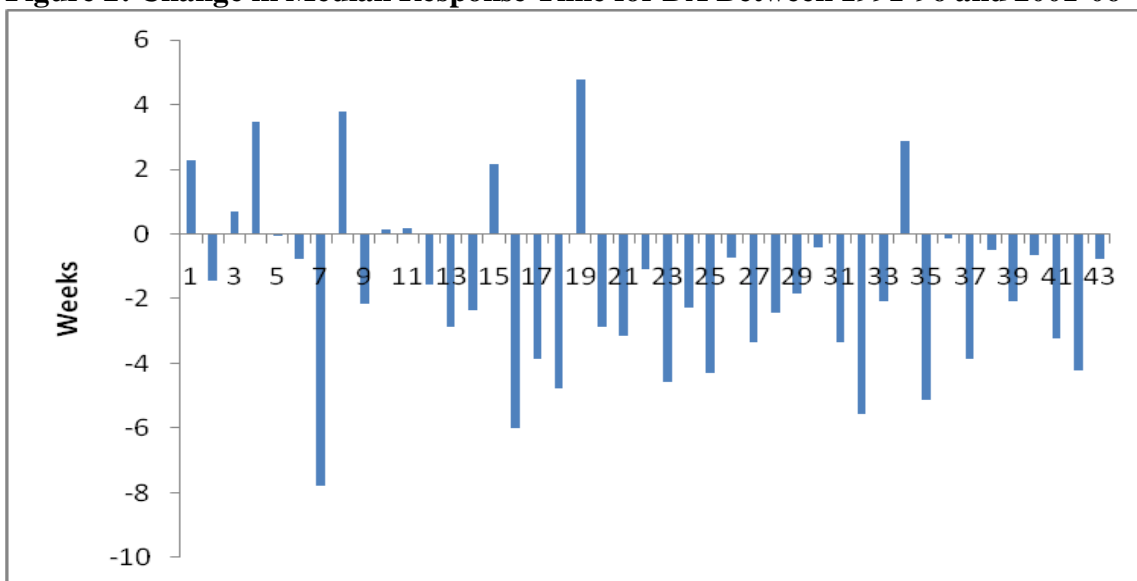
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Notes: : Instruments used for property prices are income, population, the nominal 10 year bond rate and the real 10 year bond rate. The numbers in brackets are heteroskedasticity-robust standard errors (White, 1980). *DA* is measured in weeks.

**Figure 1: Scatter-Plot of Price and Quantity Data for Selected LGAs**



**Figure 2: Change in Median Response Time for DA Between 1991-96 and 2001-06**



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**Table 1A: Sydney Local Government Areas**

<b>Inner Ring (11)</b>	<b>Middle Ring (15)</b>	<b>Outer Ring (17)</b>
Ashfield	Auburn	Baulkham Hills
Botany	Bankstown	Blacktown
Lane Cove	Burwood	Blue Mountains
Leichhardt	Canterbury	Camden
Marrickville	Canada Bay	Campbelltown
Mosman	Hunters Hill	Fairfield
North Sydney	Hurstville	Gosford
Randwick	Kogarah	Hawkesbury
Sydney	Ku-ring-gai	Holroyd
Waverley	Manly	Hornsby
Woollahra	Parramatta	Liverpool
	Rockdale	Penrith
	Ryde	Pittwater
	Strathfield	Sutherland
	Willoughby	Warringah
		Wollondilly
		Wyong