

House prices and mortgage market liberalisation in Australia *

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ABSTRACT

Financial liberalisation and innovation (FLIB) in Australia over the 1980s and 1990s provided the institutional backdrop for one of the most rapid increases in household balance sheets and house prices in the world. An error correction model of quarterly Australian house prices for 1972-2006 identifies the key long run drivers as real non-property income per house, the working age population proportion, the unemployment rate, two government policy changes, real and nominal interest rates and FLIB. All else equal, FLIB directly raised the long run level of real house prices by around 65 per cent while higher real interest rate subtracted 38 per cent from long run prices. Real interest rates are shown to have much greater impact after FLIB than before, while the opposite is true for nominal interest rates. These findings suggest that FLIB fundamentally relaxed binding credit constraints on households and enhanced opportunities for intertemporal smoothing. The paper also finds that house price dynamics tend to be mean-reverting whenever lagged real house price growth is less than 4.6 per cent. However whenever lagged price growth is greater than this, especially during booms, house prices tend to display "frenzy" behaviour measured as a cubic of lagged house price changes.

Key words: House prices, mortgage markets, financial liberalisation

JEL classification: E21, G21

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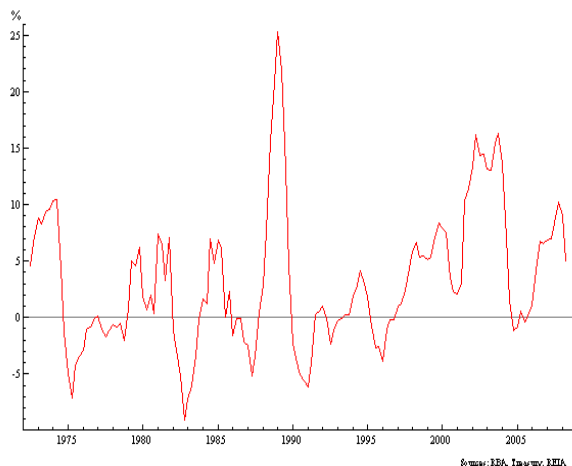
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1 Introduction

Australia has witnessed four house price booms over the past 34 years, from: 1971 to 1974; 1979 to 1981; 1987 to 1989; and 1996 to mid-2008 (Chart 1). The latter two booms are particularly interesting because they occurred in the context of financial liberalisation and innovation (FLIB) and a fundamental transformation of household balance sheets. Australia's ratio of household debt to disposable income quadrupled over 1980 to 2006, while gearing ratios (debt to assets) and debt servicing ratios (repayments to income) approximately doubled. House prices have risen from around 4.0 times annualised average incomes in the early 1980s to around 7.5 times average incomes in the 2000s.¹ The OECD (2005) cites Australia's real price gains across 1997-2005 as the 5th largest in the world.

Chart 1 : Real annual house price growth – Australia



This paper estimates an error correction model of Australian national house prices using quarterly data from 1972(3) to 2006(2). Long run house prices are shown to be driven by real income per house, financial liberalisation and innovation (FLIB), real and nominal interest rates, the unemployment rate, the working age population proportion and the introduction of the first home owners' scheme (FHOS). In the short run, house price dynamics are governed by real income growth, mean reversion (based on extrapolative expectations), "frenzy" dynamics and the quarantining of negative gearing deductions during the mid-1980s.

Two key influences on house prices are emphasised. The first is the impact of easing non-price credit conditions or FLIB - the proverbial "elephant in the room" in current housing and mortgage market analysis. FLIB incorporates several institutional developments: government deregulation across the 1980s; changes in market structure (new entrants and bank consolidation); debt product innovation²; and innovations in bank lending practices (automated credit scoring and underwriting, widespread use of mortgage-backed securities and mortgage insurance) leading to changes in lending standards (notably the relaxing of downpayment and repayment-to-income constraints).³

The effect of FLIB is four-fold. It promotes intertemporal substitution, lowers the deposit constraint on first time buyers, unlocks the collateral value of housing wealth for older, existing owners and relaxes the balance of payments constraint on the financial sector. This paper finds that the

¹See Charts 8-10 in Appendix A.

²The 1990s witnessed a proliferation of cheaper and more flexible mortgage products. Examples for owner-occupiers include mortgage equity loans allowing redraw and offset facilities (often with no penalty for prepayment), fixed rate loans and non-conforming loans. Examples for investors also include interest only loans, deposit bonds and split-purpose loans.

³Appendix B provides a summary table.

relaxation of non-price credit conditions across the 1980s and late 1990s engendered a large, structural increase in demand for housing assets. This forced higher established house prices against a highly price inelastic supply of housing assets⁴.

The model suggests FLIB relaxed binding credit constraints on Australian households and thereby directly increased the long run level of real house prices by around 65 per cent over the sample period. Furthermore, when FLIB is interacted with interest rates, nominal interest rates are shown to be much more important than real interest rates during the 1970s, whereas the reverse is true after liberalisation. Real interest rates rose 4.0 percentage points between 1979 and 2006, subtracting around 38 per cent from long run real house prices, all else equal. By contrast, nominal interest rates were 1.7 percentage points higher and subtracted only about 1 percent from long run house prices..

The second key influence is that of "frenzy" dynamics, modelled as a cubic of lagged real house price changes, that capture the behaviour of house prices during booms. Whenever lagged quarterly real house price growth exceeds around 4-5 per cent, the cubic amplifies the impact of the shock on contemporaneous house price growth and retards equilibrium error correction. Rapid house price growth may therefore persist for several quarters.

Two explanations of this phenomenon are possible. One is that trading costs - transaction and information costs for example - deter continuous optimisation by households. These trading costs are only overcome during booms because there is more information (about prices of comparable dwellings for example) or the potential capital gains are greater. Furthermore, real estate agents turn over properties more frequently during booms which facilitates their matching of preferences. An alternative explanation flows from Morris and Shin's (2002) model of strategic interaction. Agents seek not only to match their actions with fundamentals, but also to minimise the distance between their actions and the actions of other agents (similar to "herd behaviour"). Thus, agents have a natural tendency to overreact to public information at the expense of private information. The corollary is that public information (market and political commentary, television programming) tends to increase during booms and hence may exacerbate price volatility. Under either approach - market frictions or strategic interaction under uncertainty - large, non-linear price adjustments are induced when the market is highly active and help explain Australian house price booms.

2 Theory

Modelling house prices as an inverse housing demand function is advantageous for several reasons. The function has clear representative agent interpretation from consumption theory⁵, incorporates the portfolio and household formation motivations of housing demand, long and short run demand drivers. Furthermore when estimated in error correction form it captures the short run disequilibrium between supply and demand. The framework forms the basis of many reduced form econometric housing models in the UK and US literature and is used by Tu (2000, albeit implicitly) and Abelson, Joyeaux, Milunovitch and Chung (2005) in the Australian context. The housing demand function takes the form:

$$H/pop = f(y, ucc, D) \tag{1}$$

where H is housing demand, pop is population, y is real non-property income, ucc is the user cost

⁴Australia's population is concentrated in the capital cities, particularly on the east coast, where natural boundaries and/or planning restrictions preclude greenfield development. As a result, the composition of new housing investment has increasingly shifted towards renovation of the existing household stock. Real annual growth in housing supply averaged around 5.6 per cent from 1960 to 1980 but thereafter average growth slowed considerably to 3.6 per cent between 1980 to 2006. Meanwhile the average age of the dwelling net capital stock has risen from series low of 17.1 years in 1982 to 19.9 years in 2006. See Charts 11-13 of Appendix A.

⁵The cornerstone of the model is a constrained lifetime utility maximisation problem faced by a representative consumer with respect to two goods: housing (h) and non-housing (non-durable) (c). Dougherty and Van Order (1982) and Meen (1990) provide further discussion.

of capital⁶ and D represents other demand factors. By inverting ucc , the general specification is:

$$p^h = g(H/pop, y, r, \frac{\Delta p^{he}}{p^h}, D) \quad (2)$$

Variables in D that will be considered for the Australian context include measures of FLIB, demographics, nominal interest rates, share prices, inflation, population, risk, policy dummies and a cubic term to capture non-linear adjustment during periods of market hyperactivity or "frenzy". The model also conditions on the previous end of quarter housing stock (H). This closes the model in reduced form and means that observed price changes in established house prices can be interpreted as shifts in the demand curve rather than movements along it.

3 Literature

There is a small but growing empirical literature on Australian house prices. Tu (2000), Oster (2005) and Abelson *et al* (2005) base their models on the inverse housing demand function. These models tend to have higher explanatory power than the specifications used by Bourassa and Hendershott (1995) and Bodman and Crosby (2003)⁷. Nonetheless their explanatory power is below comparable UK studies - Muellbauer and Murphy (1997), Meen (1990), and Hendry (1984) for example. There are several possible reasons for this.

First, to my knowledge no Australian study to date has employed a measure of income that excludes property-related earnings (capital gains and rent), is post-tax and that includes secondary income such as transfer payments. Non-property disposable income is the most appropriate household income metric according to consumption theory (Blinder and Deaton, 1985), also known the Haig-Simons-Hicks income concept, and corresponds to the level of consumption that leaves real wealth unchanged. Abelson *et al* (2005) and Oster (2005) adopt household gross disposable income from the national accounts⁸, which is at least post-tax and includes transfer payments. However the national accounts measure includes realised property income (including rent but not capital gains) and excludes losses on assets (or gains on liabilities) due to inflation. It will therefore be distorted during swings in inflation (Lattimore (1994), Muellbauer (1994)). Alternative income measures that perform less favourably in the Australian literature include employment and real wages (Bourassa

⁶The user cost of capital (expressed as a rate) is:

$$ucc = \frac{MU_h}{MU_c} = p^h(r + \delta - \frac{\Delta p^{he}}{p^h})$$

where MU_h and MU_c are the marginal utilities of housing and non-housing consumption, p^h is established house prices, r is the after-tax real interest rate, δ is depreciation and p^{he} is the expected house price.

⁷The latter base their specifications on the so-called "housing bubbles" approach by Abraham and Hendershott (1993, 1996) as follows. Actual house price changes (Δp) are argued to be a function of "fundamental" price changes (Δp^*) - based on changes in key economic or demographic variables (Δx_i) - plus a dynamic component (θ):

$$\begin{aligned} \Delta p_t &= \Delta p_t^* + \theta_t \text{ where} \\ \Delta p_t^* &= \sum \hat{\beta}_i \Delta x_{it} \\ \theta_t &= \lambda_0 + \lambda_1 \Delta p_{t-1} + \lambda_2 (P_{t-1}^* - P_{t-1})/P_{t-1} + \Phi_t \end{aligned}$$

The first term, the lagged price change (Δp_{t-1}), acts as a so-called "bubble builder" by making price changes persistent across periods (if $\lambda_1 > 0$). This is offset by a "bubble burster" term ($(P_{t-1}^* - P_{t-1})/P_{t-1}$), which is the percentage difference between equilibrium and actual price levels and acts to bring the model back into equilibrium after a short term disturbance. The random error is Φ .

The equilibrium level of house prices (P^*) is computed by assuming that house prices are in equilibrium at some initial point (P_0) and then scaling by the estimated Δp^* from that point:

$$P_{t-1}^* = P_0 \prod_{i=1}^{t-1} (1 + \Delta p_i^*)$$

⁸Australian Bureau of Statistics (ABS): 5206, Table 68.

and Hendershott, 1995), real weekly earnings per employee (Tu, 2000), GDP per capita (Bodman and Crosby, 2003), employment (Chowdbury and Mallik, 2004), and the change in state final demand and unemployment rate (Otto, 2007).

Second, house prices should be conditioned on the lagged housing supply so that house price changes can be interpreted as demand curve shifts. Abelson *et al* (2005) and Hendry (1984) condition on the previous end-of-quarter real net dwelling capital stock while Muellbauer and Murphy (1997) and Meen (1990) use the number of houses⁹. Australian models that perform less well use housing completions (Tu, 2000), which are small relative to the overall dwelling capital stock, population (Oster, 2005), dwelling approvals per capita (Otto, 2007) and, under an urban growth framework, construction costs (Bourassa and Hendershott (1995), Bodman and Crosby (2003)). Chowdhury and Mallik (2005) do not control for housing supply.

Third, a wider range of explanatory variables could be considered. To my knowledge, no Australian study to date has attempted to quantify the impact of financial liberalisation and innovation over the 1980s and 1990s, nor its interaction with real and log nominal interest rates. Most studies include *either* real or nominal interest rates, but FLIB may make interest rates important at different times. That is, nominal interest rates may be important for credit constrained households in tightly regulated financial markets, but real interest rates become important in liberalised markets because the price mechanism is used to clear the credit market rather than quantity controls and greater intertemporal smoothing is possible. To measure risk, so far only the unemployment rate has been tested but in some cases this was included as a proxy for income. Muellbauer and Murphy (1997) and Fernandez-Corugedo and Muellbauer (2006) develop a richer representation of risk by including the unemployment rate, interest rate volatility, inflation volatility and a dummy for negative housing returns over the previous year. Furthermore, few measures of demographics have been explored for Australia. Bodman and Crosby (2003) had poor results using the proportion of the population aged 60-64. Tu (2000) found net immigration to be insignificant. Oster (2005) and Otto (2007) tested population in their models, though in the former's case this proxied for an omitted housing supply variable. In the latter's case, population growth was wrongly signed in two of the six models.

Fourth, the US literature (see Cho (1996) for a summary) suggests that house price models should not be strictly based on rational expectations since house prices are shown to be less than fully informationally efficient. Extrapolative expectations are instead approximated in this paper by including lagged real house price changes and cubed house price changes (that is, "frenzy" dynamics). These short run structural dynamics partly and temporarily offset the error correction dynamics.

Finally, only three known studies have attempted to explain the boom and bust dynamics of Australian house prices. Bourassa and Hendershott (1995) and Bodman and Crosby (2003) employ the methodology of Abraham and Hendershott (1993, 1996; see footnote 8), however their so-called "bubble-builder" and bubble-burster" terms were not correctly signed. Abelson *et al* (2005) employ an asymmetric error correction mechanism showing that error correction is 30 per cent faster during house price booms. However, the R^2 of the model is only 0.4. In the UK, Hendry (1984) and Muellbauer and Murphy (1997) find highly significant non-linear "frenzy" dynamics (that is, cubed lagged real house price changes) and the explanatory power of their models are substantially higher.

In summary, modelling house prices as an inverse demand function allows a clear, representative agent consumption theory interpretation and, when estimated in error correction formulation, also captures the short term disequilibrium between demand and supply. The long run equation ideally should include a measure of non-property household disposable income, the lagged housing stock, demography, risk and a representation of non-price credit conditions (FLIB) interacted with real and nominal interest rates. Furthermore the dynamics of the model should seek to explain the "boom and bust" cycles of Australian house prices.

⁹The former housing stock measure is available for Australia while the latter is not.

4 Specification and estimation methodology

The long run empirical form of the inverse housing demand function is specified in log linear terms as:

$$rhp = a + (y - H) + Z\gamma \quad (3)$$

where rhp is real house prices, y is real non-property income per capita, H is real net dwelling stock per capita (housing supply)¹⁰ and Z is a vector of long run variables (in levels) that shift the demand curve. The long run model is parameterised into a dynamic specification as follows:

$$\begin{aligned} \Delta rhp_t &= \alpha(a_0 + ecm_t + Z\gamma) + \Delta X\beta + \phi\Delta p_t + \varepsilon_t \\ \text{where } ecm_t &= \psi(y_{t-1} - H_{t-1}) - rhp_{t-1} \end{aligned} \quad (4)$$

where α is the speed of adjustment, ecm_t is real income per house¹¹ and ΔX is a matrix of I(0) structural dynamics. Preliminary regressions showed the coefficient on current inflation (ϕ) to be approximately minus one, indicating that the dependent variable can be reparameterised as the change in nominal house prices (Δnhp_t). The general unrestricted model (GUM) thus takes the following form:

$$\Delta nhp_t = \alpha(a_0 + ecm_t + Z\gamma) + \Delta X\beta + \varepsilon_t \quad (5)$$

The GUM is estimated in AutoMetrics (Doornik, 2007) which employs a general-to-specific model reduction strategy to omit insignificant Z and ΔX variables and deduce a parsimonious specification¹². Strong priors are held about the variables in the GUM as guided by consumption theory, previous Australian studies and by institutional features of the Australian market. The steady state and dynamic solutions are *jointly* estimated. Direct estimation is supported by Kremers, Ericsson and Dolado (1992) who argue that this provides a more efficient estimation of the long run parameters where there is a unique cointegrating vector suggested by economic theory. In combining a general-to-specific model reduction strategy with a direct estimation cointegration strategy, an encompassing parsimonious model is sought that while congruent with theory is also flexible to the nuances of the data. The parsimonious empirical model is shown to deliver greater explanatory power in terms of adjusted R² and similar to comparable UK specifications.¹³

¹⁰The income elasticity of housing demand is assumed to be one, a standard approach in the literature. Supplementary estimations relaxing the constraint show the income elasticity to be within a standard error of one.

¹¹The model is estimated under an income elasticity constraint of $\psi = 2$. UK estimates for the long run elasticity of house prices to income range from 1.5 to 2 (see Muellbauer and Murphy (1997, 2006)). Tu (2000) found an income elasticity of 2 for Australia.

The justification for the constraint on ψ is that the general specification is a highly parameterised model that contains a variety of dynamic adjustment terms in addition to the long-run solution. A constraint on the income elasticity of real house prices brings additional information to bear in the model selection procedure carried out using AutoMetrics. The ecm_t variable is expected to have a positive coefficient and is critical component of the error correction process. In any case, supplementary estimations based on Model 1 below relaxed the income elasticity constraint and showed ψ to be around 2.3 and within a standard error of 2.

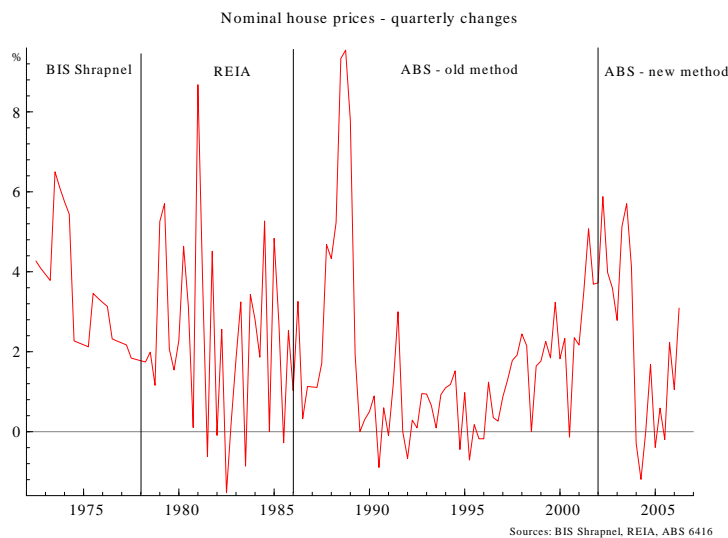
¹²AutoMetrics applies a general-to-specific model reduction strategy to deliver a data-congruent, undominated parsimonious specification. The basic methodology is as follows (Hendry and Krolzig, 2001). A GUM is initially specified by the modeller, consonant with economic theory and including all potentially relevant information about the data generating process (DGP). Second, pre-selection checks in Autogets omit highly insignificant variables from the GUM and add dummy variables for quarters where residuals exceed 2.6 standard errors. The GUM is then tested for congruency with the DGP using mis-specification tests that verify white-noise errors, conditionally and unconditionally homoscedastic errors, normally distributed errors and constant parameters. Fourth, the model is simplified by omitting statistically insignificant variables. Mis-specification tests are conducted on each reduction, and each reduced model is compared on the basis of congruency with the DGP and minimisation of the information loss from the previous stage. The final model chosen is the model that encompasses rivals, including the GUM, satisfies mis-specification tests and conforms with priors.

¹³Note that the model is conditional on the lagged economic and demographic explanatory variables and therefore does not attempt to provide a general equilibrium solution enabling long range house price forecasts.

4.1 Data

The house price index employed has been spliced together from four sources: BIS Shrapnel (1972(3) to 1978(2)) via Treasury; the Real Estate Institute of Australia (REIA: 1978(3) to 1986(1)); the ABS "old" series (1986(2) to 2001(4)); and the ABS "renovated" series (2002(1) to 2006(2)).¹⁴ The log of this composite index is nhp . Chart 2 highlights the different volatility in each series which supports the use of heteroskedasticity and autocorrelation consistent standard errors (HACSEs) to conduct model reduction in AutoMetrics. A log real house price series (rhp) is constructed by subtracting the log household consumption implicit price deflator (p) (ABS 5206, Table 12) from nhp .

Chart 2 : Australian nominal house prices
(quarterly changes)



The GUM incorporates the key elements of the inverse housing demand function¹⁵: log real non-property disposable income (y_{t-1}) per unit housing supply (H_{t-1}); the user cost of capital (real interest rates (r_{t-1}) and expected housing capital gains proxied by autoregressive terms ($\Delta_4 rhp_{t-1}$, $\Delta rhp_{t-1,t-2}$, $frenzy_{t-1}$)¹⁶ assuming extrapolative expectations); and other factors that shift the demand curve. These factors include: FLIB represented by a time trend (t) beginning in 1972(3) and three split trend dummies ($FLIB_{79}$, $FLIB_{92}$, $FLIB_{98}$)¹⁷; log nominal interest rates (Li), which are important for credit-constrained households; interaction effects between FLIB and interest rates ($(FLIB^* \times r)$, $(FLIB^* \times Li)$)¹⁸; demographic variables (WA_{t-5} , $\Delta_4 dem1_{t-1}$, $\Delta_4 dem2_{t-1}$, $\Delta_4 pop_{t-1}$)¹⁹, the log unemployment rate (Lue_{t-1}) and the first home owners' grant ($FHOS_{t-1,t-5}$).

¹⁴There is a trade-off between sample length and the potential for measurement error in the earlier (non-ABS) data. The ABS series are superior to the REIA and BIS Shrapnel data because they use compositional adjustment (that is, houses traded across time period are roughly matched by location and size). The ABS new method is more timely than the old method because it is based on the exchange of contracts date rather than settlement date. REIA data shows the most volatility which is likely due to a lack of compositional adjustment. To ensure consistency across data sets, the model is estimated across two sample periods: 1972(3) to 2006(2) and 1979(1) to 2006(2). The 1979(1) to 2006(2) sample includes only data from REIA and ABS which are superior in coverage to the BIS Shrapnel data.

¹⁵In the notation that follows, $\Delta rhp_{t-1,t-2}$ is an abbreviation for Δrhp_{t-1} and Δrhp_{t-2} .

¹⁶ $frenzy$ is defined in Section 4.2.4.

¹⁷These are four quarter moving averages of linear trends beginning in 1979(1), 1992(1) and 1998(1) corresponding to the turning points identified in Section 5.1.

¹⁸Real and log nominal interest rates are de-meanned using the arithmetic means of r and Li respectively. These are interacted with a composite of the FLIB process $FLIB^* = FLIB_{79} - FLIB_{92} + FLIB_{98}$. These constraints are correspond to the analysis of Section 5.1.

¹⁹Respectively these are: the proportion of the resident population of working age (15-64 years); annual growth in the population of first home buyer aged persons (22-34 years); annual growth in the population of investor aged persons

The dynamic terms include changes in: per capita income ($\Delta_4 y_{t-1}, \Delta y_{t-1,t-2}$)²⁰; log nominal interest rates ($\Delta_4 Li_{t-1}, \Delta Li_{t-1,t-2}$); inflation ($\Delta \Delta p_{t-1,t-2}$); share prices ($\Delta_4 s_{t-1}, \Delta s_{t-1,t-2}$); the imposition of restrictions on negative gearing deductibility (NG_t); risk variables (inflation volatility ($infvol_{t-1}$), nominal interest rate volatility ($intsup_{t-1}$), change in the unemployment rate ($\Delta_4 Lue_{t-1}, \Delta Lue_{t-1,t-2}$); downside risk ($DSrisk_{t-1}$); and seasonal and outlier dummies. Appendix C provides more detail.

Table 1 : Explanatory variables in the GUM

Type	Long run variables (Z)	Short run variables (ΔX)
FLIB	$t, FLIB_{79}, FLIB_{92}, FLIB_{98}$	
Log income per house	$y_{t-1} - H_{t-1}$	
Interest rates	r_{t-1}, Li_{t-1}	$\Delta_4 Li_{t-1}, \Delta Li_{t-1,t-2}$
FLIB interaction terms	$FLIB^* \times Li_{t-1}, FLIB^* \times r_{t-1}$	
Demographics	$WA_{t-5}, \Delta_4 dem1_{t-1}, \Delta_4 dem2_{t-1}, \Delta_4 pop_{t-1}$	
Policy dummies	$FHOS_{t-1}, FHOS_{t-5}$	NG_t
Risk - unemployment rate	Lue_{t-1}	$\Delta_4 Lue_{t-1}, \Delta Lue_{t-1,t-2}$
interest rate volatility		$intsup_{t-1}$
inflation volatility		$infvol_{t-1}$
downside risk		$DSrisk_{t-1}$
Share price dynamics		$\Delta_4 s_{t-1}, \Delta s_{t-1,t-2}$
Inflation dynamics		$\Delta \Delta p_{t-1,t-2}$
Autoregressive terms		$\Delta_4 rhp_{t-1}, \Delta rhp_{t-1,t-2}$ $frenzy_{t-1}$

4.2 Explanation of key variables

4.2.1 Non-property income

A measure of per capita log real *non-property* household disposable income (y) for Australia consistent with the Haig-Simons-Hicks concept (Blinder and Deaton, 1985) is constructed from the household income account (ABS 5206, Table 68). To calculate y , the log household consumption deflator (p) and log resident population (pop) are subtracted from log nominal non-property household disposable income (npv). To calculate npv , a measure of "non-property income payable" (npv payable) is deducted from a measure of "non-property income receivable" (npv receivable). The measures are in gross terms (before depreciation) but net of tax. Non-property income *receivable* is defined as gross compensation of employees (wages and salaries), gross mixed income (profits of unincorporated businesses owned by households, (GMI)) plus secondary income receivable (social benefits such as workers' compensation payouts, social assistance benefits etc). Alternatively, this can be constructed as total income receivable (*total income rec*) less "gross operating surplus on dwellings" (*GOS on dwellings*) less "property income receivable" (*prop income rec*).

Non-property income *payable* is defined as total income payable less *interest on dwellings* and less income tax attributable to dwellings²¹. Note, there is no tax on imputed rent for owner-occupiers however, unlike the US (and the UK until 2001), mortgage interest is not deductible for owner-occupiers. "Income tax payable" includes taxes on wages and salaries, unincorporated profits as well

(35-64 years); and the annual change in the resident population.

²⁰Note that preliminary estimations showed Δy_{t-1} with a negative coefficient of around 0.2 indicating that real income per house in ecm_t could be reparametrised as $y_{t-2} - H_{t-1}$. This is a purely cosmetic change to show Δy_{t-1} with a positive coefficient. Equivalently it suggests that long run house prices are a function of real income per house with income as a lagged two quarter moving average.

²¹The main components of "total income payable" are income tax payable, property income payable (interest on dwellings and consumer debt interest), net non-life insurance premiums and social contributions to workers' compensation. The objective is to strip out the property related components of "total income payable".

as property related taxes. This presents a problem: property related tax applies to commercial rents (at marginal tax rates) and capital gains (of which owner-occupied dwellings are exempt but investor properties attract different CGT treatments depending on the time of purchase). National accounts data, Australia Tax Office tax statistics and Treasury Budget data do not provide sufficient detail on personal tax revenue to separately identify revenue related to the taxation of rent and capital gains for investors.

To overcome this dilemma, "income tax payable" is multiplied by a proxy for the proportion "likely" to be attributable to dwellings. This proxy is based on the proportion of total income *received* from dwellings - that is, property income receivable ("gross operating surplus (GOS) on dwellings" plus "property income receivable") as a proportion of total gross income receivable. This proportion is multiplied by income tax payable to derive the estimate.

The methodology is summarised as follows:

$$\begin{aligned}
 npy &= npy \text{ receivable} - npy \text{ payable} \\
 npy \text{ receivable} &= \text{gross comp of employees} + GMI + \text{secondary income rec} \\
 &= \text{total income rec} - GOS \text{ on dwellings} - \text{prop income rec} \\
 npy \text{ payable} &= \text{total income payable} - \text{interest on dwellings} \\
 &\quad - \left(\frac{GOS \text{ on dwellings} + \text{prop income rec}}{\text{total income rec}} \right) \times \text{income tax payable}
 \end{aligned}$$

Chart 3 shows the ratio of household disposable non-property income to GDP for Australia. The downward trend reflects a rising profit share (in part due to the increasing incorporation of small businesses since the 1980s) as well as an increasing share of income from dwellings.

Chart 3 : Non – property household disposable income
(as a proportion of GDP)



4.2.2 Government policy changes

Two major government policy changes are tested in this paper. First, negative gearing deductions were quarantined²² between 17 July 1985 and 15 September 1987 resulting in a collapse in investor demand. An impulse dummy (NG) is constructed that equals 1 between 1985(3) and 1987(3) and equals 0 otherwise.

²²Losses in relation to rental properties could only be deducted against rental income (not ordinary income).

Second, the first home owners' scheme (FHOS) introduced in July 2000 provided a \$7,000 grant for first time owner-occupying home buyers purchasing new and established dwellings. The government extended the grant in March 2001 by providing an *additional* \$7,000 for first time buyers of newly constructed dwellings. The *additional* FHOS was reduced to \$3,000 from January to June 2002 and ceased thereafter²³. During 2000 and 2001 around 147,126 grants were approved at a cost of around \$1 billion (Chowdhury and Mallik, 2004). Chowdhury and Mallik (2004) found a significant FHOS effect measured a simple binary step dummy. However their measure did not reflect the additional grant provided from 2001(1) and the nominal grant amount was not scaled relative to its purchasing power against nominal house price levels.

The *FHOS* dummy in this paper is calculated as a four quarter moving average of the nominal amount of the grant divided by the nominal median Australian house price level. A median house price level series is constructed using a point estimate (September quarter 2004) from the REIA's "Market Facts" publication and then scaling this by the change in the nominal house price index (Δnhp).

4.2.3 Risk

Movements in risk may play an important role in house price dynamics. Four measures of risk are introduced by Muellbauer and Murphy (1997) for UK house prices and by Fernandez-Corugedo and Muellbauer (2006) for UK mortgage credit: inflation volatility, nominal interest rate volatility or surprise; the unemployment rate and downside (asymmetric) risk. Inflation volatility (*invol*) is a four quarter moving average of the absolute annual change in annual inflation ($abs(\Delta_4 p_t - \Delta_4 p_{t-4})$). Interest rate surprise (*intsup*) is defined as unanticipated changes in the log nominal mortgage interest rate (Li). To measure unanticipated changes, a general model of log mortgage interest rates (Li_t) is estimated in AutoMetrics using lagged mortgage interest rates (Li_t), four lags of the 90 day bank bill rate ($90BB$), four lags of the 10 year Treasury bond rate ($10TB$) and one lag (owing to data limitations) of the 5 year Treasury bond rate. *intsup* is the residual of the parsimonious model²⁴. The log unemployment rate appears in the long run solution as well as in the dynamics. Higher unemployment indicates labour market instability and increases the risk of mortgage default.

Downside risk (*DSrisk*) reflects potential asymmetric risk aversion. Households may be highly averse to periods of negative rates of returns, but are neutral to receiving positive returns. This aversion may be acute for liquidity constrained households who can increase saving but not borrowing in response to fluctuating capital values. A measure of the real rate of return on housing (*ror*) is calculated as:

$$ror_t = \Delta_4 rhp_{t-1} + 0.02 - \frac{i_t}{100} \quad (6)$$

where 0.02 is an estimate of real rental returns net of maintenance and depreciation and i is the nominal interest rate. *DSrisk* is thus defined as:

$$\begin{aligned} DSrisk_t &= 0 && \text{if } ror_t \geq 0 \\ &= ror_t && \text{if } ror_t < 0 \end{aligned} \quad (7)$$

²³On 14 October 2008 the new Labor Government doubled the grant in relation to established dwellings (from \$7,000 to \$14,000) and tripled the grant in relation to newly constructed dwellings (from \$7,000 to \$21,000). The increases apply until 30 June 2009.

²⁴The expected sign on *intsup* in the house price equation is negative. Housing debt is the main liability carried by households and so unanticipated movements in nominal interest rates impact on the short term cash flow of households, especially credit constrained ones.

4.2.4 Frenzy

Non-linear adjustment dynamics are modelled in the form of "frenzy" effects²⁵. Hendry (1984) pioneered the use of a cubic of lagged real house price changes $((\Delta rhp_{t-1})^3)$ to approximate periods of excess demand or large disequilibria. Muellbauer and Murphy (1997) find cubic effects significant in their UK model using annual data. The advantage of the cubic is that it preserves the sign of the price change - so has the advantage of acting symmetrically - and becomes infinitesimal when price changes are small. Because $(\Delta rhp_t)^3$ is collinear with other autoregressive terms in the GUM, the cubic is reparameterised in this paper as the residual of the following regression: $(\Delta rhp_t)^3 = \alpha + \beta \Delta rhp_t + \varepsilon_t$. That is, $frenzy_t = (\Delta rhp_t)^3 - \hat{\alpha} - \hat{\beta} \Delta rhp_t$. This reparameterisation ensures orthogonality between $frenzy_{t-1}$ and Δrhp_{t-1} in the house price regression. OLS estimation of the cubic regression produced $\hat{\alpha} = 2.5745 \times 10^{-7}$ and $\hat{\beta} = 0.002434$. These fitted values, combined with the coefficients on $frenzy_{t-1}$ and Δrhp_{t-1} from the house price regression, can be used to recalculate the actual estimators on $(\Delta rhp_t)^3$ and Δrhp_{t-1} .

There are at least two possible reasons that Walrasian price adjustment might be non-linear in housing markets. One hypothesis is that high transaction, computation, measurement or information costs deter trade during normal market periods. Shefrin and Thaler (1988) argue that agents adopt "rules of thumb" behaviour because trading costs discourage continuous intertemporal optimisation. These (threshold) costs are overcome when activity is high and price changes are large. Households may, for example, lack information about the price of comparable dwellings in their location except during periods of high market activity. The coordination role of real estate agents in matching demand and supply through time may be enhanced when housing turnover is high. These periods may provide agents with an opportunity to trade to restore optimisation and relieve pent-up excess demand. Abelson *et al* (2005) provide partial support for this logic finding that error correction is 30 per cent slower during periods of flat or falling prices as compared to boom periods.

An alternative justification for non-linear dynamics is derived from Morris and Shin's (2002) game theoretic model on the social value of public information. The model has its origins in the "sunspots" literature pioneered by Jevons (1884), the "beauty contest" analogy of Keynes (1936) and the "island economy" models of Phelps (1970) and Lucas (1972, 1973). Morris and Shin posit that public information has a dual role: conveying information about fundamental values (the "true state"); and as a focal point for beliefs about the actions of other agents. The assumption is that agents in their objective function care about the distance between their action and the true state *and* the distance between their action and the average action of the other agents.

If there is perfect information for all agents about the true state then the unique equilibrium of the players' game is also the social welfare maximising outcome. When information about the true state is *imperfect*, there are two possible outcomes. If agents possess no private information, greater precision in public information always increases social welfare. However, if agents possess some private information, greater precision of public information may not necessarily improve social welfare. This is because agents, in forming beliefs about the likely strategies of the other players, have a tendency to overweight the importance of public information relative to private information and so overreact to public signals. The key welfare implication is that if agents care more about aligning with the beliefs of other agents (relative aligning actions to the true state), and if their private signal is relatively precise (that is, agents are already privately well informed), then the authorities should avoid providing additional public information about the true state unless that information is of very high quality.

In the context of housing markets, periods of high activity tend to coincide with potentially noisy market and political commentary. High activity also prompts, for example, a plethora of housing-related media programming purporting to provide information to home-owners and housing market participants. During the peak of the house price boom during the early 2000s there were as many as eight housing-related lifestyle programmes between just two of the three commercial television

²⁵Also known as "threshold" dynamics.

networks in Australia.²⁶ It seems plausible that public information about true housing values becomes noisier during boom periods and leads to greater volatility in house price dynamics.

5 Preliminary analysis

5.1 Unobserved components analysis

The next step is to develop a representation of FLIB. The general model is estimated in STAMP²⁷ omitting all constants, trends and outlier dummies to examine its time series components. STAMP uses algorithms such as the Kalman filter to fit the unobserved components of time series models such as trends, seasonals, cycles and irregular components. After controlling for a wide range of economic and demographic factors (Table 1), the remaining unobserved stochastic trend present in the house price data arguably has a direct interpretation as the impact of FLIB (non-price credit conditions).

The general model is estimated as a stochastic (local linear) trend model with fixed level. This specification is imposed to show financial liberalisation and structural change as a smooth, evolutionary process:

$$\Delta nhp_t = \mu_t + \gamma_t + X\beta + \varepsilon_t \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \quad (8)$$

where μ_t is the trend, γ_t is a trigonometric seasonal component, X is a matrix of the (long and short run) economic and demographic explanatory variables, and ε_t is the irregular component. The stochastic trend component (μ_t) is estimated as:

$$\mu_t = \mu_{t-1} + \psi_{t-1} \quad (9)$$

$$\psi_t = \psi_{t-1} + \zeta_t, \quad \zeta_t \sim NID(0, \sigma_\zeta^2) \quad (10)$$

where ψ_t is the slope of the trend and ζ_t is the random error.

Table 2 gives the STAMP estimation results. STAMP is not used here for model selection or evaluation purposes - this role is played by AutoMetrics. It is nonetheless worth noting that the key long run variables ecm_t , real (r_{t-1}) and nominal interest rates (Li_{t-1}) are significant at the 5 per cent level and appropriately signed. The standard error of the model is 0.0142 and the coefficient on the ecm_t indicates a speed of adjustment of around 17 per cent per quarter. This is consistent with other Australian error correction models.

The more important result is that, after conditioning on a wide range of economic and demographic factors, STAMP reveals an unobserved stochastic trend in the house price model. The stochastic trend, plotted in Chart 4, broadly corresponds with the pattern of financial sector changes described in Appendix B.²⁸ It also broadly corresponds with the experiences of the UK (Fernandez-Corugedo and Muellbauer, 2006) and South Africa (Aron and Muellbauer, 2006) although the timing of the turning points are country-specific. For Australia, the estimated stochastic trend rises slowly from 1972(3) to about 1979(1), rises steeply from 1979(1), slows down between approximately 1992(1) to 1998(1), and accelerates again thereafter. The steep rise between 1979 and 1992 can be attributed to substantial government deregulation, while the rise after 1998 may reflect debt product innovation. The pause in between the two periods corresponds with a period of negative returns for the banking sector after the business lending excesses of the 1980s. In the general estimation below, four proxy variables are used to mimic the turning points of the FLIB process (t , $FLIB_{79}$, $FLIB_{92}$, $FLIB_{98}$) and interaction effects are incorporated.

²⁶These programs include: *Auction Squad* (2004) (Seven Network); *Australia's Best Backyards* (2007-) (Seven); *Backyard Blitz* (2000-) (Nine Network); *Better Homes and Gardens* (1995-) (Seven); *Burke's Backyard* (1987-2004) (Nine); *DIY Rescue* (2003) (Nine); *Ground Force* (1999-2004) (Seven); *Hot Property* (1999-2004) (Seven); *Renovation Rescue* (2006-) (Nine); and *The Block* (2003-2004) (Nine).

²⁷Structural Time Series Analyser, Modeller and Predictor (Koopman *et al*, 2000).

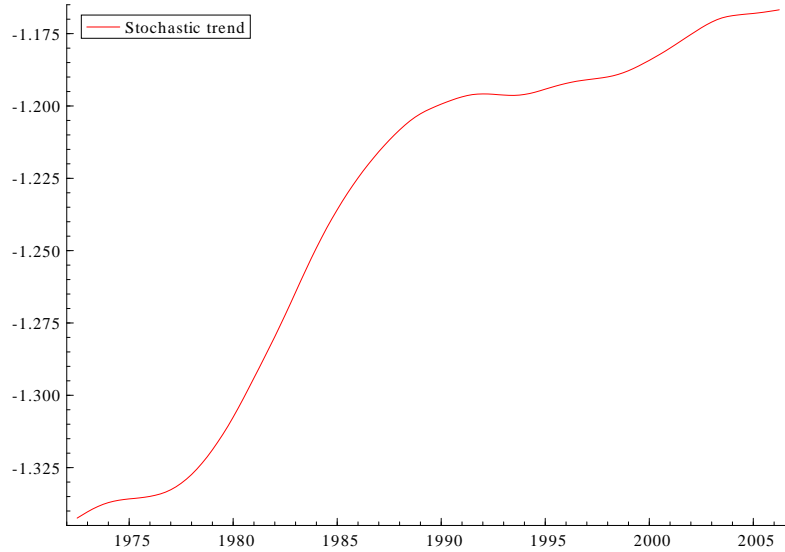
²⁸Note that STAMP cannot estimate the interaction effects between the stochastic trend and economic variables, such as interest rates, so the estimated stochastic trend can only be treated as an approximation.

Table 2 : General specification STAMP results²⁹

*Dependent = Δnhp_t
1972(3) to 2006(2)*

Variable	Coefficient	Rmse	Variable	Coefficient	Rmse
Li_{t-1}	-0.0679**	0.0289	$\Delta_4 Li_{t-1}$	0.0053	0.0306
r_{t-1}	-0.4585**	0.1752	$\Delta_4 s_{t-1}$	-0.0453**	0.0138
ecm_t	0.1659**	0.0695	Δs_{t-1}	0.0420*	0.0217
Lue_{t-1}	-0.0075	0.0270	Δs_{t-2}	0.0613**	0.0223
WA_{t-5}	0.0516	0.0447	$\Delta \Delta p_t$	-0.3832	0.2731
$\Delta_4 pop_{t-1}$	2.5391	1.9374	$\Delta \Delta p_{t-1}$	-0.2797	0.3116
$\Delta_4 dem1_{t-1}$	0.0886	0.1173	$\Delta \Delta p_{t-2}$	0.0608	0.2583
$\Delta_4 dem2_{t-1}$	-0.03444	0.0811	$\Delta_4 Lue_{t-1}$	0.0030	0.0222
NG_t	-0.0201**	0.0092	ΔLue_{t-1}	0.0203	0.0343
$FHOS_{t-1}$	0.0021	0.0037	ΔLue_{t-2}	-0.0573	0.0379
$FHOS_{t-5}$	-0.0000	0.0000	$intsup_{t-1}$	0.1022	0.0866
$\Delta_4 y_{t-1}$	0.0458	0.0993	$infol_{t-1}$	-0.5253**	0.2645
Δy_{t-1}	0.2528*	0.1356	$DSrisk_{t-1}$	0.0367	0.0961
Δy_{t-2}	0.0216	0.1125	$frenzy_{t-1}$	0.0313	0.1126
ΔLi_{t-1}	-0.0714	0.0819	$\Delta_4 rhp_{t-1}$	-0.0694	0.0713
ΔLi_{t-2}	-0.0012	0.0483	Δrhp_{t-1}	0.1953*	0.1077
			Δrhp_{t-2}	0.17323	0.1069
Diagnostics					
R^2	0.65282				
Std error	0.014166				
Normality	8.5228				
DW	2.0748				

Chart 4 : STAMP model – unobserved stochastic trend



²⁹** and * denotes t-test significance at the 5 and 10 per cent levels respectively.

5.2 General model estimation

The general unrestricted model (GUM) is estimated in AutoMetrics across two sample periods. Model reduction delivers two parsimonious specifications, Model 1 and 2, shown at Table 3. Model 3 is simply Model 1 with $FLIB_{98}$ added back in and re-estimated³⁰. Heteroskedasticity and autocorrelation consistent standard errors (HACSE) are shown in parentheses. Several key terms (based on the theoretical discussion) were fixed in the parsimonious equation to assist model reduction: ecm_t , Li_{t-1} , r_{t-1} , $FLIB^* \times Li_{t-1}$ and $FLIB^* \times r_{t-1}$. With the exception of r_{t-1} and $FLIB^* \times r_{t-1}$ in Model 2 (the latter of which is significant at the 5 per cent level), all key terms are robustly significant at 1 per cent level.

³⁰That is, no model reduction is conducted.

Table 3 : Estimation results
(dependent variable is Δnhp_t)

	Model 1	Model 2	Model 3
	<i>1972(3)-2006(2)</i>	<i>1979(1)-2006(2)</i>	<i>1972(3)-2006(2)</i>
<i>Constant</i>	-2.2502 (0.3212)	-2.4715 (0.5677)	-1.9642 (0.3806)
<i>ecm_t</i>	0.1437 (0.0172)	0.1369 (0.0249)	0.1723 (0.0224)
<i>Li_{t-1}</i>	-0.1252 (0.0161)	-0.1698 (0.0399)	-0.1035 (0.0184)
<i>r_{t-1}</i>	-0.2059 (0.0749)	-0.2682 (0.2819)	-0.1281 (0.0831)
<i>t</i>		-0.0219 (0.0042)	
<i>FLIB₇₉</i>	0.0017 (0.0002)	0.0227 (0.0043)	0.0019 (0.0002)
<i>FLIB₉₂</i>	-0.0022 (0.0003)	-0.0011 (0.00041)	-0.0028 (0.0004)
<i>FLIB₉₈</i>			0.0018 (0.0005)
<i>FLIB* × Li_{t-1}</i>	0.0021 (0.0005)	0.0026 (0.0007)	0.0011 (0.0005)
<i>FLIB* × r_{t-1}</i>	-0.0217 (0.0031)	-0.0139 (0.0057)	-0.0180 (0.0031)
<i>WA_{t-5}</i>	0.0605 (0.0065)	0.0685 (0.0114)	0.0627 (0.0067)
<i>Δ₄pop_{t-1}</i>		4.1794 (1.453)	
<i>DSrisk_{t-1}</i>		0.1422 (0.0560)	
<i>Lue_{t-1}</i>	-0.0362 (0.0069)		-0.0337 (0.0075)
<i>Δy_{t-1}</i>	0.2070 (0.0489)	0.1762 (0.0599)	0.2369 (0.0482)
<i>Δrhp_{t-1}</i>	0.1824 (0.0784)	0.1842 (0.0856)	0.1955 (0.0783)
<i>Δ₄rhp_{t-1}</i>	-0.1133 (0.0285)	-0.1331 (0.0412)	-0.0898 (0.0343)
<i>frenzy_{t-1}</i>	190.455 (18.30)	186.381 (19.06)	193.281 (19.57)
<i>NG_t</i>	-0.0174 (0.0025)	-0.0159 (0.0032)	-0.0183 (0.0023)
<i>FHOS_{t-5}</i>	0.0098 (0.0019)	0.0109 (0.0021)	0.0086 (0.0020)
<i>Seasonal_{t-1}</i>	0.0064 (0.0019)	0.0059 (0.0020)	0.0064 (0.0019)
<i>dum81(1)</i>	0.0544 (0.0033)	0.0531 (0.0047)	0.0571 (0.0037)
<i>dum81(4)</i>	0.0308 (0.0034)		0.0314 (0.0033)
<i>dum88(3)</i>	0.0541 (0.0028)	0.0486 (0.0038)	0.0556 (0.0030)
<i>dum91(3)</i>	0.0342 (0.0026)	0.0363 (0.0031)	0.0359 (0.0027)
<i>dum00(3)_t</i>	-0.0113 (0.0022)		-0.0101 (0.0029)
	Model 1	Model 2	Model 3*
	<i>1972(3) -2006(2)</i>	<i>1979(1)-2006(2)</i>	<i>1972(3) -2006(2)</i>
Std error	0.00975118	0.00966421	0.00963404
R ²	0.824576	0.848559	0.830268
DW	2.03	2.20	2.08
parameters	22	23	23
T	136	110	136
<i>Diagnostics</i>			
<i>(p-values):</i>			
AR 1-5 test	0.1062	0.1247	0.0640
ARCH 1-4 test	0.1528	0.1143	0.0872
Normality test	0.6048	0.5686	0.6713
Hetero test	0.3198	0.5529	0.6792
RESET test	0.3726	0.1916	0.3350

6 Discussion

6.0.1 Overview

All variables display correct signs and are robustly significant. The parsimonious models display high explanatory power and satisfy diagnostic tests for autocorrelation, heteroskedasticity and normality. The standard errors of Model 1 and 2 are virtually identical at 0.0098 and 0.0097 respectively.

Model 1 and 2 are in most respects identical in terms of regressors, diagnostics and fit. In the dynamics, Models 1 and 2 both retain lagged changes in income per capita (Δy_{t-1}), lagged real annual house price changes ($\Delta_4 rhp_{t-1}$), lagged real quarterly house price changes (Δrhp_{t-1}) and the lagged residual of the cubic equation ($frenzy_{t-1}$). These dynamics were selected from a general model that included dynamic terms covering share prices, income, inflation, demography and risk.

Model 2 retains from the GUM t (the full sample linear trend), $\Delta_4 pop_{t-1}$, and $DSrisk_{t-1}$; and discards Lue_{t-1} and two impulse dummies (GST_t and $dum81(4)$). The negative coefficient on t paradoxically suggests that credit conditions were tightening, not flat before 1980. But based on only four observations this term is unlikely to be well-estimated and possibly proxies for some other variable (relevant for those four quarters) that should not have been omitted from the GUM. In any case the impact of t is neutralised by the positive coefficient on $FLIB_{79}$ so the economic interpretation is then the same as for Model 1.

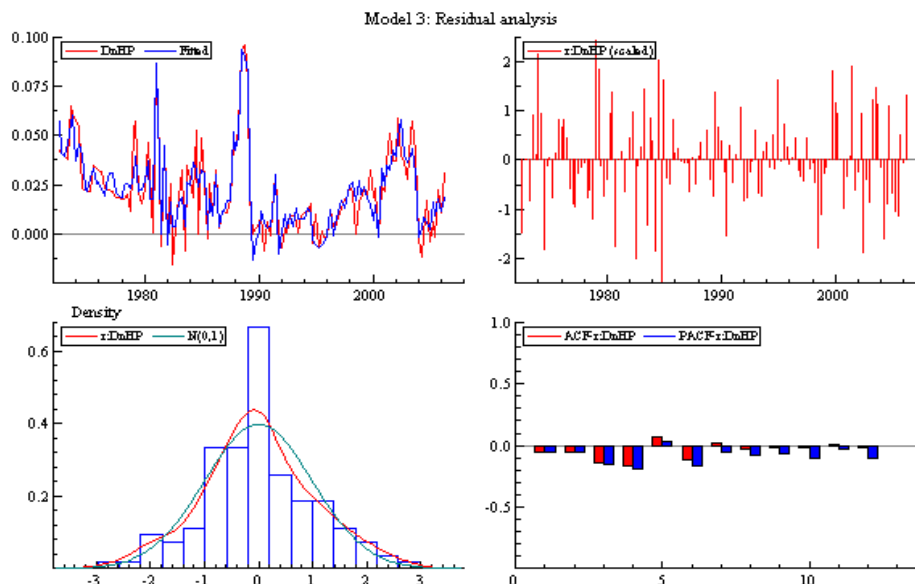
A surprising aspect of Model 1 is the implied shape of the FLIB process. Because $FLIB_{98}$ is not retained from the GUM, Model 1 suggests that financial conditions *continued* to tighten even over the late 1990s³¹. An omitted variable F-test on Model 1 shows that $FLIB_{98}$ barely fails at the 5 per cent level (p-value = 0.0588). Adding $FLIB_{98}$ to Model 1 and re-estimating gives Model 3, presented in Table 3 above.

Model 3 has a standard error of 0.00963, meaning that 95 per cent of the fitted values of quarterly nominal house price changes predicted by the model are within 1.92 per cent (0.0096×2 standard errors) of the actual price change. This is a satisfactory level of explanatory power considering the standard deviation of the dependent variable (Δnhp) over the full sample period is 2.14 per cent. Model 3 has a slightly better fit than Model 1 however the diagnostics are marginally poorer, though still acceptable. Like Model 1, Model 3 passes all tests for autocorrelation and heteroskedasticity at 5 per cent level. However unlike Model 1, it fails the AR1-5 and ARCH1-4 tests at the 10 per cent level.

Chart panel 5 shows the residuals of Model 3. The scaled residuals show slightly higher variation in the first part of the sample period. This is likely due to measurement error (and higher variance) in the house price data because of a lack of compositional adjustment and narrower survey coverage before 1986 (that is, pre-Australian Bureau of Statistics data). The ACF/PACF chart also shows some mild autocorrelation present at the third and fourth lags. Although neither present serious concerns - since the models satisfy diagnostic tests for autocorrelation and heteroskedasticity tests at the 5 per cent level - these findings support the use of HACSEs for model reduction. Finally, the coefficients on the regressors are virtually identical to Model 1, however the shape of the FLIB process accords a little better with priors. On balance therefore, Model 3 is preferred to Model 1.

³¹The prior was that credit conditions tightened only temporarily between 1992 and 1998, and that credit conditions loosened again with the accelerated pace of debt product innovation during the late-1990s.

Chart panel 5 : Residual analysis of Model 3



6.0.2 Cointegration

Model 3 implies the following long run relationship³²:

$$\begin{aligned}
 rhp_t = & -11.4 + 2(y_{t-2} - H_{t-1}) + 0.364WA_{t-5} \\
 & -0.196Lue_{t-1} - 0.043Li_{t-1} - 9.606r_{t-1} \\
 & +0.05FHOS_{t-5} + 0.011FLIB_{79} - 0.016FLIB_{92} \\
 & +0.010FLIB_{98} + \mu_t
 \end{aligned}$$

The steady state variables accord with economic theory, are correctly signed and robustly significant at the 1 per cent level. Cointegration occurs between the following I(1) variables. The positive long run influences are FLIB across 1979(1) to 1992(1) and 1998(1) to 2006(2), real income per house (as part of ecm_t)³³, the proportion of the population of working age (15-64 years) (WA_{t-5})³⁴, the introduction of the first home owners' scheme ($FHOS_{t-5}$). The negative long run influences are real interest rates (r_{t-1}) which affect the cost of capital facing home buyers and which are amplified by interaction effects with financial liberalisation ($FLIB^* \times r_{t-1}$). Nominal interest rates (Li_{t-1}), which matter for credit constrained borrowers, are also a negative long run influence but with an offsetting positive interaction effect ($FLIB^* \times Li_{t-1}$). Other negative long run influences are a tightening of financial conditions after 1992 ($FLIB_{92}$) and the log unemployment rate (Lue_{t-1})³⁵. A negative unity constraint is imposed on current inflation.

³²Interest rate elasticities also include the FLIB interaction effects as at 2006(2).

³³Note also that when y_{t-1} and Δy_{t-1} are included in the dynamic specification, the latter returns a significant and mildly negative sign. A reparameterisation thus includes y_{t-2} in the steady state allowing Δy_{t-1} to have a mildly positive sign. This reparameterisation is cosmetic but possibly indicates that house prices are a function of income as a lagged two-quarter moving average.

³⁴It is difficult to be conclusive about the order of integration of WA since it is an interpolated variable and the ADF test is based on only 30 annual observations. An alternative strategy would be to exclude all interpolated annual variables because of their ambiguous orders of integration. However this approach would be asserting that demography plays no role in the determination of house prices, which consumption theory suggests is implausible.

³⁵An alternative interpretation is to treat Lue_{t-1} as I(0) and part of the dynamics for Model 3 (see Appendix B).

The results support cointegration following the strategy of Banerjee *et al* (1986), Kremers (1989), Kremers *et al* (1992) and Muellbauer and Murphy (1997). Direct estimation of the cointegrating relationship uses information contained in both the structural and error correction dynamics. Cointegration implies and is implied by stationarity in the residual of the long run equation. An ADF test was conducted on the residual of the long run equation ($\hat{\mu}_t$), which showed stationarity at the 1 per cent level ($t\text{-adf} = -3.822$). Finally the ecm_t term, an important part of the error correction dynamics, shows an adjustment speed of 17.2 per cent per quarter. That is, shocks to house prices take about 6 quarters to unwind. This is comparable to Abelson *et al* (2005), who in a different specification, found adjustment to the steady state to be around 21 per cent per quarter during boom periods (5 quarters) and around 14 per cent during non-boom periods. (7 quarters) Similarly Tu's (2000) adjustment speed was around 13 per cent per quarter (7.5 quarters).

6.0.3 Interpretation

The economic interpretation of Model 3 is as follows. Real non-property income relative to housing supply is especially important. A one standard deviation increase in real income per house ($y_{t-2} - H_{t-1}$) raises quarterly nominal house price growth by 5.8 per cent. The positive effect for a one standard deviation increase in the proportion of the population of working age (WA_{t-5}) is 6.3 per cent with a 5 quarter lag. The five quarter lag on the demographic variable indicates a delay in household formation after an increase in the working age proportion of the population over the previous year.³⁶ A one standard deviation increase in the log unemployment rate (Lue_{t-1}) depresses house prices by 1.2 per cent. Other important effects are discussed below.

6.0.4 Policy effects

Policy effects are clearly evident in Model 3. The quarantining of negative gearing deductions between 1985(3) and 1987(3) depressed quarterly nominal house price growth over the period by 1.8 per cent. The July 2000 introduction of the *FHOS* subsidy also had an impact, raising long real house prices by 9.3 per cent by 2006(2). In terms of short run effect, with a five quarter lag the *FHOS* promoted quarterly nominal house price growth by 0.5 per cent in the December quarter of 2001. Its impact rose, as the grant and its scope increased, to a peak of 4.1 per cent in 2003(3). After 2003(3), the positive quarterly effect of the *FHOS* on nominal house price growth waned to about 1.6 per cent by the end of the sample period.

6.0.5 Mean-reverting and non-linear dynamics

The autoregressive terms in the parsimonious specification - the lagged real house price changes (Δrhp_{t-1} and $\Delta_4 rhp_{t-1}$) and the $frenzy_{t-1}$ term - are particularly interesting. The significant negative coefficients on $\Delta_4 rhp_{t-1}$ and Δrhp_{t-1} (after reparameterisation³⁷) indicate mean-reversion with an extra weight on the most recent lag. The coefficient on Δrhp_{t-1} is consistent with Bodman and Crosby's (2003) result for Melbourne but not for Perth (all other city price models showed insignificant coefficients for the persistence terms). Mean reversion is also in concert with Bourassa and Hendershott's (1995) finding albeit the time period and other regressors used are markedly different. Conversely, Tu (2000) found a positive autoregressive term over 1989-99.

Meanwhile $frenzy_{t-1}$, with a mean of zero, acts symmetrically for positive and negative lagged house price changes. The term is highly significant ($t\text{-HACSE} = 9.88$). When lagged real house price

³⁶Equivalently, it indicates that the population proportion aged 16-65 years affects house prices.

³⁷Using the fitted values of the cubic regression (see Section 4.2.4), the coefficients from the house price equation can be reparameterised as:

	Reparameterised coefficient
Δrhp_{t-1}	-0.2750
$\Delta_4 rhp_{t-1}$	-0.0898
$(\Delta rhp_{t-1})^3$	193.281

changes are small, the cubic's effect is infinitesimal but it becomes non-linearly larger (by a power of three) as the magnitude of the lagged real house price change increases. This result contrasts with Abelson *et al*'s (2005) non-linear, but *asymmetric*, error correction dynamics.

The analysis now considers the *combined* autoregressive impact on contemporaneous nominal house price growth.³⁸ Table 4 and Chart 6 demonstrate the net effect of a one-quarter lagged real house price change on nominal house prices: that is, via the mean reversion terms (Δrhp_{t-1} and $\Delta_4 rhp_{t-1}$) and the cubic term (Δrhp_{t-1})³. If real house prices grow at their mean quarterly rate (across the full sample period) of 0.7 per cent, the net effect of the three autoregressive terms is to subtract 0.3 per cent from nominal house prices in the next period. This is almost entirely due to the effect of the lagged house price terms (Δrhp_{t-1} and $\Delta_4 rhp_{t-1}$) - the cubic's offsetting impact is infinitesimal. In fact, the net effect of the three terms is negative - and therefore mean-reverting - whenever lagged real house price changes are less than 4.6 per cent³⁹. However whenever real house price changes exceed 4.6 per cent, the cubic effect dominates and pushes Δnhp_t in the same direction as Δrhp_{t-1} . As another example, real house price growth peaked in the late-1980s boom at 8.1 per cent in 1988(4). The net effect on one quarter ahead nominal house price growth was 7.3 per cent. This consists of a 10.3 per cent boost from the cubic term and a 3.0 per cent deduction from the mean-reverting influence of Δrhp_{t-1} and $\Delta_4 rhp_{t-1}$.

Table 4 : Sensitivity of contemporaneous nominal house price growth to one quarter lagged real house price changes
(all changes are percentages)

Real price change	Mean-reverting effect	Cubic effect	Net effect
-10.0	+3.6	-19.3	-15.7
-7.5	+2.7	-8.1	-5.4
-5.0	+1.8	-2.4	-0.6
-2.5	+0.9	-0.3	+0.6
-1	+0.4	0.0	+0.4
+1	-0.4	0.0	-0.4
+2.5	-0.9	+0.3	-0.6
+5.0	-1.8	+2.4	+0.6
+7.5	-2.7	+8.1	+5.4
+10.0	-3.6	+19.3	+15.7

³⁸To simulate the effect of Δrhp_{t-1} on Δnhp_t , the lagged quarterly and annual real house price changes were treated as equivalent (that is, $\Delta_4 rhp_{t-1} \equiv \Delta rhp_{t-1}$ and Δrhp_{t-2} , Δrhp_{t-3} , Δrhp_{t-4} are ignored). A less conservative strategy might calculate the lagged annual real house price change as simply the annualised quarterly figure (that is, $\Delta_4 rhp_{t-1} \equiv 4 \times \Delta rhp_{t-1}$). This would arguably represent an upper limit on the mean-reversion properties of the model. Either assumption allows a reasonable simulation of the mean reversion properties of the model.

³⁹If lagged annual real house price changes are simulated as the annualised quarterly change $\Delta_4 rhp_{t-1} \equiv 4 \times (\Delta rhp_{t-1})$, the cubic dominates mean reversion whenever Δrhp_{t-1} is less than 5.7 per cent.

Chart 6 : Net effect of lagged real house price changes on nominal house price growth



Symmetric but non-linear price adjustment provides a cogent explanation of house price booms. The result does not rely on the somewhat arbitrary boom versus non-boom error correction of Abelson *et al* (2005) (where a boom is defined as Δrhp_{t-1} greater than 2 per cent). The main drawback is that, even with the cubic, outlier dummies are required to explain two boom quarters, $dum81(1)$ ($\Delta nhp = 6.3$ per cent) and $dum88(3)$ ($\Delta nhp = 7.8$ per cent). However, reassuringly, no outlier dummies are required to explain the house price boom starting in the mid-1990s. The highly significant cubic and autoregressive terms are therefore important dynamic elements of the model and help explain much of the boom-like behaviour in house prices.

6.0.6 Financial liberalisation

The final part of the analysis returns to the estimation of proxy for financial liberalisation and other structural changes. The direct coefficients on the FLIB terms (t , $FLIB_{79}$, $FLIB_{92}$, and $FLIB_{98}$) are freely estimated in AutoMetrics. AutoMetrics retains only $FLIB_{79}$ and $FLIB_{92}$ in Model 1 and, based on priors, $FLIB_{98}$ was added back to create Model 3. Model 3 suggests that the FLIB process may be represented by a (four quarter moving average) of a deterministic trend that rises from 1979, flattens out or possibly diminishes slightly after 1992, and rises again after 1998. Large t-statistics of 7.96 and -7.36 and 3.89 on $FLIB_{79}$, $FLIB_{92}$ and $FLIB_{98}$ respectively indicate that they are important part of the house price story. FLIB effects also feed into house prices via the interest rate interaction terms discussed in Section 6.0.7.

The estimated shape of the FLIB trend accords with the broad pattern of financial market developments (Appendix B). After financial repression during the 1970s, a turning point was reached across 1979 and 1980 with the establishment of the Campbell Committee, the replacement of the Treasury "tap" system on T-bonds and the dismantling of interest rate ceilings on trading and savings bank deposits. Financial liberalisation accelerated during the 1980s: interest ceilings on fixed deposits and restrictions on savings banks were removed in 1982; the Australian dollar was floated and licenses for 10 new banks were announced in 1983; remaining controls on bank deposits were removed and the Australian stock exchange and securities industry were deregulated in 1984; the first foreign bank

began operations in 1985; interest rate ceilings on owner-occupier housing loans were removed in 1986; Basel I capital adequacy regulations were introduced in 1989 and so on.

The upward FLIB trend was halted, or indeed the estimated coefficients suggest partially reversed, after 1992. This is ponderous given the continuing institutional changes over the 1990s. On the regulatory front, foreign banks were allowed to operate (lending) branch networks and limits on the establishment of new banks were removed from 1992. The market itself was transforming: in 1992, the first mortgage originator ("Aussie Home Loans") commenced operations; in 1995, Westpac was allowed to acquire Challenge Bank under the "Five Pillars Policy" and Advance Bank purchased the Bank of South Australia; in 1996, banks removed the one percentage point differential between investor and owner-occupier loans; and in 1997, St George merged with Advance Bank.

An explanation for tightening credit conditions after 1992 may found in the precipitous decline in major bank return on equity suffered in 1992. Return on shareholder equity fell from an average of 20 per cent across 1986-1991 to -3.4 per cent in 1992.⁴⁰ Bank capital ratios also increased from around 9½ per cent in 1990 to a peak of 12.3 per cent in 1995(1).⁴¹ It seems likely that banks spent much of the mid-1990s recovering from loan losses, building their capital base, and responding to new technologies, industry consolidation and the entry of mortgage originators and foreign banks. The result was a reduction in the quantity of credit banks were willing to lend.

After the mid-1990s banking sector profitability improved substantially. The bank share price index (ASX/S&P200 (Banks)) increased from around 1.3 times the aggregate share price index across the early 1990s to around 3.1 times by mid-2003 and the banking sector capital ratio declined after 1995 to an average of around 10½ per cent. Model 3 suggests that further regulatory changes and debt product innovation may have loosened credit conditions from the late 1990s. Using the estimated coefficients on $FLIB_{79}$, $FLIB_{92}$ and $FLIB_{98}$, Chart 7 plots the shape of the FLIB process indicated by Models 1 and 3.

Chart 7 : Shape of FLIB implied by Models 1 and 3

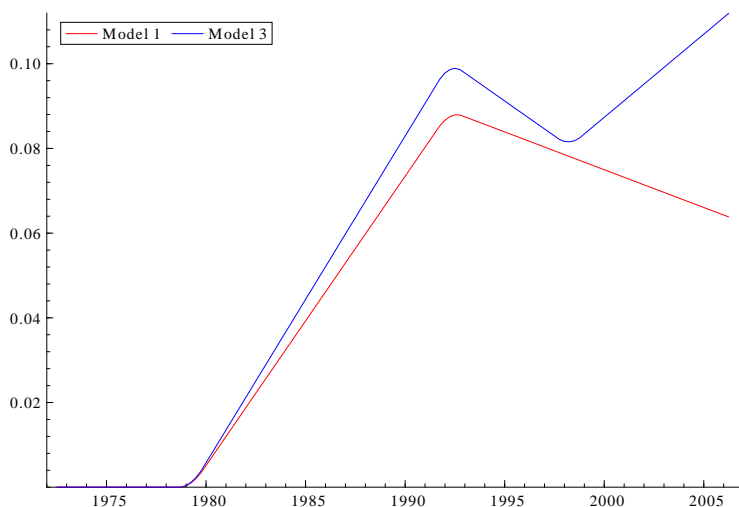


Chart 8 shows the short and long run impacts of FLIB as implied by Model 3. The estimated short run coefficients on $FLIB_{79}$, $FLIB_{92}$ and $FLIB_{98}$ are 0.0019, -0.0028 and 0.0018 respectively. Together they indicate that FLIB boosted nominal house price growth by around 0.1 percentage points at the end of the 1980s and by nearly 0.125 percentage points at the end of the sample period.

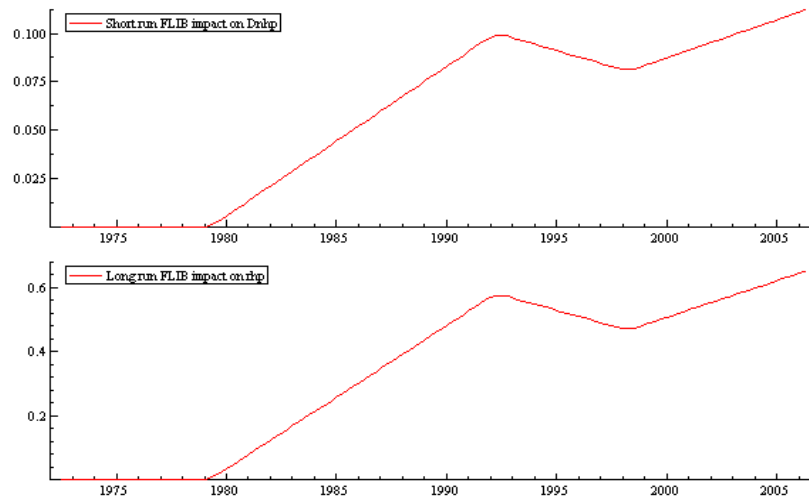
The long run coefficients are more interesting. Dividing the short run coefficients by the speed of adjustment, the long run coefficients on $FLIB_{79}$, $FLIB_{92}$ and $FLIB_{98}$ are 0.0112, -0.0160 and

⁴⁰RBA Financial Stability Review March 2007, Graph 32.

⁴¹RBA Bulletin Table B06: Consolidated group bank total capital ratio (Tier 1 and 2 capital).

0.0105 respectively. These can be multiplied by the level of the index to compare the impact of FLIB at different points in time. The split trends all have values of zero before 1979(1) so changes can be compared to that point. At 1991(4) for example, the values are on $FLIB_{79}$, $FLIB_{92}$ and $FLIB_{98}$ are 50, 0 and 0 respectively. This means that the long run impact of FLIB on the level of real house prices over 1978 to 1991 was around 0.56. At 1997(4), the split trends were 74, 22 and 0 so the net impact of FLIB relative to 1978 was 0.49. And finally at 2006(2), the split trend values are 108, 56 and 32 so the net impact of FLIB on the level of real house prices relative to 1978 was 0.65. Model 3 thus indicates that the bulk of the impact of FLIB was during the deregulation period of the 1980s. Real house price levels lost around 7 per cent of their value over 1992 to 1998, due to tightening financial conditions, but debt product innovation saw prices recover by 16 per cent after 1998. The corollary is that, all else equal, Model 3 implies that FLIB directly raised real house prices by 65 per cent over 1979 to 2006.⁴²

Chart 8 : Short and long run effects of FLIB



6.0.7 Interest rates

Interest rates affect house prices *directly* (Li_{t-1} and r_{t-1})⁴³ and *indirectly* (via the interaction terms $FLIB^* \times Li_{t-1}$ and $FLIB^* \times r_{t-1}$)⁴⁴. Real interest rates were 4.0 percentage points higher at 2006(2) relative to 1979 and so, all else being equal, detracted 38.3 per cent from long run real house prices according to Model 3. This of course offsets the direct effect of FLIB. Real interest rates are necessarily higher in a liberalised credit market because of the lesser reliance of quantity-based controls. Similar results are found for the UK (Fernandez-Corugedo and Muellbauer, 2006) and South Africa (Aron and Muellbauer, 2006). By contrast, nominal interest rates were 1.7 percentage points higher at 2006(2) relative to 1979 but detracted just 1 per cent from long run real house prices.

⁴²It is worth re-emphasising that this is a conditional model and does not constitute a general equilibrium outcome because financial liberalisation feeds back on to other economic variables - such as income, the housing stock, inflation - which are endogenous in the long run.

⁴³Note, collinearity is reduced by using the log nominal interest rate and defining the real interest rate as $MA_4(i/100 - \Delta_4 p)$.

⁴⁴De-meaned interest rates are interacted with a constrained version of the FLIB process, $FLIB^* = FLIB_{79} - FLIB_{92} + FLIB_{98}$, based on the STAMP results of Section 5.1. However Model 3 suggests that the unity constraint on $FLIB_{92}$ in $FLIB^*$ should instead be around $1\frac{1}{2}$ (that is, tighter non-price credit conditions between 1992 and 1998). If so, the direct impact of FLIB could be a little understated and the interest rate interaction effects could be a little overstated.

A more sophisticated approach would be to estimate Model 3 in EViews so that the coefficients on the components of the interaction terms can be freely estimated. Alternatively, Model 3 could be re-estimated in a second stage using the $1\frac{1}{2}$ constraint on $FLIB_{92}$ in the interaction terms.

Prior to financial liberalisation (pre-1979), $FLIB^*$ equaled zero so nominal house price growth was only influenced by the direct interest rate terms. Taking into account the direct and interaction terms, the combined coefficients indicate that nominal interest rates were much more important than real interest rates before deregulation. In the 1970s, a one standard deviation increase in nominal and real interest rates depresses nominal house price growth by 3.0 per cent and 0.5 per cent respectively. However after financial liberalisation the situation is reversed. By 1992 a one standard deviation increase in nominal and real interest rates lowers nominal house price growth by 1.3 and 4.3 per cent respectively. By 2006, the situation was starker. A one standard deviation increase lowers nominal house price growth by 0.2 and 6.6 per cent respectively.⁴⁵ The corollary is that FLIB appears to have relaxed binding credit constraints on households and enhanced opportunities for intertemporal smoothing. Accordingly, real interest rates are much more important in liberalised financial markets than in tightly regulated markets while nominal interest rates were more important in the tightly regulated financial system of the 1970s.

7 Conclusion

Australian long run real house prices are driven by real non-property income per house, financial liberalisation and innovation, real and log nominal interest rates, the log unemployment rate, the working age population proportion and the introduction of the first home owners' grant (FHOS). Real interest rates became much more important after financial markets were liberalised because of the diminished reliance on quantity controls to clear the credit market. All else equal, FLIB directly raised the real level of house prices by about 65 per cent between 1979 and 2006. Conversely, the 4.0 percentage point increase in real interest rates relative to 1979 subtracted around 38 per cent from real house prices while the 1.7 percentage point increase in nominal interest rates subtracted only about 1 per cent from long run house prices. Although by no means a general equilibrium result, the conditional model confirms that FLIB after 1979 substantially relaxed credit constraints on households and promoted opportunities for intertemporal smoothing.

The structural dynamics of Australian house prices include income growth, negative gearing policy, lagged real house price changes (indicating mean reversion and extrapolative expectations) and frenzy dynamics. The latter, modelled as a cubic of lagged real house price changes, provides a possible explanation for Australian house price booms. The long run equation shows an (error correction) speed of adjustment at around 17 per cent per quarter, indicating that house price shocks take about 6 quarters to unwind. However, whenever real house price growth is greater than 4.6 per cent per quarter, the model's short run dynamics are dominated by "frenzy". "Frenzy" behaviour amplifies house price shocks and slows down the error correction process. This effect is non-linear and symmetric in contrast to Abelson *et al's* (2005) asymmetric and linear explanation. One should thus expect to see large house price shocks persist well beyond 6 quarters.

The significance of the cubic is consistent with Morris and Shin's (2002) model of strategic action under uncertainty. Public information becomes more prevalent during boom periods and the cubic captures the natural tendency of agents to overreact to public information at the expense of private information. If agents care more about other agents' beliefs (relative to correctly guessing the true state) and if public information is relatively less precise than private information, then these "frenzy" effects may be detrimental to social welfare. Alternatively, frenzy effects may highlight the role of transaction, information and other costs that deter continuous optimisation and thus dampen price adjustment during quiet market periods. In this case, frictions are overcome when markets are highly active ("boom" periods) and so price adjustment to conditions of excess demand is rapid.

There are four contributions to the literature. First, the paper provides to my knowledge the first indicator of FLIB or non-price credit conditions for Australia and estimates its impact on housing markets. After controlling for economic and demographic factors, an unobserved stochastic trend is

⁴⁵ And Model 2 goes even further - the insignificance of r_{t-1} indicates that real interest rates are *only* relevant after deregulation.

revealed that appears to provide a reasonable approximation of the likely net impact of FLIB and that can be represented by a combination of linear split trend dummy variables. Second, a measure of non-property gross disposable income, which conforms better to economic theory, is constructed from the national accounts and applied to an Australian house price model. Third, the paper quantifies the impact of two key government policy changes. The quarantining of negative gearing deductions from 1985(3) to 1987(3) subtracted around 1.8 per cent from quarterly house price growth, while the introduction of the FHOS after 2000 boosted house price growth by up to 4.1 per cent. Fourth, frenzy dynamics help explain the short term dynamics of housing booms in Australia. The significance of the frenzy term suggests that more precise public information regarding housing markets (for example, better data) could assist in overcoming some of the noise generated by increased political and market commentary and media programming during boom periods. Equilibrium adjustment might also be accelerated by reducing transaction-based taxes (such as conveyancing) levied at state and local government level.

The results suggest policy-makers should incorporate non-price credit conditions into their long run models. The paper has demonstrated that changes in non-price credit conditions will directly affect house price levels and indirectly affect the sensitivity of households to real versus nominal interest rates. Take the current global credit freeze for example. If non-price credit conditions were to tighten by similar magnitude as witnessed following the early 1990s recession then, all else equal, FLIB would directly subtract about 7 per cent from the level of real house prices. However, in response to a decelerating economy (including two quarters of negative house price growth), the Reserve Bank cut nominal interest rates by 300 basis points between September to December 2008. Assuming full pass-through to mortgage interest rates, the model suggests this would provide a 1.6 per cent fillip to real house prices. Moreover if annual inflation is assumed to retreat from 3.3 per cent in mid-2008 to, say, the middle of the RBA's target band (that is, 2.5 per cent), the real interest rate might fall by 2.2 percentage points and this conditional impact could raise long run real house prices by as much as 21 per cent. The model therefore lends support to the aggressive and early action taken by the Reserve Bank in the latter part of 2008 as insurance against a downturn in non-price credit conditions.

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Appendix A: Background charts

Chart 9 : Australian median house prices
(relative to annualised average weekly earnings)

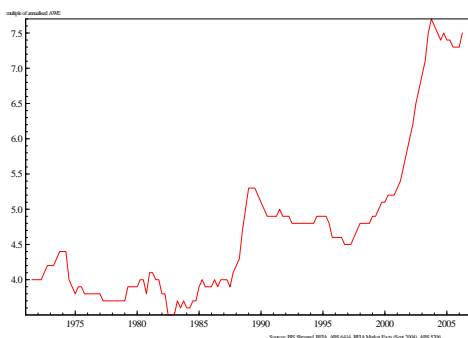


Chart 10 : Household debt (%)
(as a proportion of household disposable income)

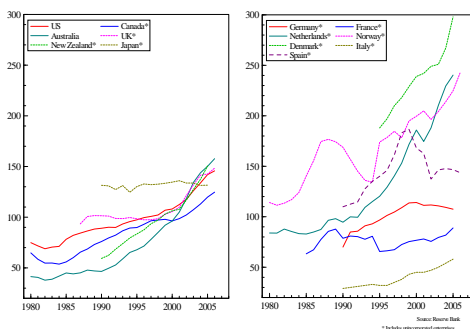


Chart 11 : Household interest payments (%)
(as a proportion of household disposable income)

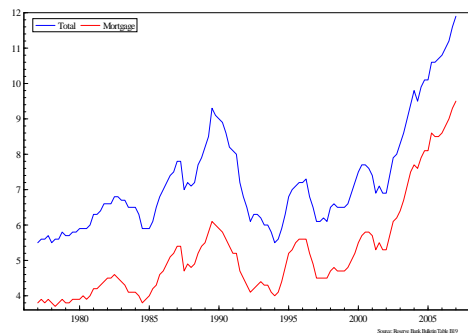


Chart 12 : Gearing ratios
(% of assets)

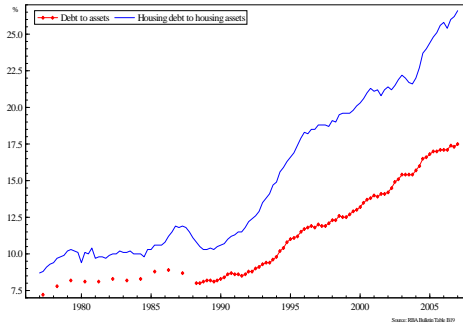


Chart 13 : Real net dwelling capital stock
(annual growth)

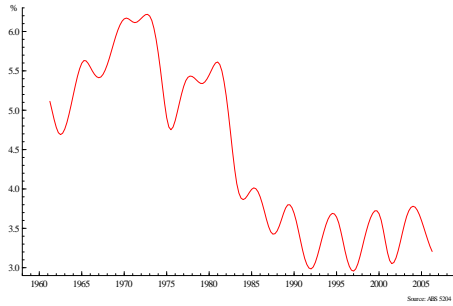


Chart 14 : Dwelling capital formation
(gross, as a percentage of real GDP)

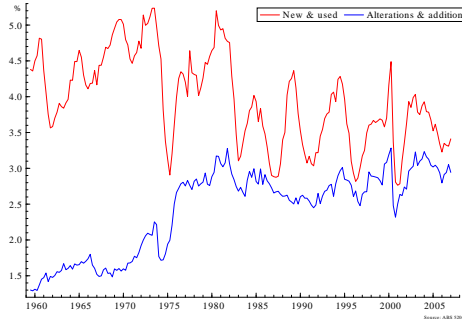
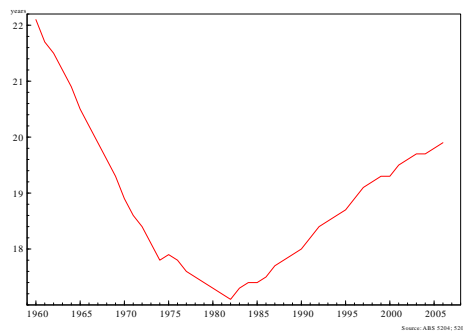


Chart 15 : Average age of dwelling capital stock



Appendix B: Summary of institutional developments

Selected timeline of major financial sector policy changes and events

- 1979 The Treasury (T-Note) tender system replaces the “tap” system: the price of government debt is now set by the market.
Australian Financial System Inquiry (Campbell Committee) is established.
- 1980 Interest rate ceilings on trading and savings bank deposits are dismantled from this time; some limits on minimum and maximum terms on fixed deposits remain.
- 1981 Australian Financial System Inquiry (Campbell Committee) tables its final report
- 1982 Savings banks are allowed to accept deposits of up to \$100,000 from trading or profit making bodies.
The minimum term on trading bank fixed deposits is reduced from 30 to 14 days for amounts greater than \$50,000, and from 3 months to 30 days for amounts less than \$50,000.
The Treasury Bond (T-Bond) tender system is approved.
- 1983 The Commonwealth Government announces that it will allow entry of 10 new banks, including foreign banks.
The Australian dollar is floated and most exchange controls are abolished.
The Treasurer announces the formation of the Martin Committee of Review to assess the Campbell Report.
- 1984 The Martin Committee of Review endorses the Campbell Report.
All remaining controls on bank deposits are removed: minimum and maximum terms on deposits, savings bank exclusions from offering chequeing facilities, and the prohibition of interest on cheque accounts.
The Australian stock exchanges and the securities industry are deregulated.
- 1985 Sixteen foreign banks are invited to establish trading operations in Australia. The first foreign bank begins operations in the last quarter.
Electronic funds transfer at point of sale is introduced.
Capital gains tax (CGT) is introduced. Pre-1985 assets are exempt.
Negative gearing restrictions come into effect.
- 1986 The first award based superannuation schemes are established.
The cessation of double tax on company dividends is announced. Imputation is introduced.
Interest rate ceilings are removed on owner-occupied housing loans.

- 1987 The dividend imputation system takes effect from mid-year.
 The Australian Stock Exchange (ASX) commences operations and amalgamates state exchanges.
 Negative gearing restrictions are removed.
 World stock markets crash.
 The late-1980s house price boom begins.
- 1988 An issues paper *Towards a National Retirement Incomes Policy* (The Cass Report) recommends establishing superannuation as an integral component of the retirement income system.
 The RBA introduces consolidated risk-weighted capital requirements for banks, consistent with Bank for International Settlements' proposals. Housing assets held by banks are "risk weighted" at 50 per cent.
 Perth based merchant bank Rothwell's collapses.
- 1989 The Reserve Bank first adopts interest rate targeting. Official interest rates reach 17 per cent.
 The late-1980s house price boom ends
- 1990 The Commonwealth Government announces the 'six pillars' policy banning mergers between the six largest domestic banks.
 Pyramid Building Society collapses.
- 1991 Commonwealth Bank shares are offered to the public for the first time and it acquires the State Bank of Victoria.
 The Martin Parliamentary Committee recommends a feasibility study of direct payments system access for NBFIs and the establishment of a high-value electronic payments system.
 Australia experiences a deep recession.
- 1992 Authorised foreign banks are allowed to operate branches in Australia, but not to accept retail deposits. Limits on the number of new banks that can be established are removed.
 The first mortgage originator, 'Aussie Home Loans', commences operations.
 The Australian Payments Clearing Association (APSC) is established.
- 1993 The Commonwealth Government Banking Policy Statement is announced, including changes to the interest withholding tax arrangements and a call for monitoring credit card interest rates and fees.
 The Australian Bankers' Association releases a code of banking practice to be monitored by the APSC.
 Reserve Bank begins to articulate a 2-3 per cent medium term inflation target.

- 1995 The government adopts a “five pillars” banking merger policy, allowing Westpac to acquire Challenge Bank.
Advance Bank purchases the State Bank of South Australia.
Stored value international cards are trialled in Australia.
- 1996 The Financial System Inquiry (Wallis Committee) is announced.
Commonwealth Bank shares are offered to the public for the second time.
The government signs an agreement with the Reserve Bank for an explicit 2-3 per cent CPI target on average over the business cycle.
Banks remove the 1 percentage point differential between investor and owner-occupier housing loans.
The late-1990s/early-2000s house price boom begins.
- 1997 St George Bank merges with Advance Bank.
Banks, building societies, credit unions and life companies are allowed to provide retirement savings accounts.
- 1999 CGT discounting is introduced while averaging and indexation concessions are abolished.
- 2000 The New Tax System is introduced, with a goods and services tax (GST) at 10 per cent, the removal of several indirect taxes and substantial personal income tax cuts.
The first home owners’ scheme (FHOS) is introduced.
The housing construction industry enters a post- GST slump.
House price growth accelerates markedly.
- 2001 Global stock markets deteriorate after September 11 and a world economic slowdown begins.
The additional FHOS is introduced.
- 2002 The additional FHOS phased out.
- 2004 The late-1990s/early-2000s house price boom ends.

Source: Financial System Inquiry Final Report 1997; Reserve Bank

Appendix C: Data

Descriptive statistics

Variable	1972(3) to 2006(2)					
	Mean	Std dev	Variable	Mean	Std dev	
<i>rhp</i>	0.7681	0.2726	Δrhp	0.0075	0.0218	
<i>nhp</i>	4.7695	0.7964	Δnhp	0.0221	0.0214	
<i>Li</i>	-2.3268	0.2879	ΔLi	0.0005	0.0460	
<i>r</i>	0.0423	0.0400	Δp	0.0147	0.0112	
<i>ecm</i>	-13.988	0.5563	$\Delta\Delta p$	7.9823e-006	0.0070	
<i>y</i>	-9.9496	0.1136	Δy	0.0034	0.0171	
<i>WA</i>	66.802	1.0074	Δs	0.0038	0.1017	
<i>DSrisk</i>	-0.0251	0.0344	$\Delta dem1$	-0.0265	0.1956	
<i>intsup</i>	-0.0002	0.0334	$\Delta dem2$	0.2278	0.1842	
<i>infvol</i>	0.0155	0.0135	Δpop	0.0129	0.0020	
$FLIB^* \times Li$	3.7903	12.071	<i>FHOS</i>	0.4497	1.0836	
$FLIB^* \times r$	0.8567	1.0417	$(\Delta rhp_{t-1})^3$	1.8575e-005	7.2202e-005	
<i>Lue</i>	1.8766	0.3493	ΔLue	0.0054	0.0657	

Unit root tests

ADF tests suggest that the following variables are I(1) for both sample periods: real (*rhp*) and nominal (*nhp*) house prices, *ecm*, real (*r*) and log nominal (*Li*) interest rates, inflation (Δp), share prices (*s*), non-property income per capita (*y*), and interaction variables ($FLIB^* \times Li$ and $FLIB^* \times r$). The cubic of lagged quarterly real house prices ($(\Delta rhp_{t-1})^3$), *DSrisk*, change in inflation ($\Delta\Delta p$), interest rate surprise (*intsup*), inflation volatility (*infvol*) and *FHOS* are all I(0).

One interpretation of AutoMetrics' choice of final model is that Lue_{t-1} may actually be I(0) over 1972-2006 and a Type 1 error has been made by treating Lue_{t-1} as I(1) (and thus part of the long run solution) at the 5 per cent level. If this is true, then Lue_{t-1} is really part of the the dynamics for Model 1 whereas, for Model 2, AutoMetrics finds that the dynamics over the short sample are better determined by population growth ($\Delta_{4pop_{t-1}}$) and downside risk ($DSrisk_{t-1}$). Overall, despite initial concerns about the quality of 1970s house price data, the high similarity between the two models (and white noise residuals) suggests that little is lost by preferring Model 3 based on its larger sample. Lue_{t-1} is thus treated as I(1) and part of the long run solution.

Demographic variables were problematic since interpolated annual data do not lend themselves to unit root testing. Unit root tests are instead conducted on the annual series although the power of the tests are quite weak with only 36 annual observations (and less after differencing). This presents a quandary for the modeller. The solved-out life-cycle consumption model applied to aggregate data indicates that age demographics may be an important long run driver of house prices through their influence on the marginal propensities to consume out of income and wealth⁴⁶. Yet *WA* appears, in a weak test, to be I(2) in level terms. Differencing yields an I(1) variable but information about age proportions is lost. *WA* combines with I(1) variables to provide a stable and economically meaningful long run solution with an I(0) residual implying cointegration. On this basis, concerns about the order of integration for demographic variables are set aside. $\Delta dem1$ and $\Delta dem2$ also appear to be I(1), while Δpop was I(0).

⁴⁶As illustrated in Muellbauer and Lattimore (1995).

Unit root tests : variables in levels

Variable	1972(3) to 2006(2)			1979(1) to 2006(2)		
	Lags (s)	t-ADF stat	Order	Lags (s)	t-ADF stat	Order
<i>rhp</i>	1	1.028	I(1)	1	0.441	I(1)
<i>nhp</i>	1	-1.238	I(1)	1	-1.111	I(1)
<i>Li</i>	3	-1.816	I(1)	2	-1.652	I(1)
<i>r</i>	0	-1.848	I(1)	0	-2.021	I(1)
<i>s</i>	0	-0.745	I(1)	0	-1.287	I(1)
<i>DSrisk</i>	2	-3.744**	I(0)	2	-3.683**	I(0)
<i>intsup</i>	0	-10.50**	I(0)	0	-8.340**	I(0)
<i>infvol</i>	0	-4.728**	I(0)	0	-5.622**	I(0)
<i>FLIB* × Li</i>	1	-1.785	I(1)	1	-1.650	I(1)
<i>FLIB* × r</i>	3	-1.717	I(1)	2	-2.047	I(1)
<i>Lue</i>	1	-3.617*	I(1)	2	-2.866	I(1)
<i>ecm</i>	0	-2.373	I(1)	0	-2.503	I(1)
<i>y</i>	1	-1.289	I(1)	1	-1.345	I(1)

Unit root tests : variables in differences

Variable	1972(3) to 2006(2)			1979(1) to 2006(2)		
	Lags (s)	t-ADF stat	Order	Lags (s)	t-ADF stat	Order
Δrhp	0	-6.909**	I(0)	0	-6.526**	I(0)
Δnhp	1	-5.001**	I(0)	1	-6.292**	I(0)
ΔLi	1	-5.453**	I(0)	1	-3.907**	I(0)
Δs	0	-11.76**	I(0)	0	-11.49**	I(0)
$(\Delta rhp_{t-1})^3$	1	-6.584**	I(0)	1	-6.108**	I(0)
ΔLue	0	-6.546**	I(0)	2	-4.157**	I(0)
Δecm	0	-13.83**	I(0)	0	-12.66**	I(0)
Δy	0	-14.96**	I(0)	0	-14.09**	I(0)
Δp	1	-2.506	I(1)	2	-2.112	I(1)
$\Delta \Delta p$	2	-11.57**	I(0)	1	-12.72**	I(0)

Unit root tests : interpolated variables

(unit root tests are conducted on annual data)

Variable	1976 to 2006		Order
	Lags (s)	t-ADF stat	
<i>WA</i>	1	-2.106	I(2)
ΔWA	0	-1.510	I(1)
$\Delta dem1$	0	-1.895	I(1)
$\Delta dem2$	1	-2.014	I(1)
	1972	to 2006	
Δpop	0	-14.18**	I(0)

Other variables

Variable	2000(1) to 2006(2)		Order
	Lags (s)	t-ADF stat	
<i>FHOS</i>	1	-4.201**	I(0)

House price model – variable construction and sources

Variable	Full Name	Construction	Source	Frequency	Start date
nhp	Nominal house price index	ln HP HP splices together: BIS: SQ59-JQ78 REA: SQ78 – MQ86 ABS(old): SQ86-DQ01 ABS(new): MQ02-	ABS 6416 REIA BIS Shapnel	Quarterly	
rhp	Real house price index	ln HP – ln p			
y	Real non-property income per capita	NPY - ln p - ln pop (see Appendix D)	ABS 5206-14	Quarterly	SQ 1959
nks	Real dwelling net capital stock per capita	Ln real dwelling net capital stock – ln pop	ABS 5204-69	Annual	Jun 1960
r	Real interest rate	$i/100 - d4p$			
Li	Log nominal interest rate	Log nominal standard variable bank mortgage interest rate	RBA F05	Monthly (use qtr average)	Jan 1959
p	Price level	log household consumption implicit price deflator	ABS 5206-08	Quarterly	SQ 1959
infol	Inflation volatility	$abs(d4 p(t) - d4 p(t-4))$			
intsup	Interest rate volatility	See Appendix D			
DSrisk	Downside risk dummy	= ROR if ROR<0 = 0 if ROR>0 ROR = $D4 nHP(t-1) + 0.02 - i(t)/100$			
Lue	Unemployment rate	ln ue	ABS, OECD	ABS: Monthly (use quarterly average) OECD: Quarterly (uses mid-month)	ABS: Feb 1978 – OECD: Aug 1966 – Nov 1977
cc	Consumer confidence - current state of family finances - prospects for family finances - 1yr economic outlook - 5yr economic outlook - current buying conditions	Log index level	RBA G08 (CBA/WBC consumer confidence index sa)	Monthly (use quarterly average)	Sep 1974
s	Real share prices	Log All Ordinaries Index - p	Datastream (OECD Main Economic Indicators)	Monthly (use end-month)	Jan 1960
NG	Impulse dummy for restricted negative gearing deductions				SQ1985 – SQ1987
GST	Impulse dummy for introduction of goods and services tax				SQ2000
WA	Proportion of the population of working age (15-64yrs)	number of persons aged 15-64 / total est resident population	ABS 3201-09	Annual (use a cubic spline in PcGive to interpolate quarterly)	Jun 1971

pop	Estimated resident population	ln pop	ABS 3101 ABS 3105	ABS 3105 Historical Population Series Annual series - interpolated in PCGive using a natural cubic spline. Sep 1989 - Mar 2006: ABS 3101 Estimated resident population Cubic spine on quarterly series.	1901
Dem1	Proportion of the population aged between 22-34 yrs "Household formation age"	number of persons aged 22-34 / total est resident population	ABS 3201-09	Annual (use a cubic spline in PcGive to interpolate quarterly)	Jun 1971
Dem2	Proportion of the population aged 65+ yrs "Retirement age"	number of persons aged 65+ / total est resident population	ABS 3201-09	Annual (use a cubic spline in PcGive to interpolate quarterly)	Jun 1971
FHOS	Dummy for introduction of first home owner's grant MA4	Nominal value of grant / median house price value (based on point estimate from REIA)		SQ04 REIA Market Facts	SQ2000