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Overvaluation in Australian Housing and Equity Markets: Wealth Effects or Monetary Policy?*

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Abstract

A 7 variate SVAR model is used to identify the presence and causes of overvaluation in real house prices in Australia from 2002 to 2008. An important feature of the model is the development of a housing sector where long-run restrictions are derived from economic theory to identify housing demand and supply shocks. The empirical results show that real house prices were overvalued during the period, reaching a peak of nearly 20% by the end of 2003. Important factors driving the observed overvaluation are housing demand shocks prior to 2006, and macroeconomic shocks in the goods market post 2006. Wealth effects from portfolio shocks in equity markets are also found to be an important driver. The results also suggest that monetary policy is not an important contributing factor in the overvaluation of house prices.

Keywords: SVAR, long-run restrictions, housing supply and demand shocks, macro shocks.

JEL Classification: E21, E44, C32, R21

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1 Introduction

The subprime crisis and global financial market volatility of 2007-2009 has brought to the fore a spectrum of questions for modern macroeconomics. The extent of divergence of house prices from their fundamental values (Himmelberg, Mayer and Sinai (2005), Bourassa, Henderschott and Murphy (2001) and Stiglitz (1990)); the role of wealth effects in asset markets in determining this divergence (Case, Quigley and Shiller (2005) and Carroll, Otsuka and Slacalek (2006)); the interaction between housing market shocks and the macroeconomy (Tan and Voss (2003), Abelson, Joyeux, Milunovich and Chung (2005), Tang (2006), Campbell and Coco (2007), Dvornack and Kohler (2007), Muellbauer (2007) and Jarociński and Smets (2008)); and whether monetary policy responds to asset prices and not just prices in goods markets (Bernanke and Gertler (2001) and Mishkin (2007))?.

The aim of this paper is to address these questions by first identifying whether prices in housing and equity markets are overvalued, and if so, what are the drivers behind the overvaluation. To be able to quantify the size of the potential overvaluation in these markets it is necessary to identify some "normal" price that would occur if prices are solely driven by their market fundamentals. The approach adopted here is to specify a structural vector autoregression (SVAR) model of the Australian economy that combines the macroeconomic model of Fry, Hocking and Martin (2008) with its focus on domestic and international portfolios, with a housing sector component. The specification of a macroeconomic model for Australia incorporating a housing sector has three motivations. First, the specified model uses long-run restrictions to identify the housing demand and supply shocks which are derived from an intertemporal optimization model of housing investment based on Tobin's q.

Second, the long-run restriction imposed on the housing market relating real house prices to interest rates is of a similar form to the long-run restriction derived for equity markets by Fry, Hocking and Martin (2008). Without the imposition of these two cross-equation restrictions the model is just-identified. This suggests that a natural test of the long-run properties of the model is conducted by testing the model's over-identifying restrictions.

Third, the inclusion of a housing sector allows for the wealth effects from housing in a relatively general model that is rich in its menu of assets. An allowance for wealth

Table 1:
Contributions of housing and equity to wealth in Australia, 1991 to 2006.

Year	Housing[1]		Equity[3]	
	Wealth (A$bn)	% of GDP[2]	Wealth (A$bn)	% of GDP[2]
1991	49.6	11.4%	190.7	43.70%
1996	1,169.0	202.9%	392.8	68.20%
2001	2,073.4	290.9%	732.8	102.80%
2006	3,452.9	319.7%	1,390.30	128.70%

1. Housing stock: Following Dvornak and Kohler (2007) housing wealth is constructed using the ABS census on population and housing and the REIA median house price data. An estimate of the capitalisation of the housing sector is calculated by multiplying the median house price by the stock of dwellings.
2. GDP: Australian Bureau of Statistics (ABS) Cat 5206 Table 3.
3. Share market 1991 to 2001: from Australian Stock Exchange (2002). Share market 2006:

   http://www.asx.com.au/research/market_info/historical_equity_data.htm.

effects from housing is important empirically for Australia as the relative contribution of housing to overall wealth is larger than it is for equities, as highlighted in Table 1. This table shows that from 1991 to 2006, the contributions of housing and equities to wealth have grown significantly to levels that are now in excess of GDP. This table also shows that the contribution of housing to wealth is now nearly three times the contribution of equity to wealth. A similar statistic is reported by Jarociński and Smets (2008) for the US.

Despite the importance of housing wealth to overall wealth in Australia, there are as yet no SVAR models of Australia incorporating the housing market. In fact, most models tend not to include any asset markets, exceptions being Fry, Hocking and Martin (2008) and Dungey and Pagan (2000, 2008) who both include the stock market.

Abelson, Joyeux, Milunovich and Chung (2005) also allow for equity wealth, but adopt a multivariate cointegration model specification. In the international SVAR literature there is some work which includes the housing market. Examples for the US include Jarociński and Smets (2008) who also identify housing supply and demand shocks, Iacoviello (2005), Ludvigson, Steindel and Lettau (2002) and Baffoe-Bonnie (1998). For the UK there is work by Aoki, Proudman and Vlieghe (2002) and Elbourne (2008), whilst Iacoviello (2000) provides a comparison of the macroeconomic factors driving house prices in selected countries of the Euro area.

The key empirical result is that over the period 2002 to 2008, real house prices in Australia are overvalued, with two main periods of overvaluation. The first period is prior to 2006, where real house prices peak at around 20% above fundamentals by the end of 2003. This is comparable to the results of Bodman and Crosby (2004) who find the level of overvaluation in Sydney is about 15% and for Brisbane as high as 25%. However, are generally less than the results found by Otto (2007). Housing demand shocks explain half of the overvaluation in house prices in the first period, with shocks in demand and supply in the goods market explaining the remainder. It is these macroeconomic based shocks that are important in the second period of overvaluation from mid 2007 onwards. The evidence shows that demand and supply shocks in the goods market are characterised by wealth effects stemming from the equity market. The empirical results also show little support for the view that monetary policy contributes to the observed overvaluation of real house prices in Australia over this period.

The rest of the paper is structured as follows. A macroeconometric SVAR model is derived in Section 2 with special attention given to deriving the long-run restrictions for housing supply and demand. The econometric methods are presented in Section 3, while data issues are discussed in Section 4. The empirical results are presented in Section 5, with conclusions given in Section 6.

2 A Macroeconometric Model

This section develops a 7-variate macroeconometric model of Australia that incorporates a housing sector. The housing sector is based on Tobin's q model of investment, which yields long-run restrictions on the underlying processes that are important in the identification of demand and supply shocks in the housing market.

2.1 Housing Sector Specification

Consider an investor that is assumed to choose real gross residential investment (I) to maximise the stream of discounted profits according to the following objective function

$$\max_I \Pi(t) = \int_t^\infty e^{-R(s-t)} \left[P_h(s) h(s) - P_h(s) I(s)\right] ds, \tag{1}$$

subject to the housing stock accumulation constraint

$$\dot{h} = \psi(I) - \delta h, \tag{2}$$

where P_h is the price of a house also assumed to be equal to the price of housing investment for simplicity, h is the stock of housing, R is the nominal interest rate, $\psi(I)$ is the installation function (Hayashi (1982)) and δ is the depreciation rate. The model is easily expanded to allow for various types of taxes as well. Assuming that house prices over time follow

$$P_h(s) = P_h(t) e^{\pi(s-t)}, \tag{3}$$

where π is inflation, the objective function in (1) becomes

$$\begin{aligned} \max_I \Pi(t) &= \int_t^\infty e^{-R(s-t)} \left[P_h(t) e^{\pi(s-t)} h(s) - P_h(t) e^{\pi(s-t)} I(s)\right] ds, \\ &= \int_t^\infty e^{-(R-\pi)(s-t)} \left[P_h(t) h(s) - P_h(t) I(s)\right] ds, \\ &= P_h(t) \int_t^\infty e^{-(R-\pi)(s-t)} \left[h(s) - I(s)\right] ds. \end{aligned} \tag{4}$$

The current value Hamiltonian is

$$V = P_h h - P_h I + \lambda(\psi(I) - \delta h). \tag{5}$$

The optimality conditions are (Kamien and Schwartz (1981))

$$\frac{\partial V}{\partial I} = -P_h + \lambda \psi_I(I) = 0, \tag{6}$$

$$\dot{\lambda} = (R-\pi)\lambda - \frac{\partial V}{\partial h} = (R-\pi)\lambda - P_h + \lambda\delta, \tag{7}$$

$$\dot{h} = \frac{\partial V}{\partial \lambda} = \psi(I) - \delta h. \tag{8}$$

Setting (6) to zero and rearranging gives

$$P_h = \lambda\psi_I(I). \tag{9}$$

Assuming quadratic installation costs with parameter γ

$$\psi(I) = \frac{1}{2}\gamma I^2, \tag{10}$$

then

$$\psi_I(I) = \frac{d}{dI}\left(\frac{1}{2}\gamma I^2\right) = \gamma I,$$

so (9) yields upon rearranging the optimal solution for housing investment

$$I = \frac{P_h}{\lambda\gamma}. \tag{11}$$

Substituting (11) into the $\dot{h}$ equation in (8) and using the quadratic installation specification in (10), gives

$$\begin{aligned}\dot{h} &= \frac{1}{2}\gamma I^2 - \delta h,\\ &= \frac{1}{2}\gamma\left(\frac{P_h}{\lambda\gamma}\right)^2 - \delta h.\end{aligned} \tag{12}$$

An important feature of the identification of the model's dynamics is the imposition of long-run restrictions on the relationships amongst the variables. To derive the form of these long-run restrictions for the housing sector, from (7) and (12) respectively set

$$\dot{\lambda} = \dot{h} = 0. \tag{13}$$

This results in the following two equation system in terms of λ and h,

$$\begin{aligned}0 &= (R-\pi)\lambda - P_h + \lambda\delta,\\ 0 &= \frac{1}{2}\gamma\left(\frac{P_h}{\lambda\gamma}\right)^2 - \delta h.\end{aligned} \tag{14}$$

As this system is recursive, λ is simply derived from the first equation in (14)

$$\lambda = \frac{P_h}{R-\pi+\delta}. \tag{15}$$

Alternatively, this equation is rearranged to give an expression for Tobin's marginal q (Hayashi (1982))

$$q_m = \frac{\lambda}{P_h} = \frac{1}{(R-\pi+\delta)}. \tag{16}$$

Using this result in the second equation in (14), gives

$$\frac{1}{2}\gamma\left(\frac{1}{\lambda q}\right)^{2}-\delta h=0,$$

which is rearranged to yield a long-run solution for the stock of housing

$$h=\frac{1}{2}\frac{\gamma}{\delta}\left(\frac{1}{\lambda q}\right)^{2}=\frac{1}{2}\frac{\gamma}{\delta}\left(\frac{R-\pi+\delta}{\lambda}\right)^{2}. \tag{17}$$

Now define Tobin's average q as (Hayashi (1982))

$$q_a=\frac{P_h}{L^{\alpha}C^{1-\alpha}}, \tag{18}$$

where L is land costs and C is construction costs. Abelson, Joyeux, Milunovich and Chung (2005) argue that the inclusion of the cost of housing in a model of house prices is not relevant, whilst Bourassa and Hendershott (1995) argue the opposite. Assuming that the firm is a price taker and the production function and the installation function are homogeneous (Hayashi p.218, Proposition 1), marginal and average q are equivalent. By equating equations (16) and (18) this yields a solution for house prices in terms of land and construction costs, as well as the real interest rate net of depreciation (Madsen (2007) adopts a similar strategy in developing a model of housing for Australia)

$$P_h=\frac{L^{\alpha}C^{1-\alpha}}{(R-\pi+\delta)}. \tag{19}$$

By taking natural logarithms and given the homogeneity assumption, the log of the price of housing relative to the cost of land is

$$p_h=\alpha c-\ln\left(R-\pi+\delta\right), \tag{20}$$

with $p_h=\ln\left(P_h/L\right)$ representing the price of housing per the price of land and $c=\ln\left(C/L\right)$ the relative construction costs per the price of land. The role of land prices in the model is consistent with Capozza and Helsley (1986) and Bourassa and Hendershott (1995).

Equation (20) shows that in the long-run the log of the price of housing relative to land costs is a positive function of the log of construction-land costs and an inverse function of the log of the real interest rate. An important question investigated in the empirical section is how nominal interest rate shocks affect the economy and the housing sector in particular. To achieve this aim define $\ln\left(R-\pi+\delta\right)=r+\phi$, where

$r = \ln R$ and $\phi = -\ln(1 - (\pi - \delta)/R)$. In which case the long-run specification in (20) becomes

$$p_h = \alpha c - r + \phi. \tag{21}$$

Provided that $(\pi - \delta)$ and R are cointegrated, the key long-run relationship is between p_h, c and r. This expression has a number of important empirical implications. First, there is a linear relationship between the log housing-land price p_h and the log construction-land price c, with parameter α. Second, the log nominal interest rate enters the specification with a parameter equal to -1. This means that an aggregate demand shock that raises nominal interest rates, reduces house prices p_h by the same magnitude in the long-run. A similar result is obtained in Fry, Hocking and Martin where an inverse relationship between log real equity prices and log nominal interest rates is established in the long-run which provides a natural restriction from economic theory to help identify aggregate demand shocks. Empirically this restriction is testable both for the housing sector and jointly for all asset markets in general. Thirdly, given the cointegrating assumptions imposed on the relationship between $(\pi - \delta)$ and R, it is not necessary from a long-run perspective to identify depreciation costs over time δ, which can potentially be difficult to derive accurate data for.

To complete the specification of the housing sector, a long-run cost function is specified whereby the price of housing relative to the price of land (c), is a function of real output (y) according to

$$c = \beta y, \tag{22}$$

where β is the long-run cost parameter. Alternatively, using (22) to substitute out c from (21) gives the long-run house price equation as

$$p_h = \alpha\beta y - r + \phi. \tag{23}$$

Equations (22) and (23) are used to identify the demand and supply equations for housing. As the supply equation is presented in terms of a cost function, a positive supply shock is identified as a negative cost shock which corresponds to the cost function shifting downwards as costs are now lower for each level of output.

2.2 Macroeconomic Specification

The macroeconomic model consists of augmenting the 5 variate SVAR model of Fry, Hocking and Martin (2008) to include the housing specifications in (22) and (23). This results in a 7 variate system containing the variables

$$z = \{y, r, s, p, f, c, p_h\}, \tag{24}$$

where y is the log of real GDP, r is the log of the nominal interest rate, s is the log of the real price of Australian equities, p is the log of the nominal goods market price level, f is the log of the real price of foreign equities expressed in Australian dollars, c is the log of the ratio of construction costs to land costs, and p_h is the log of the price of housing relative to the cost of land.

The dynamics of the macroeconometric model are represented in terms of a vector autoregression (VAR) with K lags

$$\left(I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^K\right) \Delta z_t = \vartheta + e_t, \tag{25}$$

where $L^k \Delta Z_t = \Delta Z_{t-k}$ is the lag operator, Φ_k are (7×7) matrices of autoregressive parameters, ϑ is a $(7\times\ 1)$ vector of intercepts, and e_t is a multivariate normal random disturbance term with the properties of zero mean $E[e_t] = 0$, contemporaneous covariance matrix $E[e_t e_t'] = \Omega$, and no autocorrelation $E\left[e_t e_{t-s}'\right] = 0, \forall \neq 0$. Specifying the VAR in differences of the variables Δz_t means that the variables are expressed in growth rates in the short run.

The structural shocks driving the processes are represented by the disturbance vector v_t, which captures aggregate supply and demand shocks in the goods market, domestic and foreign portfolio shocks, nominal shocks in the money market, and demand and supply shocks in the housing market. The shocks are ordered as follows:

$$v_t = \begin{bmatrix} \text{Aggregate supply} \\ \text{Aggregate demand} \\ \text{Australian portfolio} \\ \text{Nominal} \\ \text{Foreign portfolio} \\ \text{Housing supply} \\ \text{Housing demand} \end{bmatrix}. \tag{26}$$

The structural shocks have the properties $E[v_t] = 0$, $E[v_t v_t'] = I$, and $E\left[v_t v_{t-s}'\right] = 0, \forall s \neq 0$. To be able to identify v_t using the z_t variables given in equation (24), the structural shocks v_t and the VAR disturbance vector e_t in equation (25), are related as

$$e_t = Gv_t, \tag{27}$$

where G is a matrix of unknown structural parameters that needs to be estimated. To identify the parameters in G, a set of long-run restrictions are imposed on the model's dynamics by defining (Blanchard and Quah (1989))

$$G = (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)\, H, \tag{28}$$

where the $\Phi_i s$ are once again the VAR autoregressive parameters defined in (25), and H is a matrix containing the unknown parameters that control the long-run properties of the model. To see that H indeed captures the long-run properties of the model, use equations (27) and (28) to write (25) in terms of the structural shocks v_t

$$\left(I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^K\right) \Delta z_t = \vartheta + (I - \Phi_1 - \Phi_2 - \ldots - \Phi_p)\, H v_t. \tag{29}$$

In long-run equilibrium, the growth rates of the variables are constant given by $\overline{\Delta z}_t$, so (29) reduces to

$$(I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)\, \overline{\Delta z}_t = \vartheta + (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)\, H v_t.$$

Upon rearranging

$$\overline{\Delta z} = (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)^{-1}\, \vartheta + H v_t, \tag{30}$$

shows that the effect of a structural shock on the variables in the long-run is given by H.

2.3 Restrictions

The restrictions embodied in H in equation (28) are summarised as

$$H = \begin{bmatrix} \lambda_1 & 0 & \lambda_3 & 0 & \lambda_5 & 0 & 0 \\ \psi_1 & \psi_2 & \psi_3 & 0 & 0 & \psi_6 & \psi_7 \\ \delta_1 & -\psi_2 & \delta_3 & 0 & \delta_5 & \delta_6 & \delta_7 \\ \gamma_1 & \gamma_2 & \gamma_3 & \gamma_4 & \gamma_5 & \gamma_6 & \gamma_7 \\ 0 & 0 & 0 & 0 & \varpi_5 & 0 & 0 \\ \varphi_1 & 0 & 0 & 0 & 0 & \varphi_6 & 0 \\ \kappa_1 & -\psi_2 & 0 & 0 & 0 & \kappa_6 & \kappa_7 \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} \\ H_{2,1} & H_{2,2} \end{bmatrix}, \tag{31}$$

where the partitioned matrices are

$$H_{1,1} = \begin{bmatrix} \lambda_1 & 0 & \lambda_3 & 0 & \lambda_5 \\ \psi_1 & \psi_2 & \psi_3 & 0 & \psi_5 \\ \delta_1 & -\psi_2 & \delta_3 & 0 & \delta_5 \\ \gamma_1 & \gamma_2 & \gamma_3 & \gamma_4 & \gamma_5 \\ 0 & 0 & 0 & 0 & \varpi_5 \end{bmatrix}, \qquad H_{1,2} = \begin{bmatrix} 0 & 0 \\ \psi_6 & \psi_7 \\ \delta_6 & \delta_7 \\ \gamma_6 & \gamma_7 \\ 0 & 0 \end{bmatrix},$$

$$H_{2,1} = \begin{bmatrix} \varphi_1 & 0 & 0 & 0 & 0 \\ \kappa_1 & -\psi_2 & 0 & 0 & 0 \end{bmatrix}, \qquad H_{2,2} = \begin{bmatrix} \varphi_6 & 0 \\ \kappa_6 & \kappa_7 \end{bmatrix}.$$

2.3.1 The Macroeconomy without the Housing Sector

The top left hand (5×5) block $H_{1,1}$, is the Fry, Hocking and Martin (2008) specification with some additional parameterisations. The first row of $H_{1,1}$ shows that output in the long-run is determined by shocks to aggregate supply in the goods market $(\lambda_1 > 0)$ and portfolio shocks to equities in Australia $(\lambda_3 > 0)$ and the US $(\lambda_5 > 0)$. The inclusion of the portfolio effects is consistent with a Tobin macroeconomic model whereby shocks to wealth affect the marginal efficiency of capital which impact upon output in the long-run (Sargent (1987), p.84). Eliminating these wealth effects from the output equation results in output operating at its natural rate where only output shocks affect output in the long-run.

The second row shows interest rates are affected by shocks to aggregate supply $(\psi_1 > 0)$ and demand $(\psi_2 > 0)$ in the goods market, Australian portfolio shocks $(\psi_3 > 0)$, US portfolio shocks $(\psi_5 > 0)$, but not nominal shocks.

The third row shows that Australian real equity prices are affected by aggregate supply shocks $(\delta_1 > 0)$ and demand shocks $(-\psi_2 < 0)$ in the goods market, portfolio shocks in Australia $(\delta_3 > 0)$ and the US $(\delta_5 > 0)$. The cross-equation restriction that the effects of aggregate demand shocks in the interest rate and equity equations are equal, but opposite in signs arises from real equity prices being determined by present value levels.

The fourth row shows that the aggregate price level in the goods market is affected by all shocks.

The final row of $H_{1,1}$ shows that real foreign equity prices are exogenous. This restriction is based on purchasing power parity being satisfied in the long-run whereby an increase in the domestic price is perfectly outweighed by a depreciation of the Australian currency.

2.3.2 The Housing Sector to the Macroeconomy

The $H_{1,2}$ block represents the long-run effects of housing supply and demand shocks on the first five macroeconomic variables in z_t in (24). Real output in the goods market and the real foreign price of equities are unaffected by supply and demand shocks in the housing market.

Interest rates are however, affected by shocks to housing supply ($\psi_6 \gtrless 0$) and demand ($\psi_7 > 0$). The effects of a housing supply shock on interest rates is ambiguous, as an increase in housing supply lowers house prices with the net effect on wealth dependent on the housing demand elasticity. The effects of housing demand shocks on the interest rate are expected to be positive as a result of wealth and credit channels. The total value of housing increases through simultaneous increases in house prices and the stock of housing. This, in turn, stimulates wealth which adds to aggregate demand in the goods market and causes the interest rate to increase. The second linkage is the credit channel whereby increases in the price of housing caused by the initial increase in housing demand, increases the demand for credit to finance the purchase of housing, putting direct pressure on the interest rate as the cost of borrowing rises.

The third row of $H_{1,2}$ shows that real Australian equities are affected by housing supply ($\delta_6 > 0$) and demand ($\delta_7 \gtrless 0$) shocks. The effect of housing supply shocks on Australian equities is expected to be positive as expansions in housing supply coincide with a booming economy and dividend payments as output rises, as reflected by a bullish share market. Wealth effects may also be positive if increases in home equity of consumers flow through to the share market. The effect of housing demand on Australian shares in ambiguous as there is both a substitution effect and a wealth effect working in opposite directions. A positive housing demand shock represents a substitution away from Australian shares, into another class of assets namely housing, causing a fall in the price of shares in the long-run. However, there is a positive wealth effect caused by the housing demand shock as discussed immediately above that can also further stimulate the demand for other forms of wealth, including equity investment, particularly as dividends are likely to increase as output rises.

The aggregate price level in the goods market is affected by the housing demand shock through an increase in house prices which feeds positively into the aggregate price level ($\gamma_7 > 0$). The corresponding channel from housing supply shocks to the aggregate price level are likely to flow through to the price level if the cost of constructing housing increases ($\gamma_6 > 0$). However, this channel is presumably less direct and potentially even insignificant.

2.3.3 The Macroeconomy to the Housing Sector

The $H_{2,1}$ block shows how the non-housing macroeconomic shocks affect housing costs and housing prices in the long-run. The first row of $H_{2,1}$ represents the long-run cost function in (22) whereby aggregate supply shocks affect real output which impact upon the housing cost function.

The last row of $H_{2,1}$ represents the macroeconomic shocks in the long-run house price equation in (23). The house price is a function of aggregate supply shocks ($\kappa_1 > 0$) and aggregate demand shocks in the goods market ($\kappa_2 < 0$). The aggregate demand shock in the goods market imposes a cross equation restriction through the interest rate. As aggregate demand shocks in the goods market raise the nominal interest rate by ψ_2, from the q theory of housing investment given by (23), there is a corresponding fall in the house price equal to $\kappa_2 = -\psi_2$.

2.3.4 The Housing Sector to the Housing Sector

The last block is $H_{2,2}$, identifies the long-run effects of housing supply and demand shocks on house costs and prices. Housing costs are a function of own shocks. As (22) represents a long-run housing cost function, a negative shock to house costs constitues a downward shift in the housing supply function whereby the cost of housing becomes lower for each level of real output. To ensure that a housing supply shock is indeed a positive shock in that the supply of housing increases, the normalisation $\varphi_6 < 0$, is adopted so an increase in house supply is represented by a fall in housing costs.

The final row of $H_{2,2}$ is the long-run house price equation in equation (23), whereby both housing supply ($\kappa_6 < 0$) and demand ($\kappa_7 > 0$) shocks affect the price of housing.

2.3.5 Short Run

Whilst a number of restrictions are imposed on the relationships amongst the variables in the long-run, no such restrictions are imposed on the short run dynamics, with all shocks affecting all 7 variables in the short-run.

2.4 Identification

The total number of long-run parameters to be estimated in H in equation (31) is 26. By not imposing the two cross-equation restrictions

$$\delta_1 = -\psi_2, \quad \kappa_2 = -\psi_2, \tag{32}$$

results in 28 long-run parameters to be estimated. Using equation (27), the variance-covariance matrix of the VAR residuals is

$$\Omega = E\left[e_t e_t'\right] = GG', \tag{33}$$

as $E\left[v_t v_t'\right] = I$. Now using equation (28)

$$\Omega = \left(I - \Phi_1 - \Phi_2 - \ldots - \Phi_K\right) HH' \left(I - \Phi_1 - \Phi_2 - \ldots - \Phi_K\right)'. \tag{34}$$

There are $N(N+1)/2 = 7 \times 8/2 = 28$ unique elements of Ω. As the $\Phi_i s$ are determined by the VAR, this leaves a maximum of 28 long-run parameters that can be identified. This indeed corresponds to the unconstrained version of the model while the constrained model results in two over-identifying restrictions.

3 Econometric Methods

The parameters of the SVAR are estimated using maximum likelihood methods. The log-likelihood for observation t is given by

$$\ln L_t = -\frac{N}{2}\ln(2\pi) - \frac{1}{2}\ln|\Omega|^{-1} - \frac{1}{2}e_t'\Omega^{-1}e_t, \tag{35}$$

where $N = 7$ is the number of equations, and the (7×1) VAR disturbance vector e_t is defined from (25) as

$$e_t = \left(I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^K\right)\Delta z_t - \vartheta. \tag{36}$$

The variance-covariance matrix of e_t is given by (34). The full set of parameters consist of the "mean" parameters $\{\Phi_1, \Phi_2, \cdots, \Phi_K, \vartheta\}$ and the 26 "variance" parameters contained in H given in (31).

The full log-likelihood for a sample of size T is defined as

$$\ln L = \sum_{t=1}^{T} \ln L_t. \tag{37}$$

As a result of the normality assumption of e_t, the information matrix is block diagonal between the mean and the variance parameters. This implies that asymptotically efficient parameter estimates are obtained by estimating the model in two steps. In the first step, the VAR in (25) is estimated by maximum likelihood methods to yield estimates of the mean parameters, denoted as

$$\left\{\widehat{\Phi}_1, \widehat{\Phi}_2, \cdots, \widehat{\Phi}_K, \widehat{\vartheta}\right\}. \tag{38}$$

As the explanatory variables in each equation is the same, these estimates are simply achieved by estimating each equation separately by ordinary least squares. In the second step, the variance parameters in H are estimated conditional on the mean parameter estimates in (38). Formally this involves solving the following first order condition

$$\widehat{\Omega} = \left(I - \widehat{\Phi}_1 - \widehat{\Phi}_2 - \ldots - \widehat{\Phi}_K\right) \widehat{H}\widehat{H}' \left(I - \widehat{\Phi}_1 - \widehat{\Phi}_2 - \ldots - \widehat{\Phi}_K\right)', \tag{39}$$

for the elements in H, where $\widehat{\Omega}$ is the variance-covariance matrix of the estimated residuals $\widehat{e}_t$ obtained in the first step and $\widehat{H}$ represents the matrix of estimated long-run parameter estimates that are computed in the second step. In computing $\widehat{H}$, as (39) represents a nonlinear system of equations in terms of the parameters in H, a gradient algorithm is used based on the optimisation procedure MAXLIK in GAUSS version 8.0, with all gradients evaluated numerically.

4 Data

The data used to estimate the SVAR are quarterly beginning March 1980 and ending June 2008, a total of 114 observations. The variables are real GDP (y_t), the 3 month bank accepted bill rate (r_t), the real Australian S&P/ASX200 share price index (s_t), the consumer price index (p_t), and the real foreign S&P500 share price index expressed in Australian dollars (f_t), real housing construction costs (c_t) and real house prices (p_h). The data are presented in Figure 1. Further details on data sources are contained in the Appendix A.

Housing construction costs are based on the Australian Bureau of Statistics (ABS) price index of materials used in house production. These costs contain the inputs used in the Australian housing construction industry. A component of costs not included is

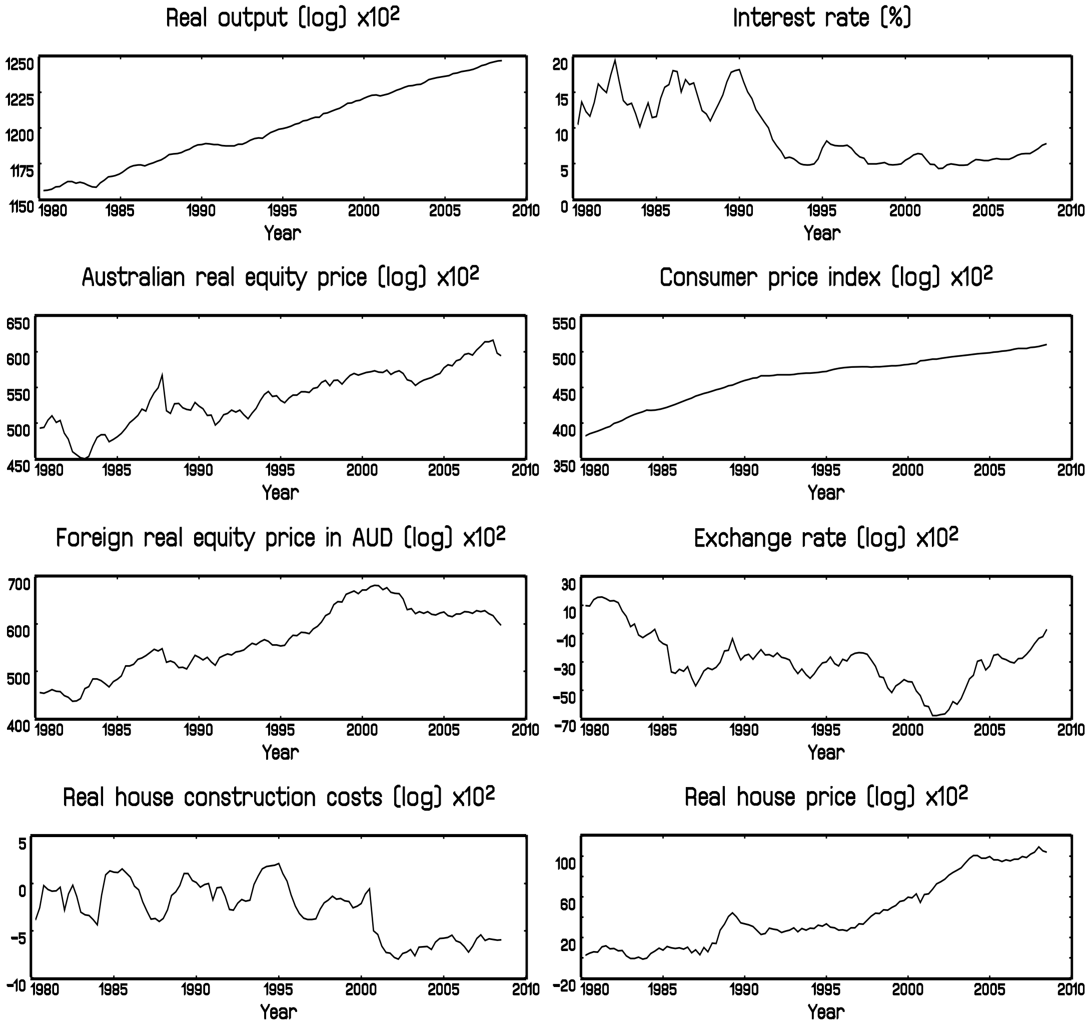

Figure 1: Data series used to estimate the SVAR model for Australia, March 1980 to June 2008.

wage costs. These costs are not included here as information on average weekly earnings for employees in the construction industry is not available for the total sample period considered here.

The availability of house price data for Australia poses challenges for conducting empirical work. Abelson and Chung (2005) provide a detailed overview of the issues surrounding the quality and construction of house prices. The two main sources of quarterly house price indices come from the ABS and the Real Estate Institute of Australia (REIA). The ABS changed the methodology in constructing the house price index in September of 2005, which was backdated officially to 2002. This change in the construction of the house price index makes it difficult to conduct analyses, particularly as the change in methodology overlaps with the period considered by some commentators as a bubble period in real estate markets. It is possible to obtain ABS data prior to 2002, but again this is based on a different method of calculation. To avoid the possibility of the detection of spurious house price overvaluation in the empirical analysis because of changes in the construction of the underlying index, the REIA series is used in this paper. A possible drawback is that compositional changes are not accounted for as they are in the ABS series. Most empirical papers focussing on the macroeconomy for Australia use either the REIA (Bodman and Crosby (2003)) series or the ABS (Otto (2007)) series.

The REIA house price data consist of indices on the median house prices of cities in Australia. An overall house price index is constructed as a weighted average of the house prices of cities with weights: Adelaide 0.103; Brisbane 0.144; Canberra 0.031; Melbourne 0.299; Perth 0.113 and Sydney 0.309. Darwin and Hobart are excluded as their median house prices are not collated until midway through the sample period. Their omission is not expected to affect the construction of the overall series greatly, as their weightings are relatively small. The choice of weights is based on a rescaling of those adopted in Abelson and Chung (2005) as a result of the exclusion of Darwin and Hobart from the house price index used here.

To convert housing construction costs and house prices into real terms, the appropriate deflator from the q theory model of housing investment in Section 2 is the price of land. Obtaining a reliable series to represent the cost of land for housing over the sample period proved to be difficult. The available time series are mostly discontinued or not updated in the mid 2000's. Voukelatos (2007) uses a proxy for land prices based on rural land price data from the Agricultural Bureau of Agricultural and Resource Economics, but this series was discontinued in June 2006. Data on rateable land values are also available, but only for the middle of the sample period. To circumvent these problems several possible solutions were explored. The rural land costs were spliced onto the rateable land values data for the start of the period, while the end period was obtained by constructing a small dynamic forecasting model to predict house land prices over the remaining period.[1] None of these solutions proved to be satisfactory. In the end, the simplest strategy is adopted, where the land cost of housing is proxied by the aggregate price index, as given by the CPI. This has the nice interpretation that housing construction costs and house prices are now defined relative to the CPI, which makes the deflation of each series comparable.

To capture a number of structural breaks in the Australian economy during the sample period, a set of dummy variables are also included in the VAR in (25). The structural breaks consist of the 1987 stock market crash in September, the sharp recovery in real house prices in June of 1988, and the effects of introducing the GST in September of 2000, and its subsequent effect in the next quarter. Some other types of stuctural breaks also investigated are the dot-com crisis in 2000 and the first home-buyers scheme in July of 2000. The inclusion of dummy variables to allow for these structural breaks does not change the qualitative results. This is not too surprising as the GST dummy variables in September and December of 2000 are already included, making it difficult to capture all of the changes occuring in the Australian economy during 2000.

5 Empirical Results

Before estimating the SVAR model, all variables in (24) are expressed in natural logarithms and scaled by 100. The maximum likelihood long-run parameter estimates of the parameters in (31) are contained in Table 2. In maximising (37) it is found that a lag structure of $K = 2$, suffices. The maximum likelihood estimates of the VAR parameters in Φ_1 and Φ_2 are not reported. Instead the unconstrained and constrained

[1] The rateable land values data begin 1984 and end 2004, when the series was discontinued. This data was kindly provided by Bryan Kavanagh from the Land Values Research Group, which, in turn, was compiled from the Commonwealth Grants Commission and ABS Cat. 5204 Table 83.

estimates of the residual variance-covariance matrix Ω are reported. The unconstrained estimate obtained from the (unconstrained) VAR residuals is

$$\widehat{\Omega}_1 = \begin{bmatrix} 0.364 & 0.641 & 0.440 & -0.018 & 0.536 & 0.031 & -0.167 \\ 0.641 & 46.389 & -6.214 & -0.175 & -0.583 & 0.488 & 0.240 \\ 0.440 & -6.214 & 29.078 & -0.323 & 19.492 & 0.024 & 1.017 \\ -0.018 & -0.175 & -0.323 & 0.259 & -0.239 & -0.239 & -0.330 \\ 0.536 & -0.583 & 19.492 & -0.239 & 41.762 & 0.250 & 0.142 \\ 0.031 & 0.488 & 0.024 & -0.239 & 0.250 & 0.367 & 0.285 \\ -0.167 & 0.240 & 1.017 & -0.330 & 0.142 & 0.285 & 5.263 \end{bmatrix}.$$

The constrained estimate obtained from estimating the model by an iterative maximum likelihood routine is

$$\widehat{\Omega}_0 = \begin{bmatrix} 0.364 & 0.638 & 0.442 & -0.017 & 0.502 & 0.030 & -0.164 \\ 0.638 & 46.369 & -6.214 & -0.167 & -0.913 & 0.476 & 0.254 \\ 0.442 & -6.214 & 29.126 & -0.339 & 0.079 & 0.045 & 1.030 \\ -0.017 & -0.167 & -0.339 & 0.261 & -0.285 & -0.241 & -0.342 \\ 0.502 & -0.913 & 20.079 & -0.285 & 42.533 & 0.261 & 0.598 \\ 0.030 & 0.476 & 0.045 & -0.241 & 0.261 & 0.366 & 0.301 \\ -0.164 & 0.254 & 1.030 & -0.342 & 0.598 & 0.301 & 5.259 \end{bmatrix}.$$

A test of the two cross-equation restrictions imposed on the long-run structure of the model in (32) is given by the likelihood ratio statistic

$$LR = -T\left(\ln\left|\widehat{\Omega}_0\right| - \ln\left|\widehat{\Omega}_1\right|\right),$$

where $\widehat{\Omega}_0$ and $\widehat{\Omega}_1$ are given immediately above. The value of the statistic is 0.251. Under the null hypothesis that the constraints are satisfied, the likelihood ratio statistic is asymptotically distributed as χ^2 with two degrees of freedom. The asymptotic p-value is 0.882, showing that the restrictions are not rejected by the data at conventional significance levels. The associated unconstrained point estimates are $\psi_2 = -2.743$, $\delta_2 = 2.547$ and $\kappa_2 = 2.810$, which are numerically close to their constrained estimates reported in Table 2.

5.1 Are House Prices Overvalued?

To be able to identify if real house prices are overvalued or not, it is necessary to identify a benchmark house price that corresponds to a "normal" price. The approach adopted is to decompose the real house price in terms of its conditional expectation and an idiosyncratic shock according to

$$p_{h,T+J} = E_T\left[p_{h,T+J}\right] + \eta_{T+J}. \tag{40}$$

Table 2:

Long run parameter estimates of the SVAR model with long-run restrictions given in equation (31). Standard errors and p-values are based on QMLE.

Variable	Shock	Parameter	Estimate	Std. err.	Prob.
Output	Agg. supply	λ_1	0.944	0.060	0.000
	Aust. portfolio	λ_3	0.050	0.095	0.600
	US portfolio	λ_5	0.397	0.065	0.000
Interest	Agg. supply	ψ_1	3.311	1.138	0.004
	Agg. demand	ψ_2	2.743	0.176	0.000
	Aust. portfolio	ψ_3	8.184	1.040	0.000
	US portfolio	ψ_5	n.a.	n.a.	n.a.
	House supply	ψ_6	3.011	1.148	0.009
	House demand	ψ_7	2.502	1.325	0.059
Aust. equity	Agg. supply	δ_1	3.312	0.567	0.000
	Agg. demand	$\delta_2 = -\psi_2$	-2.743	0.176	0.000
	Aust. portfolio	δ_3	2.123	0.860	0.013
	US portfolio	δ_5	3.437	0.679	0.000
	House supply	δ_6	0.118	0.533	0.824
	House demand	δ_7	-4.571	0.490	0.000
Price	Agg. supply	γ_1	-0.791	0.217	0.001
	Agg. demand	γ_2	0.780	0.142	0.000
	Aust. portfolio	γ_3	1.147	0.217	0.000
	Nominal	γ_4	1.412	0.104	0.000
	US portfolio	γ_5	-0.294	0.209	0.160
	House supply	γ_6	0.401	0.234	0.087
	House demand	γ_7	0.448	0.244	0.067
US equity	US portfolio	ϖ_5	8.367	0.647	0.000
House cost	Agg. supply	φ_1	0.337	0.082	0.000
	House supply	φ_6	-0.771	0.061	0.000
House price	Agg. supply	κ_1	1.734	0.412	0.000
	Agg. demand	$\kappa_2 = -\psi_2$	-2.743	0.176	0.000
	House supply	κ_6	-0.740	0.347	0.033
	House demand	κ_7	1.704	0.301	0.000
$\ln L = -1501.246$					

The first term $E_T[p_{h,T+J}]$, is the conditional expectation of the real house price at $T+J$ based on information up to T. The choice of T is March 2002, with J representing a counter corresponding to observations from June 2002 to June 2008. The conditional expectation is computed using the moving average representation of the model in (25) with all parameters replaced by their maximum likelihood estimates. If there are no shocks present in the Australian economy over the period 2002 to 2008 the actual price equals the conditional expectation. For this reason the conditional expectation is commonly referred to as the baseline projection. As the conditional expectation also represents the "rational" forecast as in all available information is being used to generate the "best" forecast of the real house price, it is also referred to as the "market fundamental" house price at each point in time as this would be the price that would occur in the absence of shocks.

The second term η_{T+J} in (40) summarises the historical shocks causing the actual house price to deviate from its conditional expectation. For the estimated SVAR model, η_{T+J} is decomposed into the 7 shocks identified in the model given in (26). Interpreting the conditional expectation as the market fundamental price, $p_{h,T+J} > E_T[p_{h,T+J}]$ provides a measure of the overvaluation of the real house price relative to its market fundamental price. The difference between the actual and the market fundamental values can be broken down into the individual contributions of each historical shock identified. More details on calculating the historical decomposition for this class of models are given in Fry, Hocking and Martin (2008).

The results of decomposing the real house price into its market fundamental and underlying shocks are given in Figure 2. Figure 2(a) shows strong evidence that real house prices operate near their market fundamental levels at the beginning of the decomposition in 2002, but quickly begin to diverge. This graph highlights that there are two periods of overvaluation; the first is prior to 2006 where the size of the overvaluation peaks in December 2003 with a value of just over 20%. The second period is post 2006 where the overvaluation peaks in December 2007 at around 12%. Distinguishing between these two periods is important as it is shown below that the factors driving house prices varies between them.

The drivers of the overvaluation in house prices over the period, the components of η_{T+J} in (40), are highlighted in Figures 2(b) to 2(h) which decompose the overvaluation

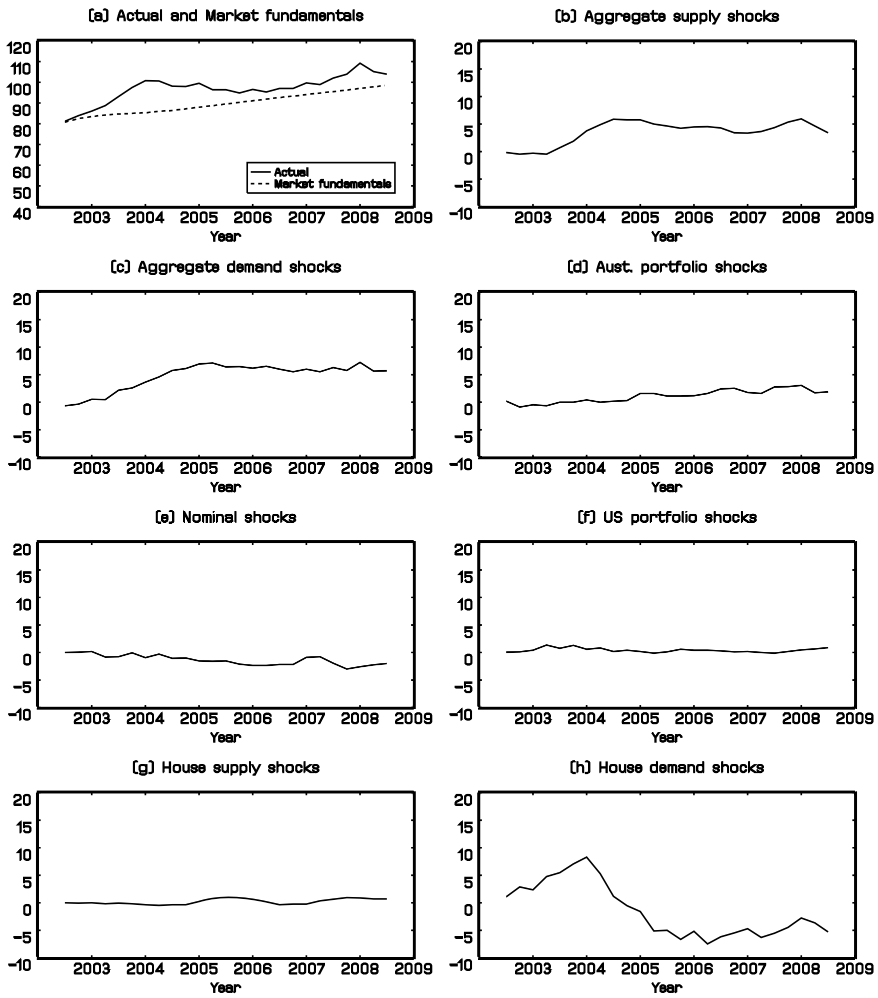

Figure 2: Historical decomposition of real house prices (logs), June 2002 to June 2008.

in terms of the 7 structural shocks in the SVAR. The results point to two main sets of factors driving the overvaluation: housing market shocks arising primarily from housing demand, and goods market shocks arising from both aggregate demand and aggregate supply shocks. The overvaluation in the pre-2006 period is dominated by housing demand shocks which contribute to about half of the overvaluation, while the rest is evenly split between aggregate demand and aggregate supply shocks in the goods market. In the second post-2006 period, the overvaluation is practically all explained by goods market shocks in aggregate demand and aggregate supply. Interestingly, housing demand shocks during this period are negative, but are nonetheless dominated by the shocks in the goods market to demand and supply.

5.2 The Role of Housing Market Shocks

5.2.1 Demand

The dynamics of a positive housing demand shock are given in Figure 3. This shock causes an instantaneous increase in the real price of housing. There are further increases in house prices which taper off after a couple of years, settling at a level comparable to the initial increase. The increase in housing demand causes an increase in the supply of housing and a corresponding increase in housing costs as the economy moves upwards along the housing cost function in (22). The effect on the supply of housing and hence housing costs dissipates after two years as the supply of housing reverts back to its long-run level, which by construction is independent of housing demand shocks.

Table 3 shows that housing demand shocks dominate movements in the real house price in the short-run, explaining just under 70% of its variance. This role diminishes in relative importance and by the long-run its contribution is just over 20%.

The macroeconomic effects of the housing demand shock are similar to an aggregate demand shock in the goods market. There are increases in output and prices in the goods market, together with increases in the nominal interest rate.[2] There is actually a small fall in the goods market price, but this is temporary and potentially reflects the contractionary effects of an increase in the interest rate. The interest rate increase is driven by the increase in demand for liquidity arising from the increase in real output, and the increase in the demand for credit arising from the need to finance the housing demand shock.

The simultaneous increases in the nominal interest rate and the goods market price cause a fall in domestic real equity values, which dominate the positive dividend effect arising from the increase in output. Real US equity values also fall initially. This fall arises from the increase in domestic prices and an immediate appreciation of the Australian dollar. The exchange rate eventually depreciates as the dollar reverts back to its purchasing power parity level in the long-run, leaving the US equity price at its pre-shock level.

[2] Jarociński and Smets (2008) find similar results for the US with output and the interest rate both increasing over the interemediate run to a housing demand shock.

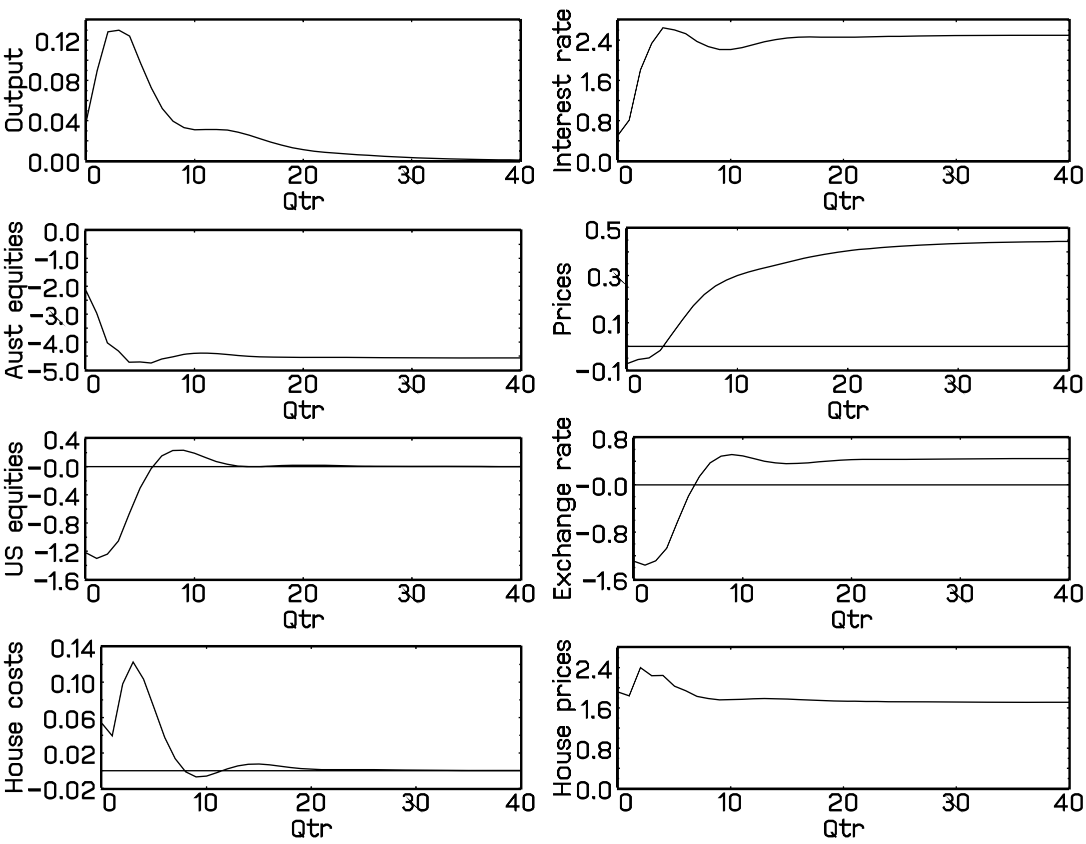

Figure 3: Impulse response functions of a one standard deviation housing demand shock.

Table 3:
Variance decompositions of housing costs and prices
in terms of shocks; percentage of total.

Variable		Agg. supply	Agg. demand	Aust. portfolio	Nominal	US portfolio	House supply	House demand
House costs	1	3.658	1.214	2.887	20.368	9.581	61.514	0.778
	4	8.008	5.001	2.488	4.990	2.215	76.084	1.215
	8	14.777	2.334	1.183	2.580	1.034	77.269	0.824
	12	15.127	1.590	0.827	1.761	0.699	79.447	0.550
	∞	16.048	0.000	0.000	0.000	0.000	83.952	0.000
House prices	1	5.981	15.431	7.493	0.083	0.018	1.159	69.835
	4	17.470	23.348	2.959	1.903	0.545	4.210	49.564
	8	20.748	37.257	1.871	2.329	0.284	3.987	33.524
	12	20.206	43.020	1.353	1.700	0.187	3.957	29.577
	∞	21.477	53.756	0.000	0.000	0.000	3.915	20.852

5.2.2 Supply

The effects of a positive housing supply shock presented in Figure 4, show simultaneous falls in housing costs and housing prices. There are further falls over time in housing costs and prices with both variables settling at lower values in the long-run. However, from the variance decomposition of the real house price presented in Table 3, the contribution of real house supply shocks in small, less than 5%, both in the short-run and the long-run.

The housing supply shock has positive macroeconomic effects on output and prices in the goods market, as well as the nominal interest rate. The effect on real output in the goods market is temporary with real output returning to its long-run level. In contrast to the housing demand shock, the effect of the housing supply shock is to raise real equity values in Australia. The increase in the domestic price coincides with a depreciation of the exchange rate with the net effect being an increase in real US equity values in Australia as well. The size of the depreciation falls over time resulting in US real equity values in Australia falling as the exchange rate returns to its purchasing power parity level.

5.3 The Role of Goods Market Shocks

5.3.1 Demand

The effects of a positive shock in aggregate demand in the goods market are given in Figure 5. There are simultaneous increases in output and the price in the goods market. The goods market price continues to increase over time to a higher level in the long-run, whereas output returns to its long-run natural rate level. There is an increase in the nominal interest rate which reduces the present value of equities causing a fall in the real equity price in Australia. The real US equity price also falls as a result of the increase in the domestic price level as well as the appreciation of the Australian dollar caused by the aggregate demand shock. The effect on US real equity prices is temporary though as the exchange rate eventually depreciates by the full amount of the increase in the goods market price thereby restoring purchasing power parity.

The aggregate demand shock in the goods market affects both the supply and the demand in the housing market. The increase in goods market output arising from the aggregate demand shock, raises costs in the housing market as the economy moves

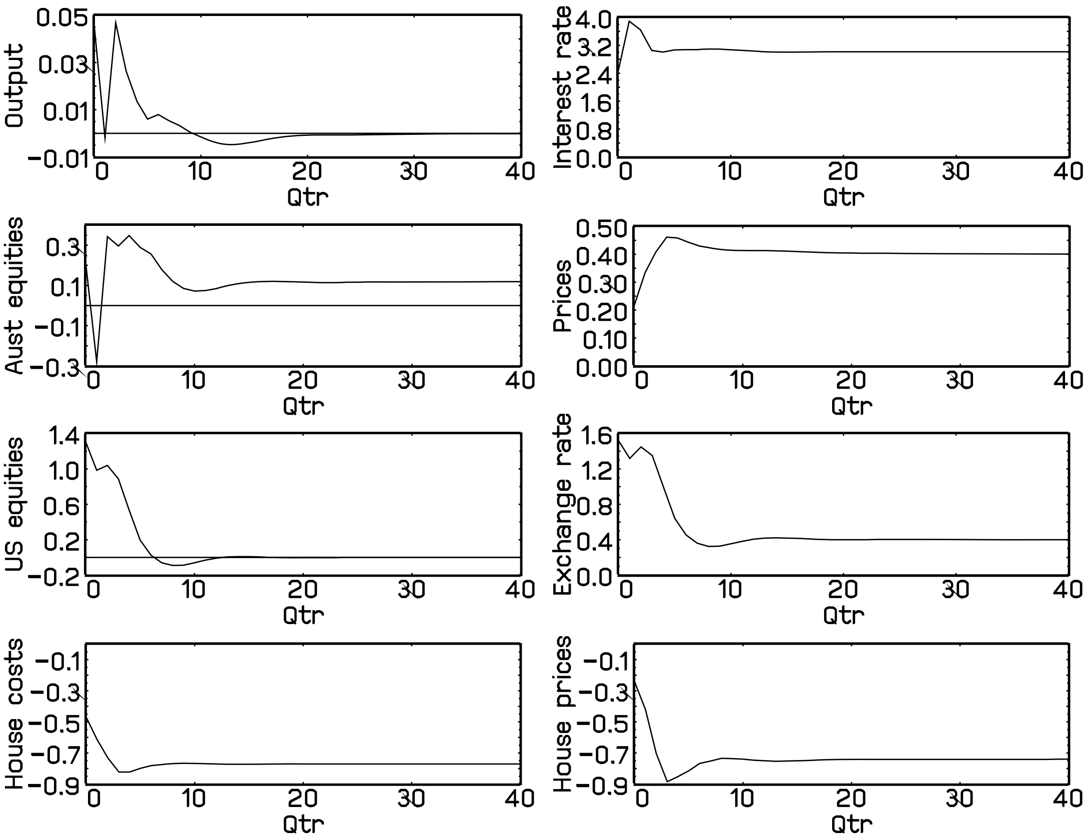

Figure 4: Impulse response functions of a one standard deviation housing supply shock.

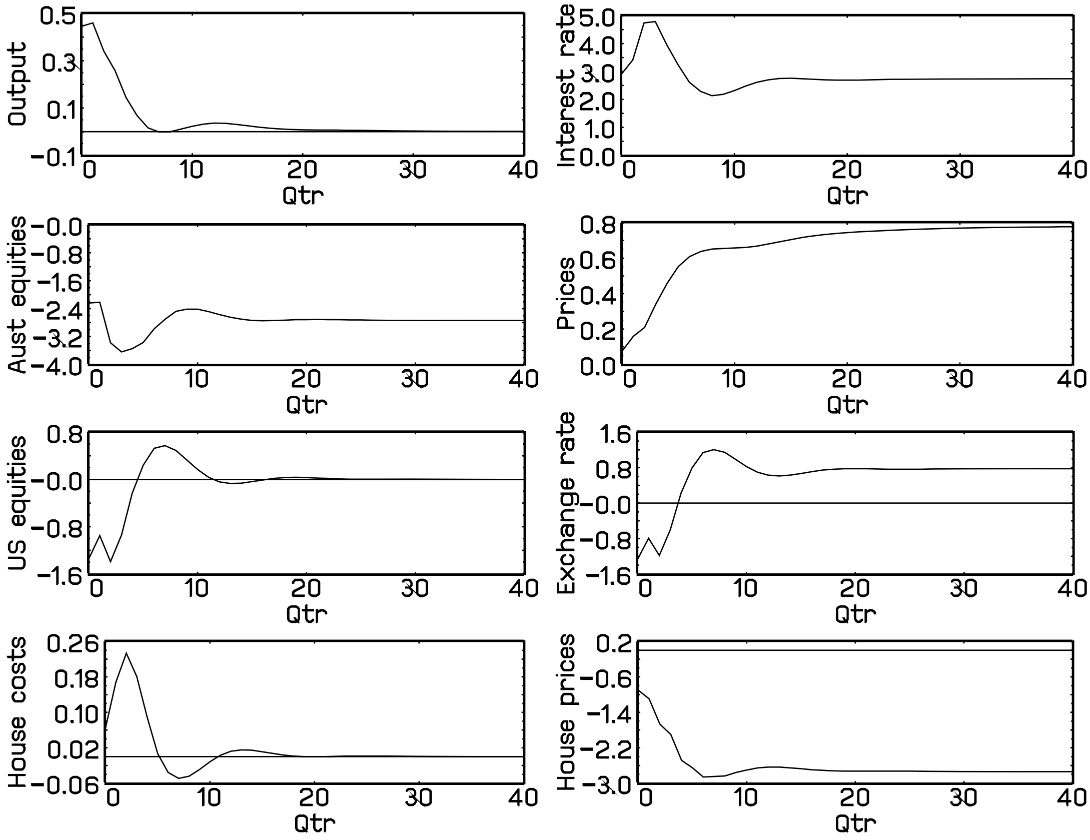

Figure 5: Impulse response functions of a one standard deviation aggregate demand shock in the goods market.

along its housing cost function. This effect is temporary as the goods market output returns to its long-run level. In contrast, the positive shock in aggregate demand in the goods market causes a substitution effect away from housing demand through the increase in the interest rate which permanently lowers real house prices. From Table 3, in the long-run the goods market aggregate demand shock dominates all other shocks with its contribution to the variance of real house being over 50%.

5.3.2 Supply

The effects of a positive shock in aggregate supply are given in Figure 6. Output in the goods market increases while its price falls. There is an initial fall in the nominal interest rate which quickly increases as a result of the positive real wealth effects from the goods market. This is caused by the fall in the goods market price, as well as from the dividend effects from the expansion in real output which raises the real value of equities in Australia. There are also positive real wealth effects from US equity values as the real US equity price increases as a result of the fall in the domestic goods price and the depreciation of the Australian dollar. In the long-run the fall in the goods market price causes the Australian dollar to appreciate returning the currency to its purchasing power parity level thereby eroding any wealth effects from US equities.

The aggregate supply shock in the goods market has a permanent positive effect on housing costs, with housing costs tending to overshoot their long-run level after about a year. The effects on the housing market of a positive goods market shock to aggregate supply is equivalent to a negative housing supply shock, with real house prices increasing over time. This effect dominates the negative effect on real house prices of higher interest rates, with the housing market characterised in the long-run by both higher costs and prices. The relative importance of shocks to aggregate supply in the goods market are highlighted by the variance decompositions reported in Table 3 which shows that it expalains just over 20% of variation in real house prices.

5.4 The Importance of Equity Wealth Effects

To gain insight into the nature of the shocks in the goods market over the period 2002 to 2008, Figure 7 gives the historical decomposition of the interest rate. Figure 7(a) shows that the gradual upward trend in the interest rate has led to an increasing divergence from its market fundamental level which has drifted downwards over time. It is clear from inspection of the shocks in Figures 7(b) to 7(h) that this divergence is primarily the result of portfolio shocks in the Australian equity market which have stimulated aggregate demand in the goods market through positive equity wealth effects.

Inspection of the historical decomposition of the real Australian equity price in Figure 8 reveals that for the post 2006 period the real equity price was overvalued for most of this period, with the overvaluation mainly a function of portfolio shocks in the Australian equity market and housing demand shocks. By contrast, Figure 8(a) also shows that the real Australian equity price was undervalued prior to 2006, a reflection of the aftermath of the dot-com crisis. Interestingly, there is an underlying negative effect from overseas on the domestic equity market with the effects of US portfolio shocks having a continual and growing negative impact on the Australian equity price over the full period of the decomposition, 2002 to 2008.

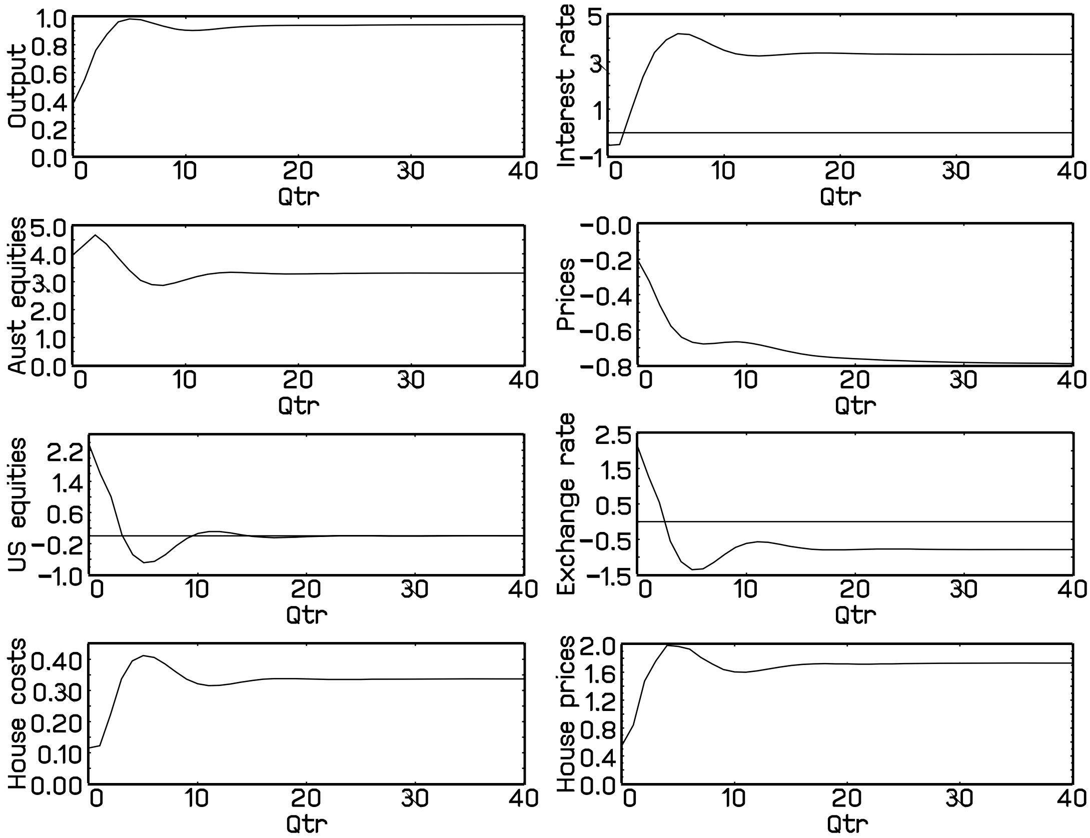

Figure 6: Impulse response functions of a one standard deviation aggregate supply shock in the goods market.

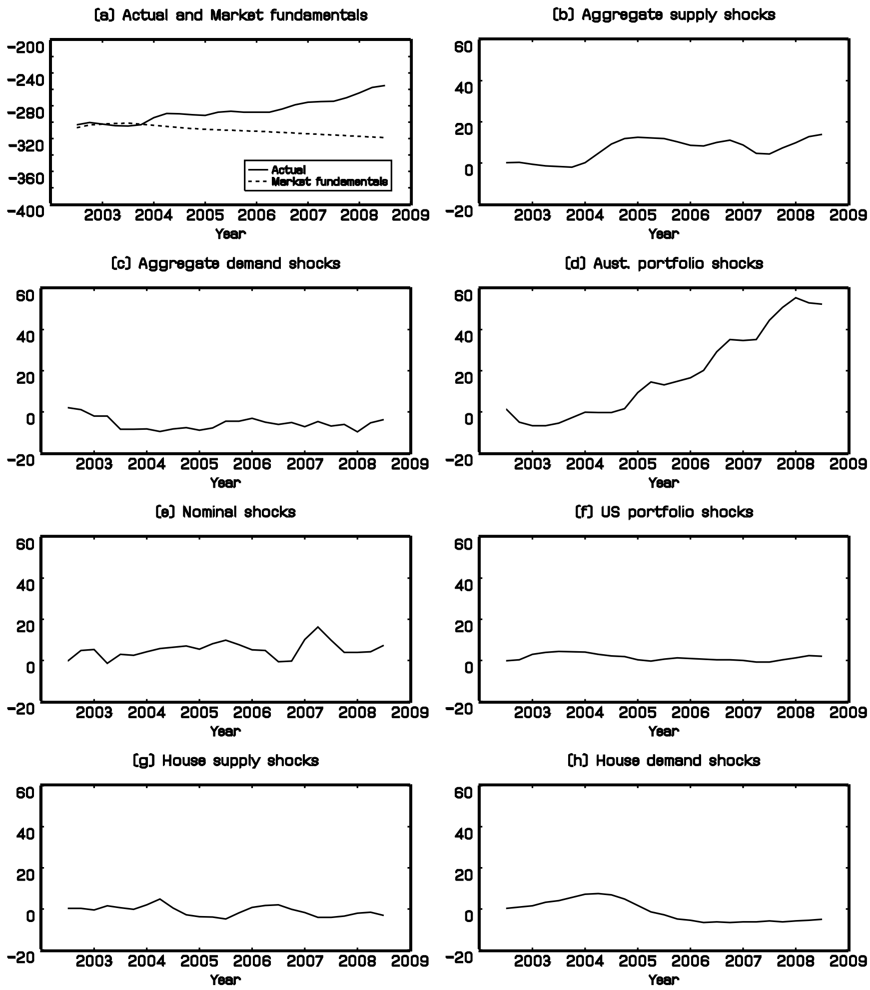

Figure 7: Historical decomposition of the nominal interest rate (logs), June 2002 to June 2008.

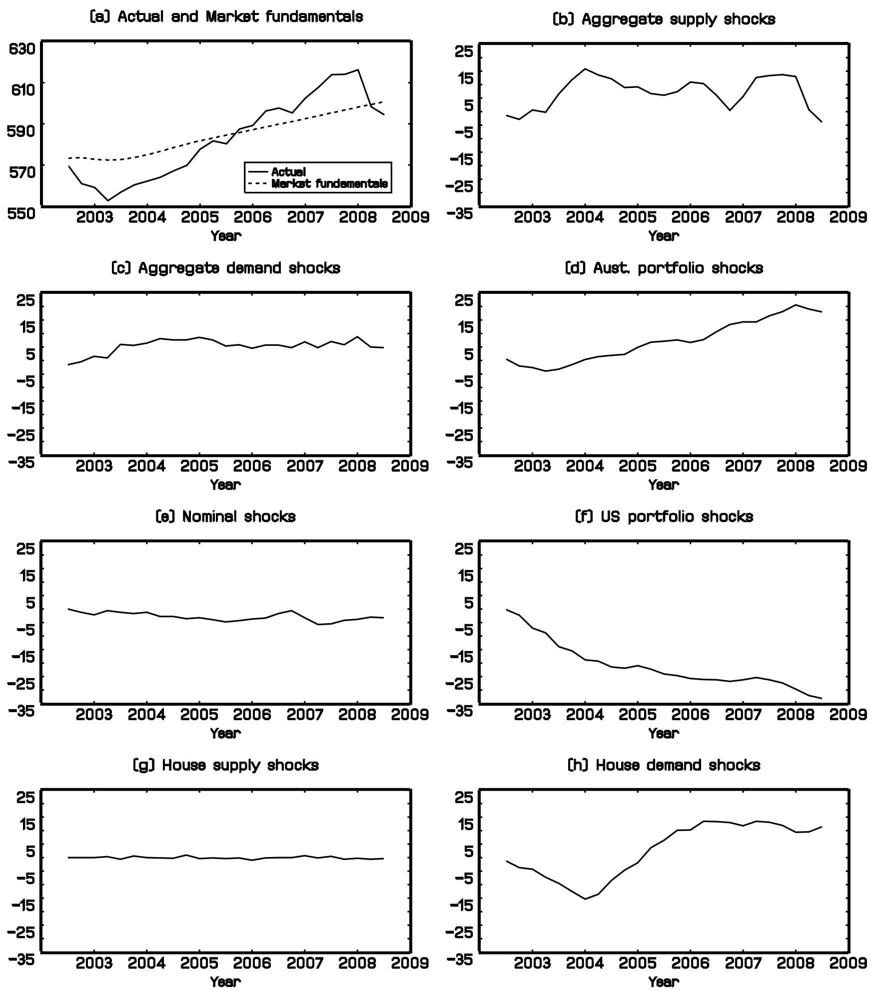

Figure 8: Historical decomposition of the Australian real equity price (logs), June 2002 to June 2008.

5.5 Implications for Monetary Policy

An implication of the results above is that the overvaluation of real house prices in Australia is not driven by the low interest rate policy, the so called Greenspan put, adopted by many central banks following financial market crises including the dot-com crisis (Goodhart (2008)). For Australia it is evident in fact from Figure 7, that interest rates are mostly above their market fundamental levels after the dot-com crisis. This observation further alludes to the importance of wealth effects in affecting the overvaluation in the real house price: Although in the partial equilibrium theoretical framework presented here there is an inverse relationship between interest rates and house prices, from the general equilibrium point of view of the SVAR the simultaneous occurrence of high interest rates (Figure 7a) and real house prices (Figure 2a) relative to their fundamentals is caused by wealth effects from Australian equity market shocks particularly post 2004 (Figure 7d), goods market shocks (Figures 7(b) and 7(e) and Figures 2(b) and (c)), or housing wealth shocks (first part of Figure 2(h)).

A further implication of the results concerns the recent cuts in the RBA's target rate. By June of 2008, the actual interest rate is 7.8%, which compares with the much lower market fundamental value of 4.125%, which is estimated as $100 \times \exp(-318.819/100)$. The recent moves by the RBA to lower the cash rate substantially are consistent with the estimated market fundamental interest rate in June of 2008.

6 Conclusions

The role of the housing sector and its interconnection with the macroeconomy has recently gained importance since the global economic events of 2008. In this paper a 7 variate macroeconomic model with a particular focus on the identification of housing supply and demand shocks, was developed. A Tobin's q model of housing investment was derived which provided a set of long-run restrictions on the model to identify these shocks. The model was used to determine whether real house prices in Australia diverged from their market fundamentals, as well as identifying the nature of the shocks underlying any observed divergence.

The empirical results showed that real house prices were overvalued over the period

2002 to 2008, peaking at about 20% by the end of 2003. The main determinants of the overvaluation prior to 2006, were housing demand shocks and to a lesser extent aggregate demand and supply shocks arising from the goods market. After 2006, it is the goods market shocks that dominate the overvaluation in house prices. The evidence shows that the demand and supply shocks in the goods market were characterised by wealth effects stemming from the Australian equity market. The empirical results also showed little support for the view that monetary policy contributed to the observed overvaluation of real house prices in Australia over this period.

The empirical results also showed evidence of overvaluation in other asset markets. In the bond market an increasing gap between the actual interest rate and its market fundamental level was identified, with the size of the gap being over 350 basis points by the end of the sample period in June 2008. This gap suggested that recent policies by the RBA to reduce the cash rate were consistent with moving actual interest rates into line with market fundamental levels. The results also showed overvaluation of the real equity price after 2006, but with the dramatic falls in equity market in 2008 the equity price was operating at, or even just below, its market fundamental price by June 2008.

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A Data Appendix

Table A1:
Data Sources and Codes

Variable	Database	Table/Code
GDP current prices, millions, s.a.	RBA	Table G11
GDP CVM, millions, s.a.	RBA	Table G11
CPI all groups	RBA	Table G02
Materials used in house production index	RBA	Table G03
Money market 90 day bank accepted bills	RBA	Table F01
Share price index Australia, S&P/ASX 200	dX database	FSPIAUASX200
Share price indices United States, S&P500	dX database	FSPIUSSP500
Exchange rate, USD per AUD	RBA	Table F11
Median house price index of established houses constructedfrom median house prices in Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney	Real Estate Institute of Australia	