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

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Abstract

A SVAR model is used to identify overvaluation in house prices in Australia from 2002 to 2008. An important feature is the development of a housing sector where long-run restrictions are derived from theory to identify housing demand and supply shocks. The results show strong evidence of overvaluation in real house prices, reaching a peak of just over 15% by the end of 2003. Factors driving the overvaluation are housing demand shocks before 2006, and macroeconomic shocks post 2006. Wealth effects from equity markets are also important. The results suggest that monetary policy is not an important contributor to 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 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>Housing(^1) Wealth (A$bn)</th>
<th>% of GDP(^2)</th>
<th>Equity(^3) Wealth (A$bn)</th>
<th>% of GDP(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>49.6</td>
<td>11.4%</td>
<td>190.7</td>
<td>43.70%</td>
</tr>
<tr>
<td>1996</td>
<td>1,169.0</td>
<td>202.9%</td>
<td>392.8</td>
<td>68.20%</td>
</tr>
<tr>
<td>2001</td>
<td>2,073.4</td>
<td>290.9%</td>
<td>732.8</td>
<td>102.80%</td>
</tr>
<tr>
<td>2006</td>
<td>3,452.9</td>
<td>319.7%</td>
<td>1,390.30</td>
<td>128.70%</td>
</tr>
</tbody>
</table>

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.


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 just over 15% above fundamentals by the end of 2003. Similar results are obtained by Bodman and Crosby (2004) who also find the level of overvaluation in Sydney is about 15% and for Brisbane as high as 25%, but are generally less than the results reported 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. During this second period house prices were overvalued by just under 12%. By the end of the sample (and in the midst of the global financial crisis) in June 2008, the real house price begins to approach its market fundamental level. 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 net cash flow according to the following objective function

\[
\max_{I(t)} \Pi(t) = \int_t^\infty e^{-R(s-t)} [P_h(s) F(h(s)) - P_h(s) I] \, ds,
\]

subject to the housing stock accumulation constraint

\[
\dot{h} = \psi(I) - \delta h,
\]

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, p.216)) and \( \delta \) is the depreciation rate. The model is easily expanded to allow for various types of taxes as well. The term \( P_h(s) F(h(s)) \) represents the value obtained from housing services with the form of \( F(\cdot) \) specified, and \( P_h(s) I \) is the expenditure associated with adding to the stock of housing. Assuming that house prices over time follow

\[
P_h(s) = P_h(t) e^{\pi(s-t)},
\]

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

\[
\max_{I(t)} \Pi(t) = \int_t^\infty e^{-R(s-t)} [P_h(t) e^{\pi(s-t)} F(h(s)) - P_h(t) e^{\pi(s-t)} I] \, ds,
\]

\[
= \int_t^\infty e^{-(R-\pi)(s-t)} [P_h(t) F(h(s)) - P_h(t) I] \, ds,
\]

\[
= P_h(t) \int_t^\infty e^{-(R-\pi)(s-t)} [F(h(s)) - I] \, ds.
\]

The current value Hamiltonian is

\[
V = P_h F(h) - P_h I + \lambda (\psi(I) - \delta h).
\]
The optimality conditions are (Kamien and Schwartz (1981))

\[ \frac{\partial V}{\partial I} = -P_h + \lambda \psi_I (I), \quad (6) \]

\[ \dot{\lambda} = (R - \pi) \lambda - \frac{\partial V}{\partial h} = (R - \pi) \lambda - P_h F_h + \lambda \delta, \quad (7) \]

\[ \dot{h} = \frac{\partial V}{\partial \lambda} = \psi (I) - \delta h. \quad (8) \]

Setting (6) to zero and rearranging gives

\[ P_h = \lambda \psi_I (I). \quad (9) \]

Assuming concave installation costs (Hayashi (1982, p.216)) with parameter \(0 < \gamma < 1\)

\[ \psi (I) = I^\gamma, \quad (10) \]

then

\[ \psi_I (I) = \gamma I^{\gamma - 1}, \]

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

\[ I = \left( \frac{P_h}{\lambda \gamma} \right)^{(\gamma - 1)^{-1}}. \quad (11) \]

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

\[ \dot{h} = \left( \frac{P_h}{\lambda \gamma} \right)^{\frac{\gamma}{\gamma - 1}} - \delta h. \quad (12) \]

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

\[ \dot{\lambda} = \dot{h} = 0. \quad (13) \]

This results in the following two equation system in terms of \( \lambda \) and \( h \),

\[ 0 = (R - \pi) \lambda - P_h F_h + \lambda \delta, \quad (14) \]

\[ 0 = \left( \frac{P_h}{\lambda \gamma} \right)^{\frac{\gamma}{\gamma - 1}} - \delta h. \]
As this system is recursive, $\lambda$ is immediately derived from the first equation in (14)

$$\lambda = \frac{P_h F_h}{R - \pi + \delta}.$$  \hspace{1cm} (15)

Alternatively, this equation is rearranged to give an expression for Tobin’s marginal $q$ (Hayashi (1982), p.217)

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

For simplicity, the function $F$ is specified as

$$F = \rho h,$$  \hspace{1cm} (17)

with unknown parameter $\rho$, so services from housing are expressed as a proportion of the housing stock, resulting in $F_h = \rho$.\(^1\) Using this result together with (16) in the second equation in (14), yields an expression for the long-run stock of housing

$$h = \frac{1}{\delta} \left( \frac{1}{q_m \gamma} \right)^{\frac{1}{1-\gamma}} = \frac{1}{\delta} \left( \frac{R - \pi + \delta}{\gamma \rho} \right)^{\frac{1}{1-\gamma}}.$$  \hspace{1cm} (18)

Now define Tobin’s average $q$ as (Hayashi (1982, p.217))

$$q_a = \frac{P_h}{L^\alpha C^{1-\alpha}},$$  \hspace{1cm} (19)

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 (19) this yields a solution for house prices in terms of land and construction costs, as well as the real interest rate net of depreciation; see also Madsen (2007) adopts a similar strategy in developing a model of housing for Australia. The price of housing becomes

$$P_h = \frac{\rho L^\alpha C^{1-\alpha}}{(R - \pi + \delta)}.$$  \hspace{1cm} (20)

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

$$p_h = \ln \rho + \alpha c - \ln (R - \pi + \delta),$$  \hspace{1cm} (21)

\(^1\)We thank a referee for suggesting this interpretation.
with \( p_h = \ln \left( \frac{P_h}{L} \right) \) representing the price of housing per the price of land and \( c = \ln \left( \frac{C}{L} \right) \) 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 (21) 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 \( \phi = \ln \left( 1 - \left( \pi - \delta / R \right) \right) \). In which case the long-run specification in (21) becomes

\[
\begin{align*}
  p_h &= \ln \rho + \alpha c - r - \phi. 
\end{align*}
\]

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 \(\alpha\). 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 for example, reduces house prices \(p_h\) by the same magnitude in the long-run. A similar result is obtained in Fry, Hocking and Martin in the case of equity markets, 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 assumption imposed on the relationship between \((\pi - \delta)\) and \(R\), it is not necessary from a long-run perspective to identify depreciation costs over time \(\delta\), 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 relative construction costs per the price of land \((c)\), is a function of real output \((y)\) according to

\[
\begin{align*}
  c &= \beta y, 
\end{align*}
\]

where \(\beta\) is the long-run cost parameter. Alternatively, using (23) to substitute out \(c\)
from (22) gives the long-run house price equation as
\[ p_h = \alpha \beta y - r + \phi. \] (24)

Equations (23) and (24) are used to identify the supply and demand 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 is based on augmenting the 5-variate SVAR model of Fry, Hocking and Martin (2008) to include the housing specifications in (23) and (24), as well as replacing the goods market price level with the inflation rate. This results in a 7-variate system containing the variables
\[ z = \{ y, r, s, \pi, f, c, p_h \}, \] (25)

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, \( \pi \) is the inflation rate in the goods market, \( f \) 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.\(^2\)

The dynamics of the macroeconometric model are represented in terms of a vector autoregression (VAR) with \( K \) lags
\[ (I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_K L^K) \Delta z_t = \vartheta + \epsilon_t, \] (26)

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

\(^2\)Other specifications to the macroeconomic model adopted here could also be entertained. One approach is to treat the interest rate as stationary. This strategy is not adopted as the assumption of stationarity is not consistent with the results from unit root tests applied to the data.
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:

$$v_t = \begin{bmatrix}
\text{Aggregate supply} \\
\text{Aggregate demand} \\
\text{Australian portfolio} \\
\text{Nominal} \\
\text{Foreign portfolio} \\
\text{Housing supply} \\
\text{Housing demand}
\end{bmatrix}. \quad (27)$$

The structural shocks have the properties $E[v_t] = 0$, $E[v_tv'_s] = I$, and $E[v_tv'_{t-s}] = 0, \forall s \neq 0$. To be able to identify $v_t$ using the $z_t$ variables given in equation (25), the structural shocks $v_t$ and the VAR disturbance vector $e_t$ in equation (26), are related as

$$e_t = Gv_t, \quad (28)$$

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))

$$G = (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K) H, \quad (29)$$

where the $\Phi_i$s are once again the VAR autoregressive parameters defined in (26), 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 (28) and (29) to write (25) in terms of the structural shocks $v_t$

$$(I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^K) \Delta z_t = \vartheta + (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K) Hv_t. \quad (30)$$

In long-run equilibrium, the growth rates of the variables are constant given by $\Delta z_t$, so (30) reduces to

$$(I - \Phi_1 - \Phi_2 - \ldots - \Phi_K) \Delta z_t = \vartheta + (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K) Hv_t.$$

Upon rearranging

$$\Delta z = (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)^{-1} \vartheta + Hv_t, \quad (31)$$

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

9
2.3 Restrictions

The restrictions embodied in \( H \) in equation (29) are summarised as

\[
H = \begin{bmatrix}
\lambda_1 & 0 & \lambda_3 & 0 & \lambda_5 & 0 & 0 \\
\psi_1 & \psi_2 & \psi_3 & \psi_4 & 0 & \psi_6 & \psi_7 \\
\delta_1 & -\psi_2 & \delta_3 & 0 & \delta_5 & \delta_6 & \delta_7 \\
\gamma_1 & \gamma_2 & \gamma_3 & \gamma_4 & 0 & \gamma_6 & \gamma_7 \\
0 & 0 & 0 & 0 & \varphi_5 & 0 & 0 \\
\varphi_1 & 0 & 0 & 0 & 0 & \varphi_6 & 0 \\
\kappa_1 & -\psi_2 & 0 & 0 & 0 & \kappa_6 & \kappa_7
\end{bmatrix}
= \begin{bmatrix}
H_{1,1} & H_{1,2} \\
H_{2,1} & H_{2,2}
\end{bmatrix},
\tag{32}
\]

where the partitioned matrices are

\[
H_{1,1} = \begin{bmatrix}
\lambda_1 & 0 & \lambda_3 & 0 & \lambda_5 \\
\psi_1 & \psi_2 & \psi_3 & \psi_4 & 0 \\
\delta_1 & -\psi_2 & \delta_3 & 0 & \delta_5 \\
\gamma_1 & \gamma_2 & \gamma_3 & \gamma_4 & 0 \\
0 & 0 & 0 & 0 & \varphi_5
\end{bmatrix},
\quad H_{1,2} = \begin{bmatrix}
0 & 0 & \psi_6 & \psi_7 \\
\delta_6 & \delta_7 & \gamma_6 & \gamma_7 \\
0 & 0 & \varphi_6 & 0 \\
\kappa_6 & \kappa_7
\end{bmatrix},
\]

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

The \( H_{1,1} \) block contains the long-run restrictions imposed upon the macroeconomy without the housing sector. The \( H_{1,2} \) block gives the long-run effects of shocks in the housing sector on the macroeconomy, while \( H_{2,1} \) gives the long-run effects of housing shocks on the macroeconomy. The last block is \( H_{2,2} \), which shows the long-run effects of housing shocks on the housing market.

2.3.1 The Macroeconomy without the Housing Sector

The top left hand \((5 \times 5)\) block \( H_{1,1} \), is the Fry, Hocking and Martin (2008) specification with some additional and modified parameterisations stemming from their empirical results. 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 gives the long-run influences on the interest rate. The key determinants are shocks to aggregate supply \((\psi_1 > 0)\) and demand \((\psi_2 > 0)\) in the goods
market, Australian portfolio shocks \((\psi_3 > 0)\), and nominal shocks to inflation \((\psi_4 > 0)\). Portfolio shocks in the US \((\psi_5 = 0)\) are excluded following from empirical work.

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 inflation in the goods market is affected by all shocks, with the exception of US portfolio shocks. Increases in house prices caused by positive shocks to housing demand are expected to add to inflation in the goods market \((\gamma_7 > 0)\). Positive shocks to housing supply are also expected to add to inflation \((\gamma_6 > 0)\) with a booking housing sector having positive spillovers into the macroeconomy.

The final row of \(H_{1,1}\) shows that real foreign equity prices are exogenous. This restriction is based on assuming that purchasing power parity is satisfied in the long-run whereby an increase in the domestic price is perfectly just 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 (25). 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 \((\psi_6 > 0)\) 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 causing increases in the interest rate. 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 ($\delta_6 \geq 0$) and demand ($\delta_7 \geq 0$) shocks, although the sign of these channels are indeterminate. The effect of housing supply shocks on Australian equities has a positive channel as expansions in housing supply coincide with a booming economy and higher dividend payments as output rises, as reflected by a bullish share market. The negative channel is that a housing supply shock results in a simultaneous increase in output and a fall in house prices, with the overall effect on housing wealth dependent upon the relative magnitude of the elasticities of demand and supply in the housing market. If housing wealth falls this is expected to have a negative wealth effect on equity markets. The effect of housing demand on Australian shares is 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 equity prices. 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 inflation rate in the goods market is affected by the housing demand shock through an increase in house prices which feeds positively into inflation ($\gamma_7 > 0$). The corresponding channel from housing supply shocks to the inflation rate are likely to flow through to inflation 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 (23) 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 (24). 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 $\psi_2$, from the $q$ theory of housing investment given by (24), 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 (23) represents a long-run housing cost function, a negative shock to house costs constitutes 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 that 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 (24), 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 (32) is 26. By not imposing the two cross-equation restrictions

$$\delta_2 = -\psi_2, \quad \kappa_2 = -\psi_2,$$

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

$$\Omega = E [e_t e'_t] = GG',$$  \hspace{1cm} (34)

as $E [v_t v'_t] = I$. Now using equation (29)

$$\Omega = (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K) HH' (I - \Phi_1 - \Phi_2 - \ldots - \Phi_K)'$$  \hspace{1cm} (35)
There are $N(N + 1)/2 = 7 \times 8/2 = 28$ unique elements of $\Omega$. 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

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

where $N = 7$ is the number of equations, and the $(7 \times 1)$ VAR disturbance vector $\epsilon_t$ is defined from (26) as

$$\epsilon_t = (I - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_K L^K) \Delta z_t - \vartheta. \quad (37)$$

The variance-covariance matrix of $\epsilon_t$ is given by (35). The full set of 26 parameters consist of the “mean” parameters $\{\Phi_1, \Phi_2, \ldots, \Phi_K, \vartheta\}$ and the “variance” parameters contained in $H$ given in (32).

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

$$\ln L = \sum_{t=1}^{T} \ln L_t. \quad (38)$$

As a result of the normality assumption of $\epsilon_t$, 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 (26) is estimated by maximum likelihood methods to yield estimates of the mean parameters, denoted as

$$\left\{\hat{\Phi}_1, \hat{\Phi}_2, \ldots, \hat{\Phi}_K, \hat{\vartheta}\right\}. \quad (39)$$

As the number of explanatory variables in each equation are 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 (39). Formally this involves solving the following first order condition

$$\hat{\Omega} = \left(I - \hat{\Phi}_1 - \hat{\Phi}_2 - \ldots - \hat{\Phi}_K\right) \hat{H}' H \left(I - \hat{\Phi}_1 - \hat{\Phi}_2 - \ldots - \hat{\Phi}_K\right)'$$

(40)

for the elements in $H$, where $\hat{\Omega}$ is the variance-covariance matrix of the estimated residuals $\hat{c}_t$ obtained in the first step and $\hat{H}$ represents the matrix of estimated long-run parameter estimates that are computed in the second step. In computing $\hat{H}$, as (40) 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 annual inflation rate ($\pi_t$), 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 inflation rate is computed as the four-quarter span of the log of the CPI. The data are presented in Figure 1. The price deflators used for $s_t$ and $f_t$ are the implicit price deflators, while the deflators used to compute $c_t$ and $p_h$ are discussed below. Further details on data sources are contained in 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 wage costs as average weekly earnings for employees in the construction industry are 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
Figure 1: Data series used to estimate the SVAR model for Australia, March 1981 to June 2008.
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 focusing 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. The weights are based on the number of houses or units in each city as given in the 1991 Census, and are computed by rescaling the weights presented in Abelson and Chung (2005) as a result of the exclusion of Darwin and Hobart from the aggregate index. 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 weights are relatively small.3

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

3Following the suggestion of a referee the model was also estimated using an aggregate house price series with Perth given a zero weight to allow for potential differences in the prices of this city compared to the rest of Australia. Qualitatively the results are the same as the results reported in the empirical section which include Perth. To save space these results are not reported here.
was obtained by constructing a small dynamic forecasting model to predict house land prices over the remaining period. 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 (26). 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 structural breaks also investigated, but not included in the final empirical results, 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 presented below. 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 occurring in the Australian economy during 2000.

5 Empirical Results

Before estimating the SVAR model, all variables in (25) are scaled by 100. The maximum likelihood long-run parameter estimates of the parameters in (32) are contained in Table 2. In maximising (38) it is found that a lag structure of $K = 2$, suffices. The maximum likelihood estimates of the VAR parameters in $\Phi_1$ and $\Phi_2$ are not reported. Instead the unconstrained and constrained estimates of the residual variance-covariance matrix $\Omega$ are presented. The unconstrained estimate obtained directly from the VAR

---

4The 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.
residuals is

\[ b_1 = \begin{bmatrix} 2.666666664 \\ 0.362 \\ 0.681 \\ -6.429 \\ 0.527 \\ -1.553 \\ 0.627 \\ -0.820 \\ 0.138 \\ -0.820 \\ -0.423 \\ 0.184 \\ 0.387 \\ 0.301 \end{bmatrix} \]

\[ \hat{\Omega}_1 = \begin{bmatrix} 0.362 & 0.681 & 0.530 & -0.008 & 0.634 & 0.030 & -0.138 \\ 0.681 & 43.447 & -6.429 & 0.527 & -1.553 & 0.627 & -0.820 \\ 0.530 & -6.429 & 27.406 & -0.423 & 17.372 & 0.274 & 0.660 \\ -0.008 & 0.527 & -0.423 & 0.508 & -0.094 & -0.162 & -0.197 \\ 0.634 & -1.553 & 17.372 & -0.094 & 40.053 & 0.184 & -0.123 \\ 0.030 & 0.627 & 0.270 & -0.162 & 0.184 & 0.387 & 0.301 \\ -0.138 & -0.820 & 0.660 & -0.197 & -0.123 & 0.301 & 5.216 \end{bmatrix} \]

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

\[ \hat{\Omega}_0 = \begin{bmatrix} 0.363 & 0.759 & 0.579 & -0.008 & 0.699 & 0.030 & -0.156 \\ 0.759 & 45.305 & -6.139 & 0.563 & 0.098 & 0.667 & -1.273 \\ 0.579 & -6.139 & 27.444 & -0.566 & 19.833 & 0.372 & 0.576 \\ -0.008 & 0.563 & -0.566 & 0.575 & -1.082 & -0.194 & -0.232 \\ 0.699 & 0.098 & 19.833 & -1.082 & 43.947 & 0.375 & 0.293 \\ 0.030 & 0.667 & 0.372 & -0.194 & 0.375 & 0.393 & 0.316 \\ -0.156 & -1.273 & 0.576 & -0.232 & 0.293 & 0.316 & 5.114 \end{bmatrix} \]

A test of the two cross-equation restrictions imposed on the long-run structure of the model in (33) is given by the likelihood ratio statistic

\[ LR = (T - M) \left( \ln |\hat{\Omega}_0| - \ln |\hat{\Omega}_1| \right), \]

where \( \hat{\Omega}_0 \) and \( \hat{\Omega}_1 \) are given immediately above and \( M = 26 \) is a finite sample adjustment to the likelihood ratio statistic to take into account the loss of degrees of freedom from estimating the restricted model. The value of the \( LR \) statistic is 5.697. Under the null hypothesis that the constraints are satisfied, the likelihood ratio statistic is asymptotically distributed as \( \chi^2 \) with two degrees of freedom. The asymptotic p-value is 0.058, showing that the restrictions are not rejected by the data at conventional significance levels. The associated unconstrained point estimates corresponding to the cross-equation restrictions are \( \psi_2 = 2.447 \), \( \delta_2 = -2.833 \) and \( \kappa_2 = -2.656 \), 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
Table 2:
Long run parameter estimates of the SVAR model with long-run restrictions given in equation (32). Standard errors and p-values are based on QMLE.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Agg. supply</td>
<td>$\lambda_1$</td>
<td>0.861</td>
<td>0.098</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Aust. portfolio</td>
<td>$\lambda_3$</td>
<td>0.431</td>
<td>0.109</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>US portfolio</td>
<td>$\lambda_5$</td>
<td>0.412</td>
<td>0.080</td>
<td>0.000</td>
</tr>
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<td>Interest</td>
<td>Agg. supply</td>
<td>$\psi_1$</td>
<td>0.907</td>
<td>1.528</td>
<td>0.553</td>
</tr>
<tr>
<td></td>
<td>Agg. demand</td>
<td>$\psi_2$</td>
<td>2.696</td>
<td>0.174</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Aust. portfolio</td>
<td>$\psi_3$</td>
<td>8.378</td>
<td>1.240</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Nominal</td>
<td>$\psi_4$</td>
<td>0.913</td>
<td>0.701</td>
<td>0.193</td>
</tr>
<tr>
<td></td>
<td>House supply</td>
<td>$\psi_6$</td>
<td>1.729</td>
<td>1.034</td>
<td>0.095</td>
</tr>
<tr>
<td></td>
<td>House demand</td>
<td>$\psi_7$</td>
<td>4.128</td>
<td>1.091</td>
<td>0.000</td>
</tr>
<tr>
<td>Aust. equity</td>
<td>Agg. supply</td>
<td>$\delta_1$</td>
<td>1.710</td>
<td>0.820</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>Agg. demand</td>
<td>$\delta_2 = -\psi_2$</td>
<td>-2.696</td>
<td>0.174</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Aust. portfolio</td>
<td>$\delta_3$</td>
<td>3.930</td>
<td>0.814</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>US portfolio</td>
<td>$\delta_5$</td>
<td>3.767</td>
<td>0.641</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>House supply</td>
<td>$\delta_6$</td>
<td>-0.851</td>
<td>0.543</td>
<td>0.117</td>
</tr>
<tr>
<td></td>
<td>House demand</td>
<td>$\delta_7$</td>
<td>-3.543</td>
<td>0.660</td>
<td>0.000</td>
</tr>
<tr>
<td>Inflation</td>
<td>Agg. supply</td>
<td>$\gamma_1$</td>
<td>-0.278</td>
<td>0.150</td>
<td>0.064</td>
</tr>
<tr>
<td></td>
<td>Agg. demand</td>
<td>$\gamma_2$</td>
<td>0.446</td>
<td>0.078</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Aust. portfolio</td>
<td>$\gamma_3$</td>
<td>0.533</td>
<td>0.197</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Nominal</td>
<td>$\gamma_4$</td>
<td>0.788</td>
<td>0.064</td>
<td>0.000</td>
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<tr>
<td></td>
<td>House supply</td>
<td>$\gamma_6$</td>
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<td>0.141</td>
<td>0.074</td>
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<td>House demand</td>
<td>$\gamma_7$</td>
<td>0.404</td>
<td>0.118</td>
<td>0.001</td>
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<tr>
<td>US equity</td>
<td>US portfolio</td>
<td>$\varpi_5$</td>
<td>8.674</td>
<td>0.712</td>
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<tr>
<td>House cost</td>
<td>Agg. supply</td>
<td>$\varphi_1$</td>
<td>0.394</td>
<td>0.092</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>House supply</td>
<td>$\varphi_6$</td>
<td>-0.842</td>
<td>0.073</td>
<td>0.000</td>
</tr>
<tr>
<td>House price</td>
<td>Agg. supply</td>
<td>$\kappa_1$</td>
<td>1.847</td>
<td>0.408</td>
<td>0.000</td>
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<td>-2.696</td>
<td>0.174</td>
<td>0.000</td>
</tr>
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<td></td>
<td>House supply</td>
<td>$\kappa_6$</td>
<td>-0.363</td>
<td>0.340</td>
<td>0.286</td>
</tr>
<tr>
<td></td>
<td>House demand</td>
<td>$\kappa_7$</td>
<td>1.981</td>
<td>0.283</td>
<td>0.000</td>
</tr>
</tbody>
</table>

$\ln L = -1522.372$
adopted is to decompose the real house price in terms of its conditional expectation and an idiosyncratic shock according to

\[ p_{h,T+J} = E_T [p_{h,T+J}] + \eta_{T+J}. \] (41)

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 starting value of \( T \) is March 2002, with \( J \) representing a counter corresponding to observations from June 2002 to June 2008. The start of the forecast period is chosen to avoid the dot-com crisis in 2000, and the fall in real house prices caused by the subprime crisis, beginning July 2007. The conditional expectation is computed using the moving average representation of the model in (26) with all parameters replaced by their maximum likelihood estimates using data ending in March 2002. 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 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 forecasts of the real house price are given in Figure 2. Interpreting the conditional expectation as the market fundamental price, \( p_{h,T+J} > E_T [p_{h,T+J}] \) provides a measure of the size of the overvaluation in the real house price relative to its forecast. Two main periods of overvaluation are highlighted in Figure 2 where the actual price exceeds the forecasted price. The first is prior to 2006 where the size of the overvaluation peaks in December 2003 at just over 15%. The second period is post 2006 where the overvaluation peaks in December 2007 at just under 12%. Interestingly, by the June quarter of 2008 the gap between the actual and the forecasted real house price is less than 5%, suggesting that the fall in real house prices during the subprime crisis is consistent with real house prices returning to market fundamental levels.

Given the two periods of overvaluation identified in Figure 2, it is of interest to identity the factors driving house prices in each period. One way to proceed is to decompose the second term \( \eta_{T+J} \) in (41), into the 7 shocks identified in the SVAR model in (27). This is formally known as a historical decomposition and is achieved by estimating the model over the full period and replacing the subsample parameter.
estimates in (41) by estimates obtained using the full sample.

The results of decomposing the real house price into its market fundamental, as given by \( E_T[p_{h,T+J}] \), and underlying shocks are given in Figure 3. Figure 3(a) reveals a very similar story to Figure 2 in terms of both the magnitude and timing of the overvaluation in real house prices.\(^5\) The drivers of the overvaluation in house prices over the period, the components of \( \eta_{T+J} \) in (41), are highlighted in Figures 3(b) to 3(h) which decompose the overvaluation 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 to a lesser

\(^5\) The use of Figure 2 to measure the overvaluation was suggested by a referee. As the forecasting approach and the historical decomposition approach yield very similar qualitative results as regards the size and timing of the overvaluation periods from June 2002 to June 2008, these results provide strong support for using the historical decomposition of shocks to interpret the factors underlying each overvaluation period.
extent by aggregate supply shocks. Interestingly, housing demand shocks during this period are negative, but are nonetheless dominated by the positive 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 4. Confidence intervals of 80% are also reported which are computed by simulating the model 10,000 times using both the \( \Phi \) and \( G \) matrix parameter estimates. The housing demand 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 (23). 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 74% of its variance. This role diminishes in relative importance and by the long-run its contribution is just 27%.

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 inflation in the goods market, together with increases in the nominal interest rate, although the effects on output are not found to be statistically significant.\(^6\) The interest rate is driven by the increase in the demand for credit arising from the need to finance the housing demand shock and to a lesser extent by the increase in demand for liquidity arising from the increase in real output. The simultaneous increases in the nominal interest rate and inflation in the goods market cause a fall in domestic real equity values, which dominate the positive dividend effect arising from the increase in output. Real US equity values in Australian dollars also fall at least temporarily, as a result of the increase in domestic inflation.

\(^6\)Jarociński and Smets (2008) find similar results for the US with output and the interest rate both increasing over the intermediate run to a housing demand shock.
Figure 3: Historical decomposition of real house prices (logs), June 2002 to June 2008.
Figure 4: Impulse response functions of a one standard deviation housing demand shock.

Table 3:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Agg. supply</th>
<th>Agg. demand</th>
<th>Aust. portfolio</th>
<th>Nominal supply</th>
<th>US portfolio</th>
<th>House supply</th>
<th>House demand</th>
</tr>
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<tbody>
<tr>
<td>House cost</td>
<td>1 0.598</td>
<td>1.725</td>
<td>3.192</td>
<td>6.959</td>
<td>7.117</td>
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<td></td>
<td>4 8.347</td>
<td>4.464</td>
<td>1.747</td>
<td>1.547</td>
<td>1.708</td>
<td>78.651</td>
<td>3.535</td>
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<td></td>
<td>8 17.988</td>
<td>1.986</td>
<td>0.739</td>
<td>0.723</td>
<td>0.748</td>
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<td></td>
<td>12 18.347</td>
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<td>0.474</td>
<td>0.518</td>
<td>77.692</td>
<td>1.091</td>
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<td></td>
<td>∞ 17.952</td>
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<td>0.000</td>
<td>0.000</td>
<td>82.048</td>
<td>0.000</td>
</tr>
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<td>0.015</td>
<td>0.006</td>
<td>0.684</td>
<td>74.047</td>
</tr>
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<td>4 23.026</td>
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<td>0.805</td>
<td>0.637</td>
<td>2.016</td>
<td>50.711</td>
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<td>8 26.906</td>
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<td>0.267</td>
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<td>12 25.239</td>
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<td></td>
<td>∞ 23.153</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.893</td>
<td>26.630</td>
</tr>
</tbody>
</table>
5.2.2 Supply

The effects of a positive housing supply shock presented in Figure 5, 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, the confidence intervals show that the effects on house prices are statistically insignificant, a result which is further highlighted by the point estimate on $\kappa_6$ in Table 2 which also shows that the effects of housing supply shocks on house prices are statistically insignificant. This result is further highlighted by the variance decomposition of the real house price presented in Table 3, which shows that the contribution of real house supply shocks is small, less than 3%, both in the short-run and the long-run. This result provides empirical support for the specification of the housing cost function specified in Section 2.

The housing supply shock has positive macroeconomic effects on output and inflation in the goods market, as well as the nominal interest rate. Unlike the housing demand shock in regards to inflation and the interest rate, these effects are all statistically insignificant. This result is consistent with the empirical results reported by Jarociński and Smets (2008) who also find for the US that housing supply shocks are not very important.
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 6. There are simultaneous increases in output and inflation in the goods market. Inflation continues to increase over time before plateauing at 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 inflation with this effect dissipating in the long-run as the exchange rate eventually depreciates to its purchasing power parity level.

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 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. The importance of aggregate demand shocks to real house prices is highlighted in Table 3, where its long-run contribution to the variance of real house prices dominates all other shocks, with a contribution just under 50%.

5.3.2 Supply

Figure 7 shows that a positive shock to aggregate supply in the goods market causes an expansion in output in the goods market and negative inflation. There is an initial fall in the nominal interest rate which quickly increases as a result of the positive aggregate demand effect caused by the real wealth effects from the equity markets. The real wealth effect is caused by the deflation 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 value of US equities increases as a result of the deflation in domestic goods prices.

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 the goods market aggregate supply shock 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 explains around 25% 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 8 gives the historical decomposition of the interest rate. Figure 8(a) shows that the observed 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 8(b) to 8(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 9 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 to a lesser extent, housing demand shocks. By contrast, Figure 9(a) also shows that the real Australian equity price was undervalued prior to 2006, a reflection of the aftermath of the dot-com crisis. Given the negative external effects arising from the subprime crisis from mid 2007, it is interesting to observe that the empirical results show the presence of increasing negative US portfolio shocks on the domestic equity market over the full period of the decomposition, 2002 to 2008.

5.5 Implications for Monetary Policy

An implication of these results 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 8, 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 pre-
Figure 8: Historical decomposition of the nominal interest rate (logs), June 2002 to June 2008.
Figure 9: Historical decomposition of the Australian real equity price (logs), June 2002 to June 2008.
sented 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 8(a)) and real house prices (Figure 3(a)) relative to their fundamentals is caused by wealth effects from Australian equity market shocks particularly post 2004 (Figure 8(d)), goods market shocks (Figures 8(b) and 8(e) and Figures 3(b) and (c)), or housing wealth shocks (first part of Figure 3(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 $4.223\%$, which is estimated as $100 \times \exp(-316.463/100)$. 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 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, with two main periods of overvaluation where the actual price exceeded the forecasted price. The first and largest peak was just over 15% by the end of 2003. The main determinants of the overvaluation surrounding this period were housing demand shocks and to a lesser extent aggregate demand and supply shocks arising from the goods market. In the second period of overvaluation, it was goods market shocks that dominated the overvaluation in house prices, a peak of just under 12% in December 2007. 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. By the end of the sample in June 2008, the real house price was less than 5% above the forecasted price suggesting that house prices were returning to their market fundamental levels during the global financial crisis.

Evidence of an increasing gap between the actual interest rate and its market fundamental level were 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.

Finally, real equities were found to be overvalued in Australia from 2006 to the end of 2007. The subsequent fall in equity prices at the start of 2008 represented a correction in this market with the equity price operating near its market fundamental price by June 2008.

References


## A Data Appendix

Table A1: Data Sources and Codes

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