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# The Growth of House Prices in Australian Capital Cities: What Do Economic Fundamentals Explain?

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**Abstract**

*This paper examines the ability of standard economic factors to explain the growth of real house prices in Australia's capital cities. Dynamic models are estimated for each city with the objective of identifying the major drivers of house price growth rates. The variable mortgage rate is found to be an important influence on growth rates in all eight capital cities. However, the size of the mortgage rate effect can differ substantially between cities. For example a 25 basis point rise in the mortgage rate reduces the long-run quarterly growth rate of real house prices by about 1 per cent in Sydney compared with only 0.4 per cent in Adelaide. The effects of other economic variables are less systematic, significantly affecting the growth rate of capital gains in some cities but not in others. Nevertheless, for most Australian cities economic factors are found to explain around 40 to 60 per cent of the variation in the growth rate of house prices.*

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## 1. Introduction

Over the last 20 years the growth rate of residential property prices in Australia has displayed considerable variation. House prices in many regions of the country exhibited high real growth rates in the late 1980s and then again in the period from 2001 to 2004. At the same time important regional differences in the performance of property markets have occurred, for example Adelaide, Hobart and Darwin showed little evidence of a boom in prices in the late 1980s. Despite a high level of interest in the behaviour of property markets, there appears to be no general consensus about what factors are the main causes of fluctuations in residential property prices. Many potential influences on house prices have been proposed including: the role of interest rates; demographic factors such as population growth; real income growth; constraints on the supply of new housing due to government regulations; and the performance of the stock market. However, it remains unclear as to which of these variables (if any) are quantitatively important influences on property prices.

A number of commentators have suggested that periods of rapid price rises in parts of the Australian housing market are indicative of speculative bubbles (*Economist* 2003; Gittins 2003a, 2003b). Some support for this claim is provided by Bodman and Crosby (2004) who estimate that house prices in Sydney and Brisbane exceeded their fundamental values by about 20–25 per cent in 2002 and 2003 respectively. However, as Flood and Hodrick (1990) note, there are considerable econometric difficulties with testing for the existence of speculative bubbles. Rather than trying to test for the existence of bubbles, this paper adopts the somewhat less ambitious aim of examining the degree to which the behaviour of Australian house prices can be explained by economic fundamentals. To the extent that economic fundamentals do provide a good explanation for house prices, this would seem to limit the role for speculative bubbles as an important feature of Australian property markets.

For many Australian households, housing equity remains an important asset and in aggregate it represents around 60 per cent of net household wealth. Large capital gains (or losses) on houses can lead to correspondingly large fluctuations in household wealth and this has the potential to influence private consumption expenditure and the level of aggregate demand (Dvornak and Kohler 2003; Fisher, Otto and Voss 2006). In various statements, the Reserve Bank of Australia (RBA) has expressed concerns about the effect that rapidly rising property prices may have on household borrowing and expenditures. More generally there has been considerable debate about whether or not central banks should use monetary policy to try to influence the path of asset prices (Richards and Robinson 2003). However, an even more fundamental issue concerns the effect that changes in monetary policy actually have on asset prices or returns. One contribution of this paper is to provide some estimates of the response of the growth rate of house prices to changes in the mortgage rate. Given the close link between variable mortgage rates in Australia and the cash rate these results also provide quantitative evidence on the RBA's ability to influence residential property markets.

There is a small literature on modelling the behaviour of house prices in Australia. In recent papers Abelson et al. (2005) and Oster (2005) develop models for the economy-wide level of house prices. Because they consider the level of house prices, both studies need to account for the presence of stochastic trends in the data and employ cointegration techniques to estimate error correction models. In contrast Abelson (1994), Bourassa and Hendershott (1995), Bewley, Dvornak and Livera (2004) and Bodman and Crosby (2004) model the growth rate (rather than the level) of house prices, thus avoiding some of the problems associated with non-stationary data.[1] These studies also employ more disaggregated data by using house price series for state and territory capital cities.

This paper follows the approach of the latter studies and models the growth rates of house prices in Australia's capital cities. One advantage of developing city-specific models is that it is possible to examine regional differences in the determinants of house prices. Over the period 1986 to 2005 real annual house price growth across Australian capital cities averaged about 4 per cent. However, there is considerable regional variation, with annual growth of 5 per cent in Sydney and 1.3 per cent in Hobart. Such differences seem to be an important feature of the Australian housing market and can have implications for both regional differences in wealth and for interstate mobility (Oswald 1997).

This paper has the following structure. In Section 2 an equilibrium condition for the user cost of housing and rents is used to develop an econometric model for the growth rate of house prices (Himmelberg, Mayer and Sinai 2005). Section 3 contains a description and preliminary analysis of the data on house prices. Empirical results are presented in Section 4 and Section 5 concludes.

## 2. Econometric Model

The user cost of housing provides a useful theoretical framework for identifying some of the main influences on house prices (Hendershott and Slemrod 1983; Poterba 1984; Himmelberg, Mayer and Sinai 2005). Following the last, consider the equilibrium condition,

$$R_t^h = P_t^h u_t \tag{1}$$

where $R_t^h$ is rent per period, $P_t^h$ is the price of a house and $u_t$ is the user cost of owner-occupied housing. Equation (1) is a no-arbitrage condition requiring the cost per period of owning a house $P_t^h u_t$ equal the cost of renting. The user cost of housing $u_t$ depends on a number of factors including: the real interest rate; property tax rates; subsidies to housing; the cost of maintenance or depreciation; expected capital gains; and any risk premium associated with owning rather than renting. In this paper I only focus on two of these factors, the real interest rate and expected capital gains to housing. This choice reflects the unavailability of time series data on the other variables and implicitly assumes they are constant over time.

Equation (1) can be re-arranged so that the price-to-rent ratio equals the inverse of the user cost of housing,

$$\frac{P_t^h}{R_t^h} = \frac{1}{u\left(r_t, E_t \Delta \log P_{t+1}^h\right)} \tag{2}$$

where I have written $u_t$ as a function of the real interest rate $r_t$ and expected capital gains on housing $E_t \Delta \log P_{t+1}^h$. The user cost of housing is increasing in the real interest rate and decreasing in expected capital gains. Given the relatively high transactions costs associated with switching between owner-occupied housing and rental accommodation equation (2) is unlikely to hold on a period by period basis. Nevertheless, deviations from (2) will yield arbitrage opportunities between buying and renting and these should be eliminated over time by changes in house prices.[2] This suggests a simple dynamic model for the growth rate of house prices of the form

$$\Delta \log P_{t+1}^h = \lambda \left[ \frac{P_t^h}{R_t^h} - \frac{1}{u\left(r_t, E_t \Delta \log P_{t+1}^h\right)} \right] \tag{3}$$

where $\lambda < 0$. According to (3), for a given user cost of housing, a rise in the current ratio of house prices to rents will lead to a fall in future house prices—a negative growth rate for house prices. A rise in the real interest rate will increase the user cost of housing and ceteris paribus produce negative growth in house prices. Finally, an increase in expected capital gains to housing lowers the user cost of housing and requires an increase in the growth rate of house prices to restore equilibrium.

While equation (3) provides a theoretical basis for modelling the growth rate of house prices, empirically it seems likely that a more general dynamic specification will be required. To this end I embed equation (3) in a general autoregressive distributed lag model,

$$\begin{aligned} \Delta \log P_t^h = {} & \mu + \sum_{i=1}^{k} \gamma_i \Delta \log P_{t-i}^h \\ & + \sum_{i=1}^{k} \lambda_{1i} \log \frac{P_{t-i}^h}{R_{t-i}^h} + \sum_{i=1}^{k} \lambda_{2i} i_{t-i} \\ & + \sum_{i=1}^{k} \lambda_{3i} \pi_{t-i} + \lambda_4 E_t \\ & \times \Delta \log P_{t+1}^h + v_t \end{aligned} \tag{4}$$

In the above model the real interest rate is allowed to enter in an unrestricted form by separately including the nominal interest rate $i_t$ and inflation $\pi_t$.[3] We can evaluate the degree of empirical support for the above model by considering the signs and significance of the coefficient estimates. The user cost model predicts $\lambda_{1i} < 0$, $\lambda_{2i} < 0$, $\lambda_{3i} > 0$ and $\lambda_4 > 0$. However, given the potentially large number of coefficients in (4), in the empirical analysis I focus on the signs and significance of the sums of the coefficients (for example $\lambda_{11} + \cdots + \lambda_{1k}$) and the long-run effects [for example $(\lambda_{11} + \cdots + \lambda_{1k})/(1 - \gamma_1 - \cdots - \gamma_k)$] rather than each individual coefficient.

One difficulty with estimating equation (4) directly is that the expected capital gain on housing is unobservable. While there are a number of econometric techniques for dealing with expected variables, in the empirical section I use two simple approaches. The first approach is to estimate a version of (4) excluding $E_t \Delta \log P_{t+1}^h$. This provides a useful baseline model for the growth rate of house prices in Australian capital cities, emphasizing the effects of the price-to-rent ratio, the mortgage rate and inflation.

The second approach is to augment the basic model with economic variables that are likely to influence the future growth rate of house prices in each city. Four variables are considered. The growth rate of state final demand and the unemployment rate are used to capture the effects of local economic activity, while population growth is used to capture demographic factors. Such variables are conventionally thought to affect the demand for housing and subsequently the anticipated growth in house prices. The fourth variable is dwelling approvals per capita.

**Table 1 Summary Statistics for Real House Price Growth Rates, 1986:3–2005:2**

| | *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|---|
| *Mean* | 1.16 | 0.86 | 1.15 | 0.54 | 0.93 | 0.31 | 0.72 | 0.58 |
| *Std* | 2.90 | 3.20 | 2.64 | 2.57 | 2.52 | 1.95 | 2.47 | 2.82 |
| *AR(1)* | 0.66 | 0.20 | 0.62 | 0.20 | 0.54 | 0.16 | 0.50 | 0.22 |
| | (0.13) | (0.17) | (0.09) | (0.12) | (0.13) | (0.13) | (0.09) | (0.13) |
| Correlations | | | | | | | | |
| Sydney | 1.00 | | | | | | | |
| Melbourne | 0.52 | 1.00 | | | | | | |
| Brisbane | 0.50 | 0.30 | 1.00 | | | | | |
| Adelaide | 0.27 | 0.18 | 0.49 | 1.00 | | | | |
| Perth | 0.62 | 0.54 | 0.53 | 0.29 | 1.00 | | | |
| Hobart | 0.27 | 0.23 | 0.48 | 0.43 | 0.33 | 1.00 | | |
| Canberra | 0.53 | 0.36 | 0.72 | 0.45 | 0.47 | 0.40 | 1.00 | |
| Darwin | 0.04 | 0.06 | 0.31 | 0.27 | 0.16 | 0.30 | 0.19 | 1.00 |

*Notes*: *Std* is the standard deviation and *AR(1)* is the first-order auto-correlation coefficient. Numbers in (.) are heteroskedasticity robust standard errors (White 1980).

Inclusion of this variable is motivated by the view that supply restrictions on new housing construction due to state and local government regulations may have driven up house prices in some Australian cities (Caplin et al. 2003).

Two additional variables are considered as potential influences on the real growth of house prices. The first of these is real equity returns. Investment in the stock market is sometimes viewed as a substitute for purchases of residential property with individuals switching between the two assets depending upon expected real returns. The final variable is motivated by Abelson (1994) and Bewley, Dvornak and Livera (2004) who find evidence of a positive spillover effect from the Sydney housing market onto house prices in other Australian capital cities. While it is not immediately obvious that these latter two variables can be incorporated into the user cost framework, it seems important to allow for any possible effects that may be present in the data.

## 3. Data

To measure the growth rate of house prices for each of the eight capital cities, I use the quarterly price indexes for established houses constructed by the Australian Bureau of Statistics. Data are available for the period 1986:2–2005:2.[4] The indices measure house prices in nominal terms, so to remove the effect of inflation; the house price index for each city is divided by the city-specific consumer price index (CPI). The quarterly growth rate is calculated as the first-difference of the logarithm of this ratio multiplied by 100.

Table 1 reports some summary statistics on the quarterly growth rates of real house prices in the eight capitals. The averages show considerable variation across the capital cities. Over the sample, Sydney and Brisbane have experienced the highest average growth rates (about 1.2 per cent per quarter) while Hobart has experienced the lowest (around 0.3 per cent). Over time such differences will lead to large divergences in the level of house prices across cities. Growth rates of house prices are positively correlated across all eight cities, although Darwin has a relatively lower correlation than the others. Finally, there appears to be a degree of persistence in the growth rate of real capital gains. All of the point estimates for the AR(1) coefficients are positive, with the largest (statistically significant) coefficients arising in Sydney, Brisbane, Perth and Canberra.

The definitions and summary statistics (see Table A1) for the explanatory variables used in this study are contained in the Data Appendix. In addition Table A2 reports the results of augmented Dickey-Fuller (ADF) unit root tests for all of the variables used in the study (Dickey and Fuller 1981). In general the ADF tests indicate that it is reasonable to treat the real growth rate of house prices as a stationary I(0) series. Even in the case of Adelaide where formal evidence against a unit root is weakest, visual inspection of a graph of the growth rate of the series suggests it is more likely I(0) than I(1).

When the ADF test is applied to the explanatory variables the results are somewhat mixed. For some variables such as population growth rates and price-to-rent ratios, the formal evidence against the presence of a unit root is weak. One response to such findings would be to first-difference these variables; however, I have chosen not to do so for a number of reasons. Since the dependent variable is expressed in growth rates it seems logical to relate it to explanatory variables that are themselves growth rates (or ratios). Second, because equation (4) allows for $k$ lags of each regressor, variables are not actually prevented from entering the model in first-differences, since the coefficient estimates on the lags can sum to zero. Finally, provided at least two of the regressors in (4) are I(1), the equation is potentially balanced and can be viewed as an unrestricted error correction model.

## 4. Empirical Results

This section presents results obtained from estimating a series of regression models based around equation (4). In the empirical analysis the dependent variable in (4) is multiplied by 100 to convert it to a quarterly percentage change. All models include a constant term and dummy variable for the introduction of the GST in the September quarter of 2000. Where necessary, the effects of seasonality are accounted for by the use of seasonal dummies. For each model the results of a number of specification tests are reported along with the coefficient estimates. The specification tests include a test for serial correlation up to order five (Breusch 1978; Godfrey 1978); a formal test for heteroskedasticity (Breusch and Pagan 1979; Koenker 1981) and the RESET test (Ramsey 1969). Finally $t$ and $F$-statistics are computed using heteroskedasticity consistent variance-covariance matrices (White 1980).

### *4.1 A User Cost Model*

The initial results are for a restricted version of the user cost model that includes the mortgage rate, inflation rate and price-to-rent ratio. Table 2 reports the estimates obtained for each capital city. The number of lags for each variable is chosen to ensure that the models are free of serial correlation, however for each specific variable a common lag structure is used across all cities. Since there are a relatively large number of estimated coefficients, for the stochastic regressors I report the sum of coefficient estimates on the lagged values of each variable (plus the associated $t$-statistic) and also the $p$-value associated with an $F$-test for the joint significance of the $k$ lags of each variable.

In general the data for Australia's capitals are quite supportive of the simple user cost model. For five of the eight cities the model explains at least 40 per cent of the variation in the growth rates of house prices. The only city where the variables have relatively little explanatory power is Darwin ($\bar{R}^2 = 0.09$). Furthermore, in most circumstances the estimated effects of the explanatory variables are consistent with prior expectations and are statistically significant.

The nominal mortgage rate has a significantly negative effect on the real growth rate of house prices in all cities except Darwin. Inflation rates have a positive effect (except for Darwin) and to a first approximation the absolute value of the sum of the coefficient estimates on inflation and the mortgage rate are equal. This is consistent with the real mortgage rate being the important influence on the growth rate of real house prices. Aside from Adelaide, the sums of the coefficient estimates on the lags of the price-to-rent ratio are negative. This implies that a rise in house prices relative to rents is associated with a subsequent decline in the future growth rate of house prices. Finally, in all cities except Adelaide and Darwin lags of the dependent variable are statistically significant, indicating some persistence in the growth rate of house prices. The greatest

**Table 2 Restricted User Cost Model for the Growth Rate of Real House Prices, 1986:3–2005:2**

| | *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|---|
| *constant* | 5.214 | 9.157 | 1.457 | 3.183 | 2.364 | 3.968 | 4.144 | 1.146 |
| | (4.19) | (5.73) | (1.20) | (2.97) | (2.10) | (3.70) | (3.38) | (1.29) |
| *gstdum* | −1.455 | −10.195 | −2.565 | −4.393 | −3.301 | −5.411 | −4.416 | −4.958 |
| | (−2.97) | (−11.60) | (−2.86) | (−5.38) | (−6.43) | (−7.81) | (−8.53) | (−8.30) |
| *seasdum* | – | 0.0001 | – | – | – | – | 0.0116 | – |
| $\sum_{i=1}^{2} \Delta \log P^h_{t-i}$ | 0.377 | 0.337 | 0.644 | 0.023 | 0.792 | 0.512 | 0.569 | 0.216 |
| | (2.36) | (1.68) | (3.39) | (0.11) | (3.99) | (2.84) | (4.35) | (1.30) |
| Joint sig. | 0.0558 | 0.1808 | 0.0000 | 0.3739 | 0.0000 | 0.0167 | 0.0001 | 0.4067 |
| $\sum_{i=1}^{4} i_{t-i}$ | −3.153 | −4.32 | −1.241 | −2.309 | −1.613 | −1.440 | −1.650 | −0.049 |
| | (−5.95) | (−5.18) | (−2.99) | (−3.57) | (−3.11) | (−3.13) | (−3.73) | (−0.09) |
| Joint sig. | 0.0000 | 0.0000 | 0.0011 | 0.0006 | 0.0000 | 0.0010 | 0.0003 | 0.0245 |
| $\sum_{i=1}^{4} \pi_{t-i}$ | 3.508 | 4.636 | 2.373 | 3.095 | 2.209 | 1.129 | 2.065 | −0.553 |
| | (4.97) | (4.33) | (3.49) | (3.14) | (3.78) | (1.73) | (3.93) | (−0.40) |
| Joint sig. | 0.0000 | 0.0000 | 0.0003 | 0.0210 | 0.0007 | 0.0589 | 0.0007 | 0.0556 |
| $\sum_{i=1}^{5} \log \frac{P^h_{t-i}}{R^h_{t-i}}$ | −3.618 | −5.951 | −1.483 | 2.624 | −2.938 | −11.682 | −4.799 | – |
| | (−2.95) | (−4.06) | (−0.95) | (1.33) | (−2.16) | (−2.37) | (−1.67) | |
| Joint sig. | 0.0304 | 0.0002 | 0.0675 | 0.4378 | 0.0765 | 0.0279 | 0.0379 | – |
| $\bar{R}^2$ | 0.6225 | 0.4994 | 0.4996 | 0.1923 | 0.4614 | 0.2747 | 0.4260 | 0.0855 |
| SC(5) $p$-value | 0.7717 | 0.3969 | 0.3060 | 0.4766 | 0.8226 | 0.9086 | 0.2104 | 0.2566 |
| BPK $p$-value | 0.3771 | 0.0887 | 0.0187 | 0.5940 | 0.0003 | 0.5817 | 0.7409 | 0.5420 |
| RESET $p$-value | 0.0204 | 0.9830 | 0.0080 | 0.9023 | 0.0000 | 0.0248 | 0.6273 | 0.1492 |

*Notes*: Numbers in (.) are heteroskedasticity robust t-statistics (White 1980). SC(5) is a test for serial correlation up to order five (Breusch 1978; Godfrey 1978), BPK is a test for heteroskedasticity (Breusch and Pagan 1979; Koenker 1981) and RESET is a test for functional form misspecification (Ramsey 1969).

persistence in growth rates arises in Brisbane and Perth.

The results in Table 2 are generally consistent with the predictions of the user cost model. However, the low $p$-values for the RESET test for some capital cities does suggest the possibility of model misspecification. Therefore, I now examine whether the inclusion of additional explanatory variables can improve the performance of the basic model.

### 4.2 Additional Explanatory Variables

In total, six additional variables are considered for inclusion in the basic user cost model. The first four variables can be viewed as influences on the expected growth in future capital gains in each city. The variables are the growth rate of real state final demand *sfd*, the unemployment rate *un*, population growth *pop* and dwelling approvals per capita *dap*. The other two explanatory variables are real equity returns *sr* and lags of Sydney house price growth rates $\Delta \log P^{syd}$. In order to economise on degrees of freedom, initially each variable is included one at a time in the basic user cost model. The results obtained are reported in Table 3. The table indicates for each new variable—the sum of the coefficients on the lags (plus the associated $t$-statistic) and a test for the joint significance of all of the lags.

It is apparent from Table 3 that none of the additional regressors has a statistically significant effect on house prices in all Australian cities. However, with a couple of notable exceptions, where the sums of the coefficient estimates are statistically significant, the sign of the effect on real house price growth rates is consistent with prior expectations. The impact of local economic conditions on house price growth rates, as proxied by the growth rate of state final demand and the unemployment rate, is significant in a number of capital cities. The growth of state final demand has a positive effect on the growth rate of house prices in Sydney and Canberra. The unemployment rate

**Table 3 Effects of Additional Explanatory Variables, 1986:3–2005:2**

| | *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|---|
| $\sum_{i=1}^{4} sfd_{t-i}$ | 0.746 | −0.250 | −0.384 | 0.183 | 0.236 | −0.149 | 0.522 | −0.189 |
| | (2.07) | (−0.51) | (−1.25) | (0.62) | (0.99) | (−0.55) | (2.26) | (−1.15) |
| Joint sig. | 0.0084 | 0.7760 | 0.3738 | 0.2274 | 0.7571 | 0.9621 | 0.0245 | 0.4780 |
| $\sum_{i=1}^{4} un_{t-i}$ | −0.028 | −0.235 | −0.281 | −0.837 | 0.136 | −0.156 | −0.574 | 0.528 |
| | (−0.15) | (−1.56) | (−1.46) | (−2.44) | (0.58) | (−0.95) | (−2.36) | (2.41) |
| Joint sig. | 0.2933 | 0.0409 | 0.1214 | 0.1112 | 0.4100 | 0.0028 | 0.0613 | 0.0144 |
| $\sum_{i=1}^{4} pop_{t-i}$ | −21.298 | 11.348 | 5.778 | 14.867 | 0.935 | 10.382 | 0.537 | −2.046 |
| | (−3.77) | (3.08) | (2.27) | (1.68) | (0.27) | (3.36) | (0.21) | (−1.35) |
| Joint sig. | 0.0001 | 0.0018 | 0.0159 | 0.0241 | 0.6677 | 0.0015 | 0.5853 | 0.0159 |
| $\sum_{i=1}^{4} dap_{t-i}$ | 34.697 | 12.197 | −0.333 | 3.104 | 3.268 | 0.002 | −0.841 | −23.550 |
| | (1.69) | (0.71) | (−0.04) | (0.30) | (0.60) | (0.00) | (−0.24) | (−2.58) |
| Joint sig. | 0.1810 | 0.0037 | 0.1964 | 0.7207 | 0.0123 | 0.0158 | 0.2863 | 0.0607 |
| $\sum_{i=1}^{8} dap_{t-i}$ | 34.017 | 22.975 | 0.640 | −13.893 | −7.725 | −7.803 | −6.421 | −34.386 |
| | (1.20) | (0.93) | (0.06) | (−1.03) | (−1.07) | (−0.80) | (−1.82) | (−3.20) |
| Joint sig. | 0.0865 | 0.0000 | 0.4209 | 0.0958 | 0.0042 | 0.0050 | 0.0276 | 0.0233 |
| $\sum_{i=1}^{4} sr_{t-i}$ | −0.115 | −0.018 | −0.078 | −0.047 | −0.052 | −0.115 | −0.094 | 0.048 |
| | (−2.09) | (−0.26) | (−1.50) | (−0.69) | (−1.02) | (−2.00) | (−1.57) | (0.91) |
| Joint sig. | 0.2975 | 0.0026 | 0.0612 | 0.7004 | 0.7202 | 0.1277 | 0.0764 | 0.0049 |
| $\sum_{i=1}^{4} \Delta \log P_{t-i}^{syd}$ | – | 0.8026 | 0.334 | 0.185 | 0.581 | −0.088 | 0.214 | −0.022 |
| | | (4.75) | (1.91) | (1.07) | (3.14) | (−0.68) | (1.52) | (−0.16) |
| Joint sig. | – | 0.0000 | 0.0015 | 0.0198 | 0.0195 | 0.7389 | 0.0754 | 0.1436 |

*Notes*: Numbers in (.) are heteroskedasticity robust t-statistics (White 1980).

has a negative effect on the growth rate of house prices in most cities, although Adelaide and Canberra exhibit the only statistically significant effects. The only real anomaly for the unemployment rate is found for Darwin where the unemployment rate has a significantly positive effect.

Population growth is generally expected to have a positive effect on house prices and does so in Melbourne, Brisbane, Adelaide and Hobart. Interestingly, these cities are the ones traditionally associated with interstate migration from the southern states to Queensland. The negative effects for population growth in Sydney and Darwin are at odds with prior expectations.

Dwelling approvals per capita are included in the model as a proxy for the possible effects of supply restrictions on house prices. If the supply of new houses is restricted by government regulations this should show up in the form of reduced dwelling approvals per capita and eventually have a positive effect on the real growth rate of house prices. However, given that quarterly approvals of new dwellings are a relatively small percentage of the existing stock of houses it seems important to allow for a relatively large number of lags of *dap*. Therefore, in Table 3 I report results for $k = 8$ as well as $k = 4$. For most capital cities there seems to be no systematic effect on the growth rate of house prices from dwelling approvals per capita. While the lags of *dap* are found to be jointly significant in some cities, the sum of the coefficient estimates is not statistically significant, except for Darwin.

The performance of the Australian stock market appears to have a negative effect on house price growth rates. In particular for the Sydney, Brisbane, Hobart and Canberra markets, increases in real equity returns are associated with statistically significant declines in the growth rate of real house prices. This suggests that there is some willingness by individuals to substitute between housing and equity as a form of investment.

The final set of results reported in Table 3 confirms the finding by Bewley, Dvornak and

Livera (2004) that the Sydney housing market tends to predict the performance of housing markets in other Australian cities. Lagged values of the growth rate of Sydney house prices are found to have a statistically significant effect on growth rates of house prices in Melbourne, Brisbane, Perth and Canberra.

The results in Table 3 suggest that the basic user cost model can be improved for all cities by the inclusion of additional explanatory variables. The following section reports the results obtained from estimating a general model for the growth rate of house prices in each of the capital cities.

### *4.3 A General Model*

In order to find the most appropriate general model for each city, I used the results from Table 3 as a guide to which variables should be used to augment the basic user cost models.[5] In the initial set of estimates (reported in Table 4) I have not allowed for a Sydney effect on house prices in the other capital cities. For ease of interpretation only statistically significant long-run marginal effects are reported.[6]

One again, the empirical results point to the importance of the nominal mortgage rate in influencing the real growth rate of house prices. In all cities the estimated marginal effect of the mortgage rate on the real growth rate of house prices is negative and statistically significant. However, it is also evident that the magnitude of the mortgage rate effect shows quite large differences between cities. The growth rates of house prices are most responsive to a change in the mortgage rate in Sydney, Melbourne and Brisbane and least responsive in Darwin and Adelaide.[7] Ceteris paribus, a persistent increase in the mortgage rate of 25 basis points is estimated to reduce the long-run growth rate of real house prices in Sydney by about one per cent per quarter. This is clearly an economically important effect.

With the exception of Darwin, inflation rates are found to have a positive effect on house price growth rates. As implied by the user cost model, the estimated long-run coefficients on

**Table 4 Long-Run Marginal Effects for User Cost Model, 1986:3–2005:2**

| | *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|---|
| *State final demand* | 0.867 | – | – | – | – | – | 0.504 | – |
| | (3.35) | | | | | | (2.33) | |
| *Unemployment* | – | – | −1.200 | −0.587 | – | – | – | – |
| | | | (−2.25) | (−2.83) | | | | |
| *Population growth* | – | 12.531 | 20.874 | – | 10.532 | 8.145 | – | 3.123 |
| | | (3.38) | (2.24) | | (2.34) | (4.86) | | (2.45) |
| *Mortgage rate* | −4.350 | −4.042 | −5.726 | −1.552 | −2.221 | −2.302 | −1.708 | −1.384 |
| | (−5.58) | (−4.77) | (−2.73) | (−2.86) | (−2.54) | (−5.18) | (−3.41) | (−2.36) |
| *Inflation rate* | 5.088 | 2.966 | 4.169 | 1.513 | 3.508 | 0.579 | 3.612 | −3.030 |
| | (4.88) | (2.72) | (2.09) | (1.82) | (3.42) | (1.13) | (3.60) | (−2.45) |
| *Price-to-rent ratio* | −4.672 | −7.256 | −14.438 | – | – | −12.764 | – | – |
| | (−3.01) | (−5.21) | (−2.63) | | | (−3.08) | | |
| *Equity returns* | −0.171 | – | −0.180 | – | – | −0.062 | – | – |
| | (−2.25) | | (−1.45) | | | (−1.86) | | |
| *Dwelling approvals* | – | – | – | – | −24.288 | – | −10.352 | −50.238 |
| | | | | | (−1.99) | | (−2.29) | (−3.82) |
| $\bar{R}^2$ | 0.6497 | 0.5619 | 0.5576 | 0.2968 | 0.4674 | 0.4027 | 0.5602 | 0.2235 |
| SC(5) *p*-value | 0.2480 | 0.5293 | 0.1895 | 0.6564 | 0.2107 | 0.7446 | 0.0768 | 0.9565 |
| BPK *p*-value | 0.4548 | 0.0728 | 0.8808 | 0.4352 | 0.0497 | 0.4575 | 0.7125 | 0.0692 |
| RESET *p*-value | 0.1957 | 0.2734 | 0.0000 | 0.2718 | 0.0003 | 0.5689 | 0.0005 | 0.0000 |
| Real interest rate effect *p*-value | 0.3378 | 0.0491 | 0.3777 | 0.9369 | 0.1987 | 0.0011 | 0.0055 | 0.0011 |

*Notes*: Numbers in (.) are heteroskedasticity robust t-statistics (White 1980). SC(5) is a test for serial correlation up to order five (Breusch 1978; Godfrey 1978), BPK is a test for heteroskedasticity (Breusch and Pagan 1979; Koenker 1981) and RESET is a test for functional form misspecification (Ramsey 1969).

**Table 5 Long-Run Marginal Effects Including Sydney Effect, 1986:3–2005:2**

| | *Melbourne* | *Brisbane* | *Perth* | *Canberra* |
|---|---|---|---|---|
| *State final demand* | – | – | – | 0.464 |
| | | | | (2.81) |
| *Unemployment* | – | −0.573 | – | – |
| | | (−2.94) | | |
| *Population growth* | 7.178 | 9.619 | 5.072 | – |
| | (2.53) | (3.02) | (1.60) | |
| *Mortgage rate* | −4.116 | −1.584 | −1.577 | −1.204 |
| | (−4.89) | (−2.39) | (−3.11) | (−3.04) |
| *Inflation rate* | 3.204 | 2.723 | 1.480 | 2.476 |
| | (2.96) | (2.75) | (1.87) | (3.00) |
| *Price-to-rent ratio* | −7.441 | – | – | – |
| | (−5.47) | | | |
| *Dwelling approvals* | – | – | – | −7.473 |
| | | | | (−2.19) |
| *Sydney effect* | 0.5697 | 0.793 | 0.686 | 0.232 |
| | (4.02) | (6.22) | (5.72) | (2.99) |
| $\bar{R}^2$ | 0.6181 | 0.6225 | 0.5459 | 0.5850 |
| SC(5) *p*-value | 0.5344 | 0.9000 | 0.7810 | 0.3590 |
| BPK *p*-value | 0.5761 | 0.81398 | 0.0062 | 0.8704 |
| RESET *p*-value | 0.0273 | 0.00139 | 0.0000 | 0.0008 |
| Real interest rate effect *p*-value | 0.0702 | 0.0900 | 0.8863 | 0.0265 |

*Notes*: Heteroskedasticity robust $t$-statistics are reported in (White 1980). SC(5) is a test for serial correlation up to order five (Breusch 1978; Godfrey 1978), BPK is a test for heteroskedasticity (Breusch and Pagan 1979; Koenker 1981) and RESET is a test for functional form misspecification (Ramsey 1969).

inflation and the mortgage rate are of approximately equal magnitude (and of opposite sign). The $p$-values associated with a formal test of this hypothesis are reported in the final row of Table 4. For Sydney, Brisbane, Adelaide and Perth the hypothesis cannot be rejected, providing strong evidence that it is the level of real mortgage rates that is important in influencing the growth rate of capital gains to housing in these cities.

As indicated by the results in Table 4, the effects of the other economic variables on house prices appear to be somewhat heterogenous across the cities. Nevertheless, some interesting results do emerge. For all cities at least one of the commonly acknowledged drivers of the demand for housing, eg. state final demand, the unemployment rate and population growth has a significant long-run effect on the growth rate of house prices. For a number of cities the inclusion of these additional economic variables causes the price-to-rent ratio to become statistically insignificant. However, it remains a significant influence on the growth rate of house prices in Sydney, Melbourne, Brisbane and Hobart. Real equity returns have a negative effect in Sydney, Brisbane and Hobart. Finally, dwelling approvals per capita are found to have a significantly negative effect on the growth rate of house prices in Perth, Canberra and Darwin.

A final set of estimates for Melbourne, Brisbane, Perth and Canberra are reported in Table 5. The housing markets in these four cities show evidence of a significant Sydney effect. In each city, lags of Sydney house price growth rates have a statistically significant long-run effect. The estimates suggest that the strongest spillover effects are from the Sydney housing market to the Brisbane and Perth markets. Other things equal, a one per cent rise in the growth rate of house prices in Sydney is estimated to increase the growth rate in Brisbane by about 0.75 per cent. Notice that in some cases allowing for a Sydney effect causes changes in the other long-run coefficient estimates. Comparing the estimates in Tables 4 and 5 we see that for Brisbane, inclusion of the Sydney effect causes the price-to-rent ratio and equity returns to become insignificant, while in the case of Perth dwelling approvals become insignificant. More generally there is a tendency for the absolute magnitude of the other long-run effects to fall.

The explanation for the significance effect from lags of the growth rate of Sydney house prices is not immediately clear. One possibility is that Sydney prices simply act as a signal for some omitted variable that influences Australian housing markets, for example consumer confidence. The problem with this explanation is that it is not obvious why a Sydney effect is evident in the Adelaide, Hobart and Darwin housing markets. Alternatively, the Sydney effect may represent a true causal relationship, where changes in the returns to housing in Sydney induce buyers to move into (and out of) housing markets in other capital cities. The interstate migration figures provide some support for this view. Over the period 1986–2005 the net outflow from NSW to the other states and territories was about 23 000 per annum. Around 85 per cent of this flow was to Queensland, with Western Australia the next highest state with about 4.5 per cent.[8]

What the results in Tables 4 and 5 indicate is that for most Australian capital cities it is possible to find a set of economic fundamentals that have a significant effect on the growth rates of real house prices. In addition, the signs of the estimated effects are in general consistent with the predictions of the user cost model for house prices. Of course we cannot be completely confident that all of the major drivers of house price growth rates have been identified. The significant values of the RESET statistics for some capital cities indicate that a degree of caution is warranted.

## 5. Conclusion

The empirical results in this paper suggest that economic fundamentals play an important role in determining the growth rates of real house prices in Australia's capital cities. In particular, for Sydney, Melbourne, Brisbane, Perth and Canberra the economic variables considered can explain more than 50 per cent of the variation in house price growth rates. Moreover, for all eight capital cities economically and statistically significant influences on the long-run behaviour of the house price growth rates are identified.

One significant finding is the importance of the mortgage rate in influencing the growth rate of Australian house prices. In earlier work on the determinants of house prices in Australian cities for the period 1979–1993, Bourassa and Hendershott (1995) found a relatively small role for interest rates. Based on this paper's findings for the period 1986–2005, it appears that house prices have become increasingly sensitive to the level of mortgage rates. The most likely causes of this change are the greater use of variable rather than fixed rate mortgages and increases in the size of home loans.

An additional finding for the mortgage rate, is that the size of its marginal effect is not equal across all capital cities. The largest marginal effects from a change in the mortgage rate occur on housing markets in Sydney and Melbourne (and possibly Brisbane), while the smallest arise in Adelaide, Canberra and Darwin.

In Australia, movements in variable mortgage rates are closely tied to changes in the RBA's cash rate target. Thus the empirical findings for the mortgage rate have some broader implications with respect to monetary policy. First, the results suggest that monetary policy has a quantitatively important effect on the real return to housing. To the extent that housing returns affect household consumption decisions and portfolio choices, the results in this paper may identity at least some part of the transmission mechanism for monetary policy in Australia. A second implication is that given the differences in the estimated marginal effects for the mortgage rate among cities, there is support for the widely-held view that monetary policy can have different regional effects.

Apart from the mortgage rate (and inflation) it was not possible to successfully identify a common set of economic factors to explain house price growth rates in all eight capitals. This suggests that there is a degree of heterogeneity in regional housing markets and supports the estimation of individual models for each city. Furthermore, it cautions against attempting to pool data across all Australian cities.

There are a number of areas where further work would appear to be useful. The measurement of some explanatory variables could be improved and it would seem to be particularly worthwhile to construct city-level estimates of real income. In addition, this paper has not looked at the role that changes in tax regimes may have had in influencing changes in house prices. Finally, it may be useful to examine if the basic findings of this paper are robust to the use of alternative measures of house prices (Abelson and Chung 2005; Hansen 2006; Prasad and Richards 2006).

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## Appendix 1: Data

The definitions and sources of the variables used in the empirical analysis are provided below. All data series are quarterly and the sample period is 1986:2–2005:2.

*House Prices*

The real growth rates of house prices in the state and territory capitals are derived from quarterly price indices for established houses (Source: DX Table 6416-01). These indices are converted to real terms by dividing them by the relevant state or territory capital city CPI (Source: DX Table 6401-01).

*Unemployment Rate*

Unemployment rates for the six states are available on a seasonally adjusted basis (Source: DX Tables 6202-04B to 6202-09B). For the two territories the unemployment rates are not seasonally adjusted (Source: DX Tables 6202-12G and 6202-12H).

*Population Growth*

The population growth rates in the state and territories are derived from estimated resident populations (Source: DX Table 3101-04).

*Mortgage Rate*

The nominal mortgage rate is measured by the standard variable home loan rate offered by banks (Source: DX Table F.05). The quarterly mean of this series is 2.241 while the standard deviation is 0.826.

*State Final Demand*

The growth rate of final demand for the states and territories is derived from the seasonally adjusted CVM ($m 2000–03) measure of state final demand (Source: DX Table 5206-25).

*Inflation Rate*

Inflation rates for the state and territory capitals are derived from the corresponding CPIs (Source: DX Table 6401-01).

*GST Dummy*

This is a dummy variable for the introduction of the goods and services tax (GST). It takes the value 1 in the September quarter 2000 and 0 elsewhere.

*Dwelling Approvals*

The quarterly number of dwelling units approved for each capital city (Source: DX Table 8731-08). These are divided by respective state and territory populations to get dwelling approvals per capita.

*Stock Prices*

The monthly S&P/ASX 200 accumulation index (Source: DX Table F.07) is converted to a quarterly series by taking three month averages. A real return series is obtained by subtracting the state or territory inflation rate from the nominal growth rate.

*Rent*

Data on rents are obtained from the Real Estate Institute of Australia (REIA) and are weekly

**Table A1 Quarterly Means and Standard Deviations of Regressors, 1986:3–2005:2**

| | *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|---|
| *Population growth* | | | | | | | | |
| Mean | 0.266 | 0.278 | 0.543 | 0.144 | 0.422 | 0.110 | 0.300 | 0.359 |
| Std | 0.088 | 0.093 | 0.119 | 0.069 | 0.140 | 0.129 | 0.239 | 0.258 |
| *Unemployment rate* | | | | | | | | |
| Mean | 7.282 | 7.474 | 8.262 | 8.428 | 7.221 | 9.329 | 5.722 | 6.513 |
| Std | 1.567 | 2.086 | 1.385 | 1.611 | 1.518 | 1.438 | 1.421 | 1.694 |
| *Growth of state final demand* | | | | | | | | |
| Mean | 0.799 | 0.858 | 1.114 | 0.741 | 1.140 | 0.607 | 1.052 | 0.961 |
| Std | 1.196 | 1.494 | 1.599 | 2.742 | 2.466 | 2.714 | 2.463 | 4.579 |
| *Inflation rate* | | | | | | | | |
| Mean | 0.905 | 0.872 | 0.884 | 0.898 | 0.883 | 0.870 | 0.849 | 0.789 |
| Std | 0.838 | 0.834 | 0.774 | 0.803 | 0.874 | 0.797 | 0.807 | 0.775 |
| *Dwelling approvals per capita ($\times$100)* | | | | | | | | |
| Mean | 0.111 | 0.139 | 0.121 | 0.119 | 0.217 | 0.061 | 0.219 | 0.104 |
| Std | 0.024 | 0.037 | 0.029 | 0.056 | 0.055 | 0.021 | 0.084 | 0.055 |
| *Log price-to-rent ratio* | | | | | | | | |
| Mean | 0.168 | 0.082 | 0.213 | 0.121 | 0.035 | 0.098 | 0.088 | – |
| Std | 0.346 | 0.242 | 0.223 | 0.150 | 0.207 | 0.081 | 0.139 | – |
| *Real equity returns* | | | | | | | | |
| Mean | 1.713 | 1.746 | 1.734 | 1.720 | 1.736 | 1.748 | 1.769 | 1.829 |
| Std | 8.391 | 8.393 | 8.419 | 8.495 | 8.396 | 8.347 | 8.437 | 8.387 |

**Table A2 Unit Root Tests, 1986:3–2005:2**

| *Sydney* | *Melbourne* | *Brisbane* | *Adelaide* | *Perth* | *Hobart* | *Canberra* | *Darwin* |
|---|---|---|---|---|---|---|---|
| *Growth of real house prices* | | | | | | | |
| −3.36 | −3.05 | −2.52 | −1.97 | −3.40 | −3.23 | −3.08 | −2.45 |
| *Growth of state final demand* | | | | | | | |
| −3.20 | −2.95 | −3.29 | −5.50 | −3.92 | −4.23 | −4.80 | −4.00 |
| *Unemployment rate* | | | | | | | |
| −2.15 | −2.03 | −1.70 | −1.07 | −1.73 | −0.48 | −0.61 | −2.39 |
| *Population growth* | | | | | | | |
| −2.76 | −1.75 | −2.67 | −1.58 | −2.05 | −2.02 | −1.83 | −2.50 |
| *Inflation rate* | | | | | | | |
| −2.25 | −2.26 | −2.16 | −2.00 | −2.30 | −2.75 | −2.35 | −2.78 |
| *Log price-to-rent ratio* | | | | | | | |
| −3.88 | −0.75 | −1.45 | −0.19 | −1.96 | −1.78 | −2.42 | – |
| *Real equity returns* | | | | | | | |
| −5.83 | −5.75 | −5.92 | −5.82 | −5.78 | −5.87 | −5.89 | −5.89 |
| *Dwelling approvals per capita* | | | | | | | |
| −2.98 | −1.99 | −3.41 | −1.97 | −3.51 | −1.37 | −1.91 | −1.63 |

*Notes*: All of the test statistics are computed using the augmented Dickey-Fuller test (Dickey and Fuller 1981). The test regression includes a constant term and four lags of the dependent variable. The five and ten per cent critical values for the test are −2.86 and −2.57 respectively. The ADF(4) test statistic for the mortgage rate is −1.59.

median rents for three bedroom houses in each capital city except Darwin.[9] The series are converted to quarterly indices and then deflated by the city-specific CPI.

## Endnotes

1. Bodman and Crosby and Abelson et al. both present evidence that house prices (or the

logarithm of house prices) are I(1) in levels, but that their growth rates are I(0).

2. Adjustment to equilibrium could also come via a change in rents, although the practice of fixing rents for periods of six or twelve months is likely to reduce their responsiveness relative to house prices.

3. Abelson et al. argue that inflation may have a separate effect on house prices due to the nature of the Australian tax system.

4. These indices were discontinued by the ABS in 2005:2 and replaced by new series. However the start date for the new series is only 2002:1.

5. Given the potentially large number of variables and lags the more conventional general-to-specific modelling strategy is not really feasible.

6. A full set of results are available on request.

7. The relative magnitudes of the responses are broadly consistent with the average loan sizes for the purchase of established dwellings in the states and territories over the sample period. Ranking from highest to lowest average loan size gives; NSW, ACT, VIC, QLD, WA, NT, SA and TAS (Source: ABS Cat. 5609.0, *Housing Finance*).

8. The source of these figures is ABS Cat. 3124.0 *Migration, Australia*.

9. Rent data for Darwin only begins in 1994:1 and is not used in the empirical analysis.

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