Will Population Ageing Cause a House Price Meltdown in Australia?

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Abstract

We develop an econometric model to study the effects of population ageing dynamics on real house prices in Australia. The model takes into account the endogenous nature and the dynamic adjustment process of macroeconomic variables in contrast to the existing literature which focuses on the average effect of the old age population on real house price in a single equation model. Analysis using a vector autoregressive model suggests that retiring Baby Boomers will not induce a house price meltdown as suggested by earlier studies in the U.S. The life cycle hypothesis suggests that when the Baby Boomers retire, many are likely to sell their assets to finance their retirement, exerting downward pressure on house prices. However, our analysis indicates that the impact of the ageing effect on the variation in real house price is less than 1% in the short-run and 5% in the long-run. In the short-run, more than 80% of the variation in real house price is accounted for by housing market specific shocks.

Key words: Ageing; Baby Boomers; House prices; House price meltdown; Structural vector autoregressive; Unemployment

JEL classification: C58, G12, J11

1. Introduction

The purpose of this paper is to examine the effects of population ageing dynamics on real house prices in Australia. Similar to other developed countries, Australia has experienced a changing demographic structure due to the Baby Boom and over the next four decades a further substantial change is projected[1]. This is evident in the rapidly increasing proportion of the population classed as old aged (65+ years) and decreasing proportion of those who are young (0-19 years) or working age (20-64 years). In addition, Australians continue to have one of the longest life expectancies in the world. Male life expectancy is projected to increase from 91.5 years in 2015 to 95.1 years in 2055 and female life expectancy from 93.6 years in 2015 to 96.6 years in 2055 (Intergenerational Report, 2015, p. 8). Asset ownership statistics reveal that the largest share (43%) of assets held by Australian households consists of owner occupied housing and the Baby Boom generation which comprises 25% of the Australian population has around 50% of the housing wealth[2]. This implies that the Baby Boomers control a large component of housing wealth in Australia and in next two decades the old age population will have high potential values of housing equity compared to the current elderly population. Theoretical models such as the life cycle hypothesis (Modigliani and Brumberg 1954; Ando and Modigliani 1963) and overlapping generations models (Diamond 1965) indicate that the working aged population buy assets to save for the old age and sell when they are old. These theoretical underpinnings, the observed demographic shift and housing asset ownership statistics raise the question whether the ageing population is likely to trigger a pronounced downward pressure on real house prices in Australia?

The seminal work of Mankiw and Weil (1989) examine the effect of Baby Boomers on house prices in the United States and predict a market meltdown when Baby Boomers begin to

[1] Baby Boom generation and Baby Boomers generally relate to all Australian residents born in the years 1946 to 1965, including those who migrated to Australia from countries which did not experience a Baby Boom ("Australian Social Trends", 2004)

[2] Australian Bureau Statistics, Household Wealth and Wealth Distribution, 2011-12 (cat. no. 65540DO001)

retire. However, Mankiw and Weil's (1989) startling result of real house prices falling by 47% in the United States within 20 years from 1990 provoked considerable criticism and questioning of the validity of their forecast (see Engelhard and Poterba 1991; Hamilton 1991; Hendershott 1991; Holland 1991). With the benefit of hindsight, we also see that their prediction of a decline in real house prices by 3% annually did not eventuate in the United States.

In Australia, a very limited number of studies examine the effect of demographics on house prices (Guest and Swift 2010; Otto 2007; Bodman and Crosby 2003). However, these studies are subject to a range of limitations and shortcomings and they do not provide clear answers as to how the demographic shift, particularly the rapidly increasing proportion of the old aged population, affects house prices. Neither Bodman and Crosby (2003) nor Otto (2007) directly addresses the effect of population ageing on house prices. Their focus is to analyse the growth of house prices in Australian capital cities and include population growth as an explanatory demographic variable. Although Bodman and Crosby (2003) include the fraction of population who are 60-64 years as a demographic variable they do not explain the rationale behind it. Guest and Swift (2010) examine house prices in terms of demographics but base the analysis to a 35-59 years cohort which limits its usefulness in the context of predictions of house price meltdown due to retired Baby Boomers. The results indicate that population share of the 35-59 years cohort significantly affects real house prices in the long-run. Further, ceteris paribus 1% decline in the share of population between 35-59 years lead to a reduction in real house prices 2.26%, on average.

The econometric methodologies used in these studies employ single equation models assuming that both demographic and non-demographic variables cause to change in house prices and there is no reverse causality. For example, Bodman and Crosby (2003) use Ordinary Least Square (OLS), Otto (2007) uses Autoregressive Distributed Lag (ARDL) and

Guest and Swift (2010) use Dynamic Ordinary Least Square (DOLS) model. All three models suffer from the classical problem of endogeneity of regressors since the macroeconomic variables have a substantial endogeneity component as argued by Sims (1980). Further, the time series used in their analyses start from the 1970s.

There are four ways in which this study adds to the literature. First, we extend previous Australian research on this issue by employing a much longer time series from 1950 to 2013. This is an advantage as demographic change is a slow moving fundamental which is better captured with a longer time span. Second, we use a constant quality real house price series which controls for compositional and quality effects. Third, we treat both demographic and non-demographic variables as endogenous and reverse causality between the variables is taken into account. Fourth, we use a more rigorous econometric approach and examine the dynamic relationships between the variables using a structural vector autoregressive (SVAR) model. The advantage of this approach is that it models each variable as a function of all other variables including both contemporaneous and lagged effects.

The remainder of the paper is organised as follows. Section 2 describes the selection of variables for the structural VAR model. Following a detailed explanation of the rationale of the econometric specification in section 3, the structural VAR methodology applied in the analysis is discussed in section 4. The fifth section outlines the data sources and the construction of variables. Section 6 focuses on the model estimation. Following a discussion of empirical results in section 7, the main concluding remarks are outlined in section 8.

2. Variable Selection for the Empirical Model

A number of different models are used in the literature to investigate the effects of demographics on house prices. Some analyses consist only of demographic variables along with house price while others include both demographic variables and macroeconomic aggregates. Models which comprise demographic variables and house price only may suffer from omitted variable bias. For example, macroeconomic aggregates such as real GDP per capita and unemployment may influence the demand for housing and thus the house price. Moreover, housing assets have a dual purpose. They act as a mode of wealth storage and as a durable consumption good. According to the life cycle theory, the working age population accumulate assets as a mode of savings and de-cumulate those during the retirement life. Tobin's Q theory implies that a homogenous housing market creates profit margins when the marginal price for a house is higher than the marginal production cost. Thus house prices have an impact on construction activities and shocks to house prices may affect economic variables such as real output, unemployment and commodity prices.

In this analysis, both demographic and non-demographic variables are used. The old age ratio, which is defined as the proportion of population over 65 years divided by the population aged 0-64 years, is used to measure the impact of population ageing on house prices. From the life cycle theory we presume that old age population (65+ years) and adult population (20-64 years) are the relevant population of asset sellers and buyers. Children account for a low proportion of housing ownership though their impact is not negligible when we consider the reverse causality effect of demographics on house prices. In the literature of the impact of demographics on house prices the demographic variables most commonly used are the old age dependency ratio (65+/15-64 years), the old age population and the working age population, either individually or in combination. Such studies assume unidirectional causality from demographic variables to house prices.

When choosing an appropriate demographic variable possible changes to the fertility rate should also be considered. Excess demand for housing leads to upward pressure on house prices which would affect the purchasing decision of couples of child bearing age. The result could be to defer having a child which has an impact on the fertility rates. Dettling and

Kearney (2014) find a negative relationship going from house prices to fertility rates in the United States. That is a causal relationship from house prices to demographic variables is evident. This relationship has been neglected in the previous studies. Dettling and Kearney (2014, p. 82) further conclude that changes in house prices exert a larger effect on birth rates than do in changes in unemployment rates. Further, the increasing proportion of old age population and lower labour market participation is projected to lead to a decrease in GDP per capita of 6.2% in Australia by 2050 (Kudrna et al., 2014, p. 120). If we assume that real disposable income affects fertility decisions, other things being equal, fertility rates will be depressed even further. Accordingly, a change in the fertility rates will affect the size of the young population and hence the proportion of old age population. Therefore, old age ratio (65+/0-64 years) is used as the demographic variable to measure the effects of population ageing dynamics on house prices in this research.

Using only demographic variables to examine the effect of population ageing on asset prices is subject to criticism. This study includes two non-demographic variables, namely real GDP per capita and the unemployment rate. Real GDP per capita captures the impact of economic forces, particularly the effect of income as the richer people may be willing to pay more their housing. However, it is worth noting that increasing house prices does not necessarily imply increased income of home buyers and/or home owners.

The majority of the home buyers utilise mortgage loans and the ability to service their debts is sensitive to their employment status. Louzis et al. (2012) find that unemployment has a significant impact on the quantity of non-performing loans in their study of the Greek banking sector. Increased risk of unemployment means a higher risk of default. Unemployment is used as a variable in this study to capture two effects in the housing market. The first is the medium term effect of changes in consumer confidence over the business cycle. That is, if unemployment is high the demand for housing declines and hence it would have an impact on house prices and vice versa. The second effect is due to Baby Boomers entering into the labour market and increasing the size of the labour force. During the period from the mid-1970s to the 1980s the unemployment rate trended upwards in Australia. This upward trend in unemployment could have been partly a result of the high population growth during the Baby Boom period and their entry into the labour market[3]. Thus unemployment could be an important variable capturing the purchasing decision of houses by individuals, which will then have an impact on house prices. This is the first time in the literature that unemployment is included as a non-demographic variable to examine the effect of population ageing on the house prices.

3. Rationale for the Econometric Specification

The asset meltdown hypothesis implies that the shift in demographic structure towards population ageing creates an excess supply of housing assets and thus exerts a downward pressure on house prices. The standard demand and supply theory suggests that an equilibrium market price is determined when the quantity demanded equals to the quantity supplied at a given point of time. Therefore, an appropriate starting point would be to model the quantity demanded and supplied as functions of price and other relevant variables and derive the reduced form model for the housing price as given below.

$$D = f(P, V_d) \qquad (1)$$

$$S = f(P, V_s) \qquad (2)$$

In equilibrium;

$$D = S \qquad (3)$$

$$P = f(V_d, V_s) \qquad (4)$$

[3] Researchers have not concentrated on this aspect analysing the unemployment trends in Australia during this time

where D and S are quantity of housing demanded and supplied respectively, P is the price and V_d and V_s are vectors of other demand and supply variables. This implies that price is a function of those variables influencing demand and supply. However, estimating a reduced form model for housing markets such as this does not serve the purpose of this study. In reality shifts in demand does not have necessarily be accompanied by shifts in supply and vice versa. Instead the change in price level could be due to the change in quantity demanded or supplied driven by factors outside the demand/supply fundamentals related to the housing market. For example, the change in price level could be due to exogenous shocks such as oil price shock. Furthermore, the traditional demand/supply equations assume that the variables which influence quantity demand and supply of housing are purely exogenous to the price. However, those variables may also be affected by price and there may be feedback from price to those variables. Therefore, estimating the reduced form model as given in (4) violates the key assumption of the OLS that the right hand side variables in the regression equation are purely exogenous will lead to incorrect inferences.

Demand and supply fundamentals are affected by the information available to different participants of the housing market. Information asymmetry between real estate agents, sellers and buyers may shift the demand (supply) irrespective of the supply (demand). The "no-trade" theory of asymmetric information by Milgrom and Stokey (1982) says that uninformed agents will not trade with informed counterparts. As a result agents who are informationally disadvantaged have limited market participation. The housing market participants' responses to these information disparities may create distortions in the equilibrium price.

Implicit in the literature investigating the response of demographic variables and macroeconomic aggregates to change in house price is the assumption that the impact of one variable on house prices can be isolated while holding other variables constant. Furthermore these studies assume that the variables of interest cause the house price to change and there is no relationship in the opposite direction. However, this assumption is empirically implausible since the macroeconomic variables such as house price, GDP per capita and unemployment have a substantial endogeneity component as argued by Sims (1980). In addition, it can be argued that the demographic variable used in this study (the old age ratio) is also not purely exogenous with respect to other selected variables of the model (see section 2).

There are a number of ways in which economic conditions can affect the demographic variable used in this analysis. High income per capita countries are experiencing increasing longevity leading to increase the size of the old age population. Also the studies related to the fertility scheduling states that the child bearing decisions of women are affected by the opportunity cost (see Ben-Porath, 1973; Becker, 1960). Further, Schaller (2012) examines this issue considering labour market conditions for both males and females and concludes that there exists a negative overall relationship between unemployment rate and birth rates.

Most of the existing models to examine the demographic effects on house prices take into account only contemporaneous effects of the variables. However it is likely that there are lagged effects that should be considered. For example the dynamic version of Okun's law states that the current change in the unemployment rate is explained by the current and past values of GDP growth rates and past values of changes in unemployment rates. Thus a structural VAR model is appropriate to examine the effect of population ageing dynamics on house prices in this research. That is, each variable included in the model is described by its own lagged values plus the current and lagged values of the remaining variables. The variables selected for the structural VAR model as described in the previous section represent both demand and supply factors of the housing market.

4. Econometric Specification

A fully structural VAR model of lag p is formulated as given in Eq. (5) below.

$$B_0 y_t = \alpha + \sum_{i=1}^{p} B_i y_{t-i} + \varepsilon_t \quad (5)$$

where y_t consists of vector of variables, namely the real house price (rhp), real GDP per capita $(rgdp)$, unemployment rate $(unem)$ and old age ratio (oar); p is the lag order; B_0 is a (4×4) coefficient matrix representing the contemporaneous relationships among the variables; B_i are (4×4) coefficient matrices for lagged relationships and ε_t is a (4×1) vector of structural innovations. The ε_t vector of structural innovations consist of shocks to house price, shocks to output, shocks to unemployment and shocks to old age ratio[4]. The structural innovations ε_t have mean zero and are mutually uncorrelated, that is, $\varepsilon_t \sim (0,\ \Sigma_\varepsilon)$ where Σ_ε is a diagonal matrix.

Using an autoregressive lag polynomial of order p, Eq. (5) can be written as;

$$B(L) y_t = \varepsilon_t \text{ where } B(L) = B_0 - B_1 L - \cdots B_p L^p \quad (6)$$

The structural moving average, $MA(\infty)$ representation of Eq. (6) is given in Eq. (7).

$$y_t = B(L)^{-1} \varepsilon_t \quad (7)$$

Further, the variance-covariance matrix of structural errors (Σ_ε) are normalised such that the variances of the structural shocks to unity.

$$E(\varepsilon_t \varepsilon_t') = \Sigma_\varepsilon = I_n \quad (8)$$

To apply the standard estimation technique the structural form is first transformed to the reduced form VAR. Pre-multiplying Eq. (5) by B_0^{-1} gives

$$B_0^{-1} B_0 y_t = B_0^{-1} B_1 y_{t-1} + \cdots + B_0^{-1} B_p y_{t-p} + B_0^{-1} \varepsilon_t \quad (9)$$

[4] Bjørnland and Jacobsen, 2010 identify structural shock ε_t^{PH} from the respective equation and interpret it as “shocks to house prices”

Denoting $A_i = B_0^{-1} B_i$ (10)

and $u_t = B_0^{-1} \varepsilon_t$ (11)

$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t$ (12)

$A(L) y_t = u_t$ where $A(L) = I - A_1 L - \cdots A_p L^p$ (13)

$E(u_t u_t') = \Sigma_u = B_0^{-1} B_0^{-1'}$ (because $\Sigma_\varepsilon = I_n$) (14)

The above construction implies that structural shocks depend on the coefficient estimates of the matrix, B_0 ($\varepsilon_t = B_0 u_t$). Therefore, when B_0 is known, structural coefficients and structural innovations can be calculated using the relationships in (10) and (11). To identify the parameters of the fully structural specification at least $n^2 = 16$ restrictions are required. Since Σ_ε is symmetric, $\frac{n(n+1)}{2} = 10$ parameters in B_0^{-1} can uniquely be identified. The additional identification restrictions of $\frac{n(n-1)}{2} = 6$ are required to fully determine B_0^{-1} and the structural equations and hence to recover the structural shocks.

4.1 Short-run Identification Based on Exclusion Restrictions

The exclusion restrictions described subsequently are contemporaneous restrictions on the coefficient matrix, B_0^{-1}. Eq. (15) summarises the short-run identification restrictions based on the relationship of structural innovations and reduced form errors such that $u_t = B_0^{-1} \varepsilon_t$. Reduced form errors are weighted averages of the selected structural innovations and the weights attached to the structural shocks are represented by the elements of b_{ij} for $i = 1, \cdots, 4$ and $j = 1, \cdots, 4$.

$$\begin{bmatrix} u_{1t}^{oar} \\ u_{2t}^{rgdp} \\ u_{3t}^{unemp} \\ u_{4t}^{rhpi} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t}^{shock\ to\ old\ age\ ratio} \\ \varepsilon_{2t}^{shock\ to\ output} \\ \varepsilon_{3t}^{shock\ to\ unemployment} \\ \varepsilon_{4t}^{shock\ to\ house\ price} \end{bmatrix} \quad (15)$$

Eq. (15) is shown here in matrix form. The individual equations are found by multiplying two matrices in the right hand side. For example, the first equation is: $u_{1t}^{oar} = b_{11}\varepsilon_{1t}^{shock\ to\ old\ age\ ratio}$, the second equation is: $u_{2t}^{rgdp} = b_{21}\varepsilon_{1t}^{shock\ to\ old\ age\ ratio} + b_{22}\varepsilon_{2t}^{shocks\ to\ output}$.

It is unlikely that the old age ratio would be affected contemporaneously by shocks to house prices, GDP per capita or unemployment rate. However, the old age ratio may be affected by the past innovations of these variables as they have an impact on the fertility decisions of the households and immigrants as described in sections 2 and 3. Considering this, the old age ratio does not respond shocks to house price, output or unemployment instantaneously, but with lags.

Real GDP per capita is affected by the shocks to old age ratio contemporaneously in addition to its own shocks. An increase in the retired population (over 65 years) may affect the number in the active labour force and it may slow down economic growth. Investments decisions both in physical and human capital are characterised by the different stages of an individual's life cycle. The Hviding and Mérette (1998) growth model with exogenous human capital suggests that the population ageing causes both the capital stock and the labour force to fall and as a result real output per capita also falls[5]. However, the simulation results with endogenous human capital of Fougere and Mérette, (1999, p. 422) finds that '… population ageing increases human capital investment, which leads to a greater reduction in effective labour supply in the short run… However, the increase in human capital investment eventually offsets this by raising effective labour supply, which in turn stimulates the economic growth'. Thus, the impact of population ageing still has a negative impact on GDP per capita in the short run however intensity of the impact is lower. Therefore shocks to the old age ratio have an impact on real GDP per capita contemporaneously. Shocks to

[5] A study for seven OECD countries; Canada, Sweden, Japan, France, U.S.A., U.K. and Italy

unemployment and real house price are assumed not to affect real GDP per capita in the same period.

The third Eq. of (15) indicates that unemployment responds to shocks to old age ratio and output at the same period along with its own shocks. Unemployment may not be a consequence of the shocks to house prices instantaneously however there would be lagged effects. If increasing (decreasing) house prices are driven by the shortage (excess) in new house supply, it will have an impact on the employment opportunities in housing construction and influence the rate of unemployment in the subsequent periods. Okun's (1960) law points out a negative relationship between the unemployment rate and growth rate of real GDP. The change in the unemployment rate is modelled as a function of the growth rate of real GDP with a negative coefficient. Accordingly, we assume that the unemployment rate is contemporaneously affected by the shocks to output.

The short-run exclusion restrictions imply that the old age ratio, real GDP per capita and unemployment are treated as predetermined with respect to real house price. However, house prices are allowed to respond to shocks to these three variables contemporaneously as implied by the fourth Eq. of (15). The assumption maintained in this regard is that ε_{4t} does not affect old age ratio, real GDP per capita and unemployment instantaneously but only with a delay of at least one year.

5. Data Description and Construction

The structural VAR model described is estimated using annual data from 1950 to 2013, a total of 64 observations. However, constructing a longer and accurate time series to assess the developments in house prices in Australia is challenging. A continuous house price series is available for the post 1970 period though it possesses with a number of measurement problems such as effects from compositional change, seasonality and limited control for the changing quality of housing structures[6]. In addition, the revisions which took place in compilation of the house price index (HPI) at several times make it difficult to rely on the consistency of the time series for analytical purposes[7]. The impact of compositional and quality effects is significant as house prices evolve over a long period of time. Stapledon (2007) has constructed a constant quality real house price series for Australia covering the period 1880 to 2006. The significant improvements in this house price series include a stratification exercise which corrects the period to period volatility in the quality of the housing stock and estimations to measure the impacts of the compositional changes. Thus, the Stapledon's (2007) house price series forms the foundation for the house prices used in this study. To extend the series from 2007 to 2013, the real growth rates of the residential property price index (RPPI) of the ABS is applied to the constant quality house price of 2006 in the Stapledon's (2007, table 2.5) series[8]. This approach provides a consistent series to measure house price from 1950 to 2013.

The annual time series for nominal GDP (for financial year) is obtained from Table 1: Key National Account Aggregates, 5206.0 - *Australian National Accounts: National Income, Expenditure and Product for 1960 to 2013*, published by the Australian Bureau of Statistics (ABS). For the period from 1950 to 1959, nominal GDP (i.e. in current prices) figures were obtained from Stapledon's (2007, table B.3)[9]. The current price GDP data were converted into constant prices using consumer price index published by the RBA in table G02. The quarterly CPI series was first converted to annual average CPI series for the financial year. In order to be consistent with real house price data the current GDP series was converted to 2005 constant prices using the formula given in Eq. (16).

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[6] See ABS Research Paper, 2006, 1352.0.55.093
[7] Major revisions were made in 2004, 2007 and 2012
[8] The 2012 revision produced ADPI which aggregates HPI and Attached Dwelling Price Index (ADPI)
[9] For years prior to 1960, Stapledon (2007) has obtained nominal GDP data from Butlin (1985) and factored up by 1.185 to correct the difference for over-lapping years. Please refer to Stapledon (2007, pp. 266-267) for a detailed description of GDP prior to 1960.

$$\text{year t value in year 2005 prices} = \text{year t value} \times \frac{\text{CPI}_{2005}}{\text{CPI}_t} \qquad (16)$$

An annual series for the unemployment rate was constructed using the ABS labour force historical time series commencing 1968. The annual averages of the quarterly figures published in the months of February, May, August and November were used to construct the unemployment series from 1968 to 1997. However, for the period of 1978 to 2013 the annual averages of monthly figures were obtained. The annual unemployment rates from 1950 to 1967 were obtained from the Research Discussion Paper of Fahrer and Heath (1992, p. 5).

The data for the demographic variables are based on ABS historical and projected population statistics. The data published in catalogue number 3105.0.65.001 was used in constructing required demographic variables from 1950 to 1970, while data from catalogue number 3101.0 was used for the period from 1971 to 2013.

Figure 1 shows the original level time series for the variables, namely log of real house price, log of real GDP per capita, the unemployment rate and the old age ratio (population 65+ years /population 0-64 years). The four time series show either stochastic or deterministic trends. It can be seen that unemployment data series seems to meander in a fashion characteristic of a random walk process. There is visual evidence for deterministic time trends for the log of real GDP per capita and the old age ratio. However, the log of real house price data series shows evidence of a random walk plus drift. Therefore, all four time series show non-stationary behaviour and hence the series are transformed into stationary processes before the estimation. It is worth noting that standard unit root and stationary tests confirm that old age ratio is integrated of order two (i.e. an I(2) process).

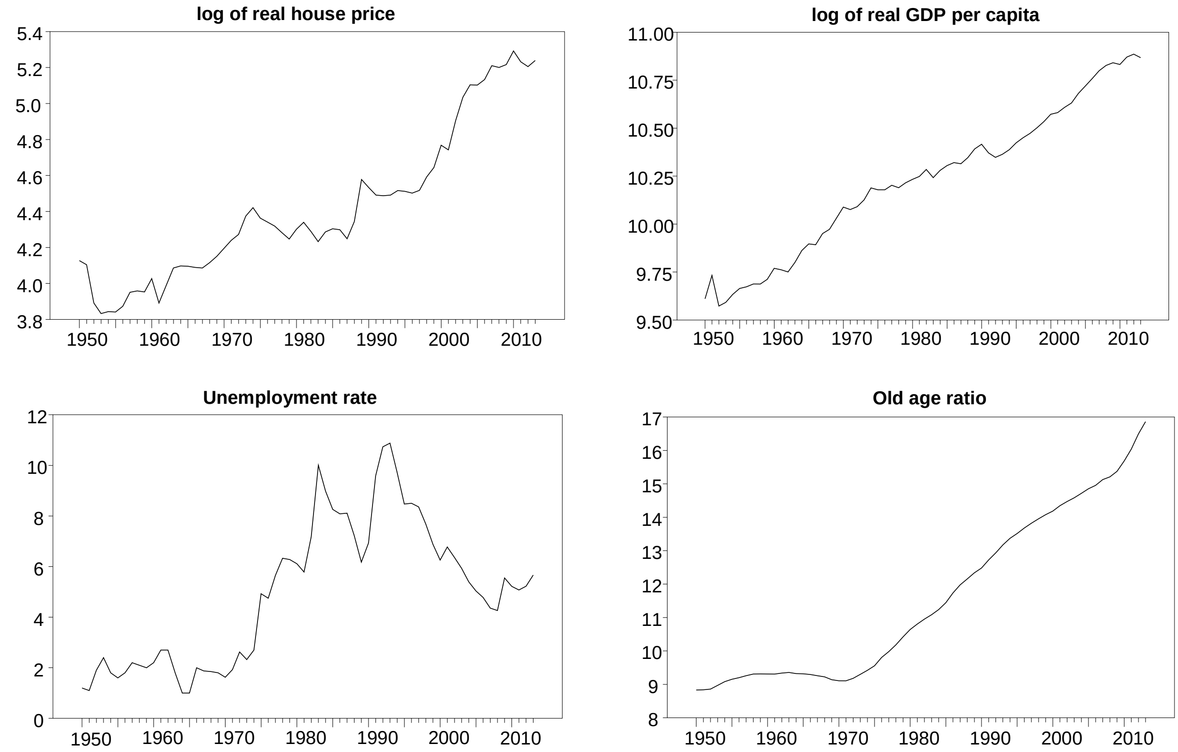


Fig. 1 Time Series Original in Levels, 1950-2013

6. Model Estimation and Lag Length Selection

The formulation of the econometric model assumes that time series is generated by a stationary, stable and finite order VAR process. Since all four time series shown in figure 1 shows non-stationary behaviour as the first step the series are transformed into stationary processes before the estimation. Two popular methods in VAR analysis for such transformations are differencing and de-trending, however in this study the Hodrick-Prescott (HP) filter is used to remove the trend, for two reasons. The first is that the time series have different causes of non-stationarity as described in section 5. DeJong and Sakarya (2015) find that '… the cyclical component of the HP filter possesses weak dependence properties when the HP filter is applied to a stationary mixing process, a linear deterministic trend process and/or a process with a unit root'. The authors further argue that inferences based on cyclical component are asymptotically correct. The second is that old age ratio is an I(2) process and the HP filter is optimal for integrated processes of order two. Fig. 2 shows the HP filtered time series using a smoothing parameter equal to 6.25[10].

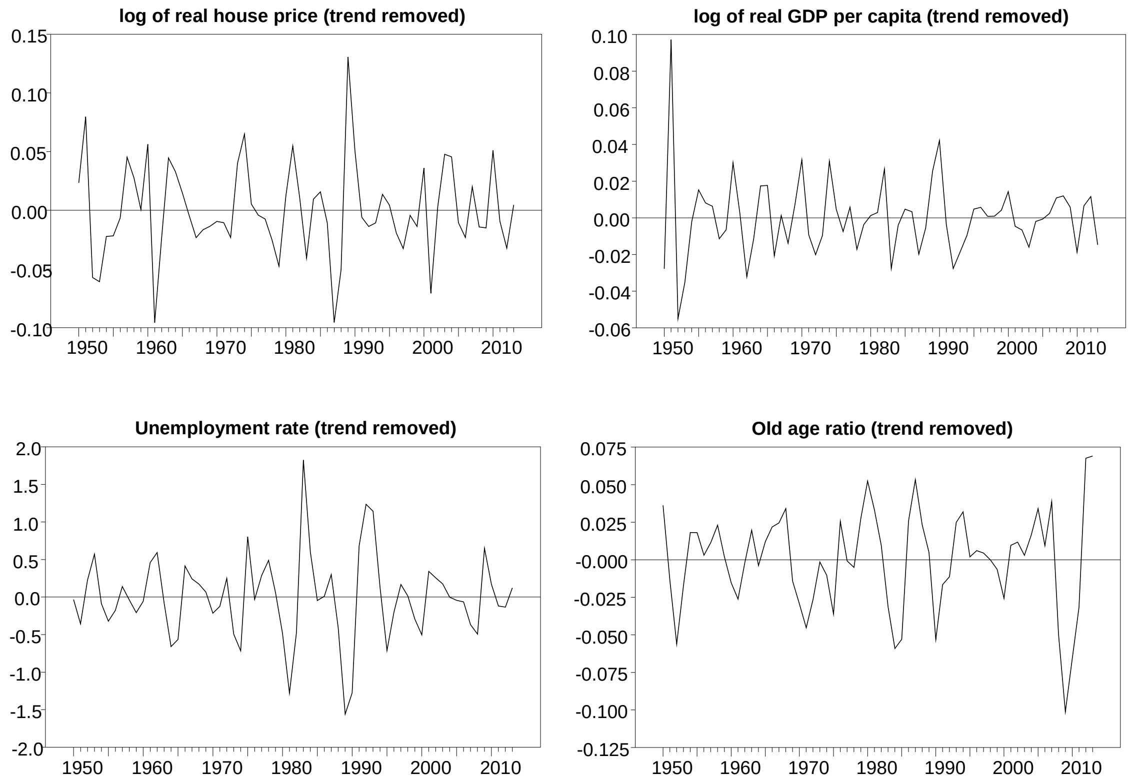


Fig. 2 Time Series HP Filtered, 1950-2013

The OLS estimation method is used for the reduced form VAR (Eq. 9) derived from the structural VAR model (Eq. 5) since the structural parameters and residuals are not estimable directly. The structural parameters are then estimated from the reduced form estimates. The short-run identification restrictions on the contemporaneous reaction of the variables to structural shocks for the unrestricted VAR model correspond to the order of the variables, old age ratio, log of real GDP per capita, the unemployment rate and log of real house price. The appropriate lag length is selected using the likelihood ratio test and two information criteria namely Akaike information criteria (AIC) and Schwarz information criteria (SC). The results are shown in Table 1.

[10] The smoothing parameter for annual data is obtained using the formula; $\lambda_A = 4^{-4}\lambda_Q$, where λ_A and λ_Q are smoothing parameters for annual and quarterly frequency respectively

Table 1 VAR Lag Order Selection for old age ratio/real GDP/unemployment/real house price, VAR(p) model, estimation period 1950-2013

Lags	AIC	SC	LR test statistic	p-value for LR test
1	-12.8998	-12.2656*	NA	NA
2	-13.1603*	-12.1225	56.9227	0.0000
3	-12.8324	-11.5086	28.6787	0.0262
4	-12.5565	-11.0975	40.8440	0.0006
5	-11.8957	-10.5408	20.1515	0.2135
6	-10.8097	-9.9158	16.7458	0.4022

* indicates lag order selected by the criteria
AIC: Akaike information criteria
SC: Schwarz information criteria
LR: Likelihood Ratio test statistic for the hypotheses $H_0 : A_p = 0$ Vs $H_1 : A_{p-1} = 0$ for $p = 6, \cdots, 2$.
The ***p***-value represents the probability of calculated LR statistic greater than the observed value, assuming that the null hypothesis is true

The LR test results suggest lag length of 3 while AIC and SC suggest 2 and 1respectively. A lag length of 2 is selected as a shorter lag length would omit important dynamics with regard to the variables used in this research. For example, old age ratio is a slow moving variable and a longer the lag length would better captures the important population ageing dynamics. Also, the residuals produced from a VAR with too few lags may not have white-noise properties and the resulting model may not capture actual error process appropriately. At the same time, we are concerned not to include too many lags since a problem of over-parameterization would be created compared with sample size[11]. Thus the VAR order selection was based on the objective of the analysis as suggested by Lütkepohl (2005, p. 146). Moreover Lütkepohl (2005, p. 157) states that '… the criteria for model choice may be regarded as criteria for deciding whether the residuals are close enough to white noise to satisfy the investigator'. The white noise properties of the residuals are also satisfied for the selected lag order of 2, which is presented in Appendix I.

[11] The n-variable VAR(p) process with constant term has $(n + n^2p)$ parameters to be estimated.

7. Analysis of Empirical Results

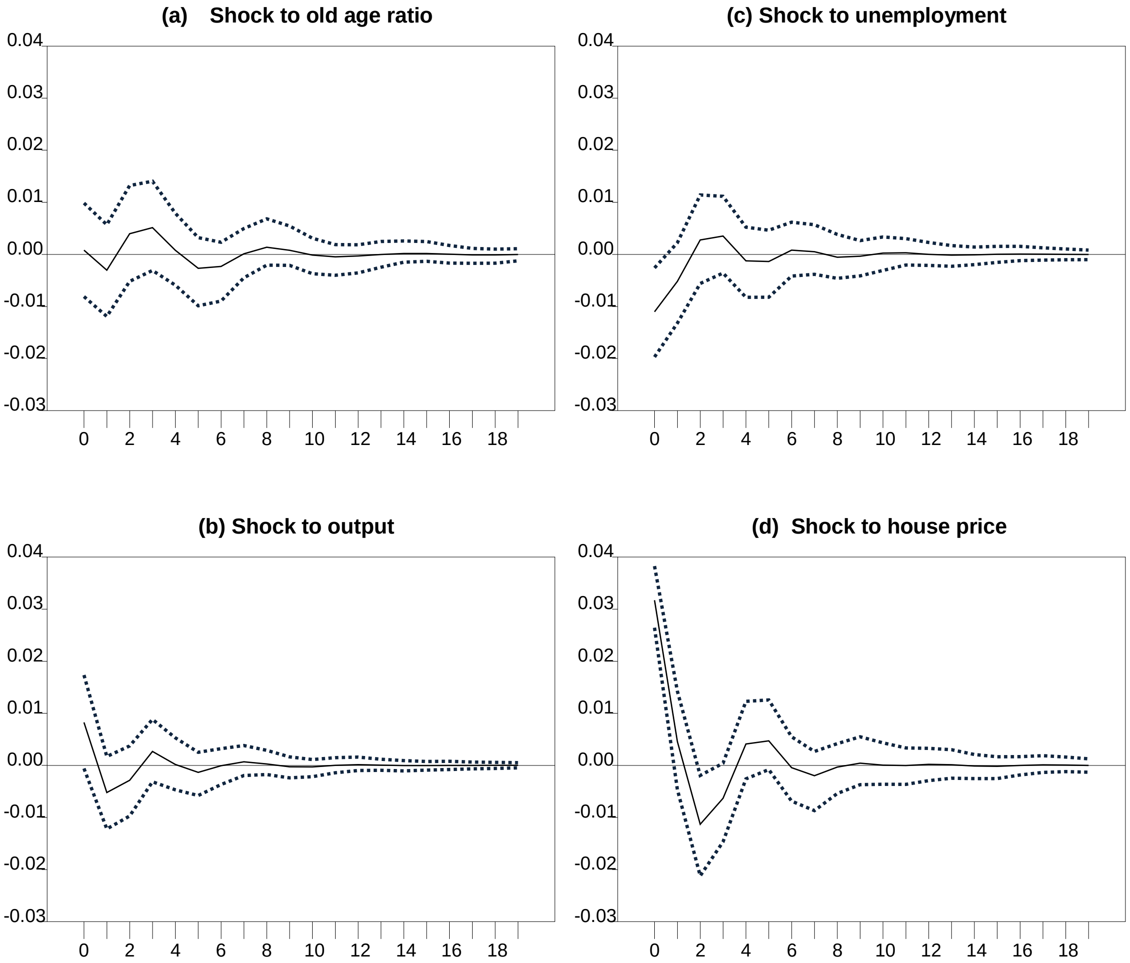
The dynamic relationships among the variables are examined by tracing the effects of structural innovations in various ways. Thus, the impulse response functions (IRF), historical decomposition and forecast error variance (FEVD) decomposition are generated after imposing short-run identification restrictions on the contemporaneous reaction of the variables to structural shocks for the unrestricted VAR(*2*) model.

The impulse response functions (IRFs) are generated to review the responses of each variable to a one standard deviation structural innovation at time *t* and for a period of 20 years from *t*. The impulse response confidence intervals are based on the Bayesian Monte Carlo integration method proposed by Sims and Sha (1999) with 10,000 replications. The IRF takes into account just an initial period shock. However, in general, structural shocks are not limited to a one-off shock. Rather they involve a vector sequence of shocks, often with different signs at different points in time[12]. The cumulative effect of such a sequence of shocks on the evolution of variables over time is examined using historical decomposition. Whilst the FEVD uses the same information as the IRF, it decomposes the forecast error variance into components due to each structural innovation. Accordingly, the FEVD quantifies the percentage contribution of the total variation in a variable attributable to each structural shock including its own shocks for different forecast periods.

7.1 The Dynamics of Real House Prices

Fig. 3 (a-d) shows the plots of the impulse responses of real house price to a one standard deviation structural innovation to old age ratio, output, unemployment and real house price itself. One-standard error confidence bands are indicated by dotted lines.

[12]See Kilian and Park (2009, p. 1272)



Notes: Estimates are based on the VAR model described in section 4 in the text. The asymptotic confidence intervals are based on the Bayesian Monte Carlo integration method proposed by Sims and Sha (1999) using 10,000 replications.

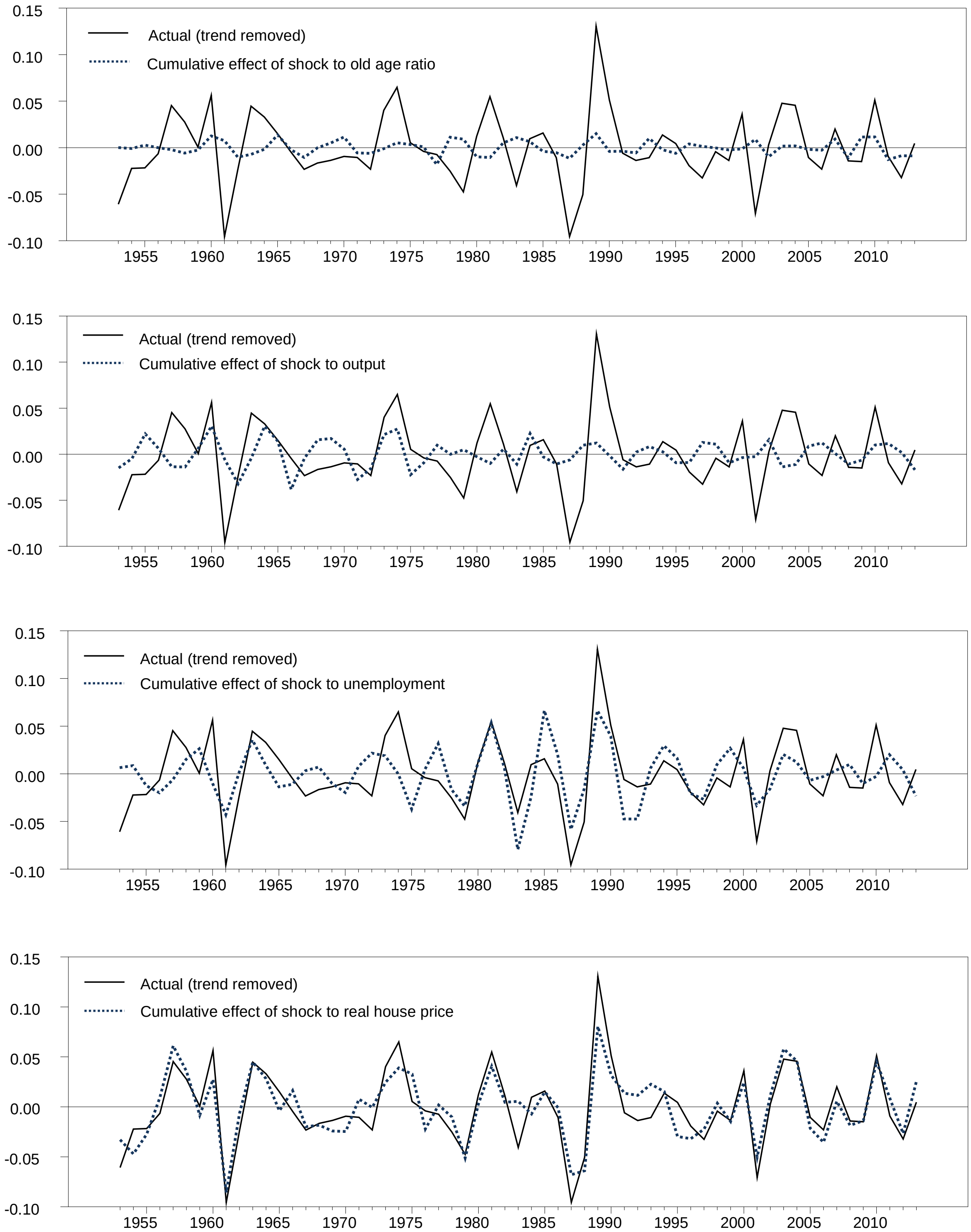
Fig. 3 Responses of the real house price to one-standard deviation structural shocks: Point estimates with one standard error bands

All impulse responses approach zero quickly and the effects of shocks after 6 years are negligible. The responses of the real house prices are more pronounced to its own shocks compared to other three shocks considered. A positive size one standard deviation shock to real house price causes an immediate increase in the real house price though the increase is not persistent.

The central item of interest in Fig. 3 is the effects of positive shock to old age ratio (plot a). The impulse response analysis suggests positive and negative effects on the real house price due to shock to old age ratio though the positive effects dominate the negative effects. The instantaneous effect on real house price is insignificant and then declines slightly within a first year. During the second and fourth years after a shock, the effect leads to an increase in real house prices and reaches its peak during the third year. However, this increase is transitory and the impulse response function crosses zero in years 4 and 7. Then after 7 years it tapers off to zero. Thus, the effects are not persistent, suggesting that there is no effect on the real house price due to a positive shock to old age ratio over a long period of time.

The shocks to output and unemployment have different effects on real house prices. A one standard deviation innovation to output causes an instantaneous increase in real house prices while a similar shock to unemployment causes a decrease. This result is consistent with the discussion of the rationale of variable selection. The negative impact from unemployment is higher than the positive impact from real GDP per capita. A one standard deviation positive shock to unemployment (approximately 0.55%) decreases the real house price index by 1.02 units immediately. This decline lasts for only for 2 years and the effect reverses back to zero. Likewise the increase in real house price is not persistent following a positive output shock. Although a one standard deviation shock to output increases real house price instantaneously, it reverses back to zero quickly. This is a plausible result since the policymakers attempt to mitigate the effects of economic booms and increasing unemployment on other sectors of the economy. Also the responses are consistent with economic theories. The positive shocks to output induce higher demand for consumption and investment (e.g. spending on houses) while increase in unemployment induce lower demand.

The historical decomposition depicting the cumulative effects of current and past shocks on the real house price is shown in Fig. 4. The figure clearly suggests that the historical fluctuations of the real house prices are mainly attributable to shocks to the real house price itself and shocks to unemployment. The cumulative effect from shocks to unemployment is more noticeable during the decade from 1980 to 1990 compared to rest of the period. The fluctuations in real house price between 1955 and 1975 were driven to some extent by shocks to output though after this period its impact has been decaying. The contribution from shocks to the old age ratio is minor for historical fluctuations in the real house price.



Notes: Estimates are based on the VAR model described in section 4 in the text.

Fig. 4 Historical Decomposition of Real House Price: 1953-2013

The FEVD presented in Table 2 quantifies the importance of each structural shock $(\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t})$ to the forecast error variance of the real house price for different forecast horizons. For example, about 84% of the 1-step forecast error variance of the real house price is accounted for by its own innovations. The two principal factors driving real house prices are house prices themselves and unemployment. In the long-run, 23% of the forecast error variance in real house price is accounted by the three structural shocks that drive the old age ratio, output and unemployment.

Table 2 Forecast Error Variance Decomposition of Real House Price

Horizon	Shock to old age ratio	Shock to output	Shock to unemployment	Shock to real house price
1	0.056	5.901	10.323	83.719
2	0.810	7.692	11.762	79.736
3	1.787	7.370	10.942	79.901
4	3.541	7.469	11.156	77.833
5	3.523	7.388	11.139	77.950
10	4.436	7.325	11.003	77.236
15	4.452	7.330	11.011	77.207
∞	4.555	7.329	11.011	77.205

In the short-run, the effect of shocks to the old age ratio on the forecast error variance of the real house price is negligible. On impact less than 1% of the variation in real house price is associated with shocks that drive old age ratio. Even for medium to long term forecasts, less than 4% of the error variance is accounted for innovations to old age ratio.

The importance of real GDP per capita is almost constant over the forecast horizons. Less than 8% of the variation in real house price is explained by the shocks to output. In contrast, the relative contribution of unemployment is over 10% even in the 1-step forecast error variance of the real house price. In the long-run, 11% of the error variance is attributable to the shocks to unemployment.

8. Conclusion

This paper uses a more rigorous approach to examine the effect of population ageing dynamics on real house price in Australia. Instead of focusing on the average effect of the old population on real house price in a single equation model, a structural VAR methodology was developed which takes into account the dynamic relationships among the variables as well as the endogenous nature of the macroeconomic variables.

In summary, the findings do not predict a permanent decline in real house prices in Australia due to the retirement of the Baby Boom cohort. Although the impulse response analysis shows a decrease in real house price after four years due to a positive shock to old age ratio, that decline is temporary. Also, historical decomposition of the fluctuations in the real house price suggests that real house price shocks historically have been driven mainly by a combination of its own shocks and shocks to unemployment and output. The cumulative effect of shock to old age ratio is not capable of explaining a substantial part of the fluctuations in real house price historically. In the short-run more than 80% of the variation in real house prices is accounted for by its own shocks. These housing market specific shocks could include shocks to material cost, shocks to land prices, credit channel shocks and behavioural shocks such as change of peoples' attitude to live surrounding major cities.

The asset ownership statistics for Australia reveal that a significant portion of population over 65 years has an owner occupied dwelling[13]. In an international comparison of home ownership statistics, Bradbury (2010, p. vi) concludes that 'among the elderly, own home ownership wealth is much greater proportion of disposable income in Australia than in all

[13] The ABS survey publication of Household Wealth and Wealth Distribution, Australia (2011-2012)

other countries'. These evidences imply that the retired population do not have a tendency to sell their houses immediately. Moreover, if the increasing retired population sell their houses to finance the retirement life, and particularly from 2011 due to retirement of the Baby Boomers, a downward pressure will be exerted on real house prices. However, such a scenario is not evident in Australia. This is in contrast to the fall in real house prices due to increase in old age population predicted by Takats (2012) considering 22 OECD countries including Australia.

One of the important findings of the analysis is that unemployment has a significant impact on the fluctuations in real house prices in Australia. Most of the previous studies related to the housing sector in Australia (Abelson et al. 2005; Otto 2007; Fry et al. 2009; Wadud et al. 2012) do not include unemployment as a variable. Even though Guest and Swift (2010) include unemployment in their analysis they do not find a statistically significant coefficient. This finding makes a significant contribution to the literature and highlights that unemployment is an important macroeconomic variable in determining real house prices in Australia in the short-run. This effect of unemployment on real house price is an expected outcome, since higher unemployment affects the ability to obtain mortgage loans and people's confidence over the business cycles. The combined effect then turns to a lower demand for housing.

Financial innovations available in Australia such as equity withdrawal facilities and reverse mortgage loans provide alternatives for retired people to trading down and delay the selling of their houses to finance consumption needs during the retirement. Even in the long-run less than 5% of the variation in real house prices is accounted for by the population ageing effect. This finding is in contrast to the Guest and Swift (2010, p. 249) conclusion of a dampening effect of ageing on house prices in Australia. Moreover, a report published by the RBA (Schwartz et al. 2007) indicates that old people are home equity withdrawers suggesting that there is a reduced pressure to sell their homes to finance consumption. Also, increasing longevity delays the time of selling or trading down an existing house. Overall, this paper rejects predictions that population ageing will lead to pronounced downward pressure on real house prices or house price meltdown due to retiring Baby Boomers in Australia.

The findings provide an important insight for the policy makers, real estate professionals, financial planners and other relevant practitioners. At present, Australia exempts owner-occupied housing from the age pension asset test and capital gains tax. Thus, many retired people have a strong incentive to keep a higher proportion of their wealth in the form of housing. Cowan and Taylor (2015) estimates the total value of pensioner home equity at $625 billion. The results give an indication the impact on house prices if the government revisits the exclusion of the owner-occupied housing from the age pension asset test due to the fiscal burden imposed by the rapidly increasing retired population and retirees are encouraged to sell their houses.

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Appendix I

Testing for Residual Autocorrelation

Table A.1 shows the Portmanteau test results for the overall significance of residual autocorrelation up to lag h from the estimated VAR(*2*) process. The null hypothesis is: no residual autocorrelation up to lag h.

$H_0: R_h = (R_1, \cdots, R_h) = 0$ vs $H_1: R_h \neq 0$

None of the p-values exceed 5% and therefore even at 5% level of significance , the null hypothesis of no residual autocorrelation is rejected for lag order higher than 2. That is at the lag lengths above 2 the estimated VAR model suffers from the problem of residual autocorrelation.

Table A.1 Portmanteau test for old age ratio/real GDP/unemployment/real house price, VAR(*2*) model, estimation period 1950-2013

H	**Q test statistic**	***p*-value**
1	11.8096	NA*
2	16.5130	NA*
3	27.9416	0.0321
4	54.0061	0.0088
5	70.2792	0.0197

* indicates test is valid only for lags larger than the VAR lag order
The ***p***-value represents the probability of calculated Q statistic greater than the observed value, assuming that the null hypothesis is true

The Lagrange Multiplier (LM) test is also used to test for residual autocorrelation in the estimated VAR(*2*) process since Lütkepohl (2005, p. 173) suggests the LM test is more suitable for small values of h. This test assumes that a VAR model for the error vector can be written as; $u_t = C_1 u_{t-1} + \cdots + C_h u_{t-h} + e_t$, where e_t is white noise. If there is no residual autocorrelation, then $e_t = u_t$ should be satisfied (Lütkepohl, 2005, p. 171). Therefore, a test of

$$H_0: C_1 = \cdots = C_h = 0 \qquad \text{vs} \qquad H_1: C_j \neq 0 \text{ for at least one } j \in \{1, \cdots, h\}$$

is used for testing that residuals are white noise. The results are shown in Table A.2.

Table A.2 LM test for old age ratio/real GDP/unemployment/real house price, VAR(*2*) model, estimation period 1950-2013

H	**LM test statistic**	***p*-value**
1	31.9997	0.0100
2	14.2137	0.5828
3	12.3888	0.7168
4	28.8044	0.0253
5	11.4184	0.3830

The ***p***-value represents the probability of calculated LM test statistic greater than the observed value, assuming that the null hypothesis is true

The null hypothesis of no residual autocorrelation cannot be rejected for the lag order 2. Thus both tests do not find evidence of residual autocorrelation for the estimated VAR(*2*) model, suggesting that the required whiteness property of the residuals is satisfied. Therefore, the selected lag order of 2 satisfies the white noise properties of the residuals.