House Price Determinants in Sydney

Xin Janet Ge
University of Technology Sydney, School of the Built Environment, Sydney, Australia

Brendan Williams
University College Dublin, School of Geography, Planning and Environmental Policy, Dublin, Ireland

Abstract

Purpose – This paper aims to study the main determinants of house price increase in Sydney using quarterly data for the period of March 1994 to June 2014. The paper examines whether variables such as population growth, family income, mortgage rate and supply factors that contribute to the changes of Sydney house prices.

Design/methodology/approach - The paper uses reduced-form equation for house price function derived on the supply and demand functions for owner-occupied housing (DiPasquale and Wheaton, 1994). Multiple regression analysis is applied to derive the significant variables effect on house prices. Collected time series variables are tested stationary using Augmented Dickey-Fuller test.

Findings – Statistical results suggest that the lack of house supply, mortgage rate, and net overseas migration are the main attributes of house price appreciation in Sydney. House prices are largely affected by the price movements from the previous periods. Multiple regression analysis is one of the methods to test causal relationship of house prices with other variables.

Research limitations/implications – There are limitations using multiple regression analysis (MRA) One of the difficulties of using MRA is to handle problems with multicollinearity and non-linearity among variables. It is worthwhile to try Vector Autoregressive (VAR) or nonlinear models that may help to solve the problem of building in regression statistics.

Practical implications - The findings would suggest that measures to increase of housing supply may help to prevent house price bubble.

Originality/value – The research updates the investigation of house price determinants and tests the using of MRA method on the nonlinear variables.

Keywords: House prices, interest rate, population, house supply, Sydney

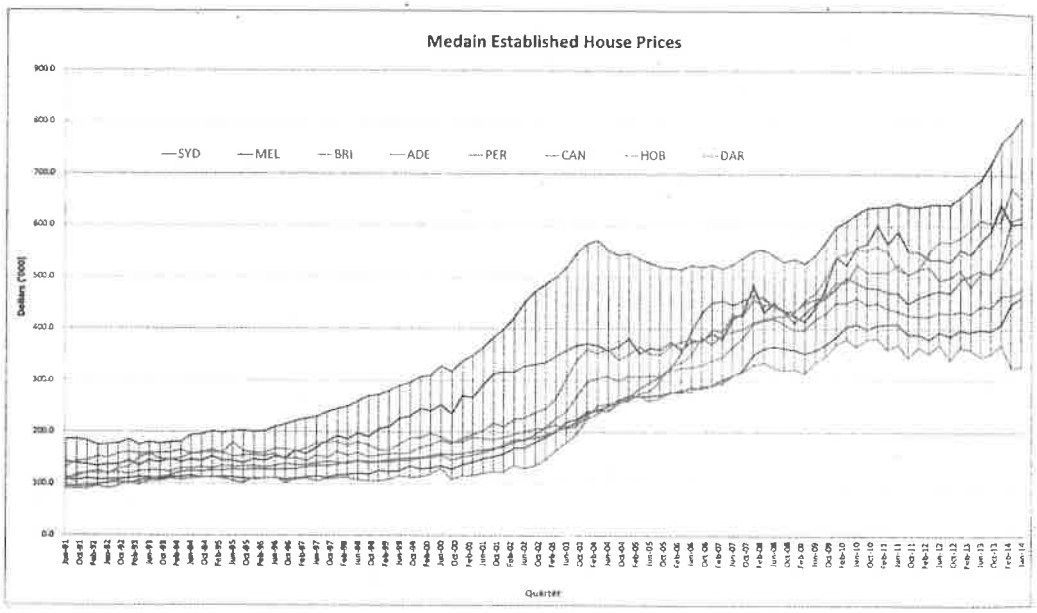
1. Introduction

House prices in Sydney have increased substantially over the last decade. In 2003, the median price of established houses was $473.630 and reached to $811,837 in June 2014, an increase of around 70 per cent. Figure 1 depicts the median price of established houses in Australian capital cities (Real Estate Institute of Australia (REIA), 2014) for the period of June 1991 to June 2014. It displays that house prices were shown relatively stable in 90s and the period of global financial crisis and great appreciation since 2000 and after GFC for most of the cities. Sydney house prices trend in a unique manner comparing to other cities in Australia. This paper explores the main determinants that cause prices to increase dramatically with families pushed into the rental market as they cannot afford to own a home at such high prices. Demographia's 10th annual survey

Proceedings: ERES2015
pp. 135-148

of house prices (2014) compares median house prices in terms of average family incomes. The survey found that Australia has the highest average house prices relative to incomes, other than Hong Kong; i.e., there are 60 per cent higher than those of the US, 12 per cent above the UK and 20 per cent above Japan. The Median Multiple (median house price divided by gross annual median household income) for Sydney is nine times, compared to 6.2 times in New York and 7.3 times in London.

***Figure 1:** Median price of established house (June 1991 – June 2014)*



(Source: REIA)

There has been extensive research and evidence on the effects of rising house prices on private consumptions and the real economy. Helbling and Terrones (2003) investigated negative effect of house price movements and found that house price busts were associated with output losses twice as large as equity bubbles. Zhu (2003) studied the relationship between real GDP and house prices and argued that increases in house prices can have a positive impact on real GDP in many countries. Rising house prices increased wealth of homeowners but also reduced the affordability of those households who want to purchase their own homes (Rahman, 2008). Rahman (2008) also suggested that rising house prices attract investment activities because there is an expectation of high returns on investment properties. The continuous increase in house prices could create house price bubbles which could lead to a major correction or bust and lead to house price decline. The up and down house price movements thus could affect the local economy and the financial system. Understanding the factors that affect house price movements is essential for formulating policies to stabilize housing market and the economy as a whole.

House price movements can be differed substantially across sectors and countries (Zhu, 2003). This paper investigates the main determinants of house prices in Sydney and examines the exogenous and endogenous factors that contribute to house price movements. The quarterly data for the period from March 1994 to June 2014 was

collected from the Australian Bureau of Statistics and Reserve Bank of Australia for conducting the analysis. Multiple regression analysis was applied to develop house price models. The remainder of the paper is organised as follows with the next section reviewing the main factors that contribute to house price movements. The house price models for Sydney are then developed. Based on the findings, a discussion of findings and concluding remarks are contained in the final section.

2. The Main drivers of house prices

House prices are primarily determined by demand for and supply of housing (Rahman, 2015). Housing demand and supply are distinct from the demand and supply of other commodities (Omar & Ruddock, 2002). This is because housing has its specific characteristics, such as durability, heterogeneity and locality (Megbolugbe *et al.* 1991; Muth and Goodman, 1989; Arnott, 1987). The durability of housing units influences the determination of the demand for housing, the specification of the housing utility function, and the income constraint on demand (Maclennan, 1982). As a durable asset, a housing structure provides both consumption and investment services (Muth & Goodman, 1989).

The housing demand decision is strongly influenced by household incomes, population growth, migration patterns and demographic composition of the market (Megbolugbe & Cho, 1993). An increased population and a reduction in the average size of households increases the demand for housing. Most literature has demonstrated that demographic factors are statistically significant, contributing to the development of housing prices in econometric models mainly in the long term (Rosen, 1979; Turner & Struyk, 1984; Anas & Eum, 1984; Haurin & Gill, 1987; Goodman, 1990; Meen, 1995; Ho & Ganesan, 1998). Manning (1989) and Potepan (1994) have each considered the role of population growth. Potepan (1994) suggests that a higher level of current population growth tends to raise current housing prices through the expectation that higher future population levels will cause higher future housing demand, and that migration influences housing price and vice versa. Dieleman *et al.* (2000) have demonstrated that population growth and employment growth seem to create differences in the rate of turnover and the differences in price levers. Woodward (1991) has argued that fluctuations in the demographic profile should have little influence on prices.

The demand for housing is amplified by increased income. Income not only influences the ability of a household to afford the continuing cash flow burdens of housing, but influences a household's lifetime wealth prospects (Pozdena, 1988). An expected rise in income will increase the aspiration of home owning and the incentive of investing in property, and housing demand increases, as does housing price (Dieleman et al., 2000). Muth (1960) concluded that housing demand is highly responsive to changes in income and price. His empirical results indicated that the most important factor in the determination of house prices is real income. According to Goodman (1988), real incomes, real mortgage lending, consumer prices and changes in household income gearing contribute significantly to explaining short-term changes in the price of existing dwellings.

The degree to which affordability constraints are binding depends on the effect of the economic and business cycle on demand levels and and the current interest rate (Pozdena, 1988). When the economy slips into recession and housing prices start to fall, the affordability of houses increases (Sven & François, 2001). The availability of housing loans and government subsidies will influence consumers' choice of whether or not to buy a home (Omar & Ruddock, 2002). Sutton (2002) examined the house price fluctuations in six advanced economies, namely, the United States, the United Kingdom, Canada, Ireland, the Netherlands and Australia. He suggested that decreases in real interest rates lead over time to increases in house prices. He found that a 100 basis point decrease in the real short-term interest rate leads to an increase in house prices in the range of ½–1½ percentage points over four quarters. For all countries, there is a weaker response of housing prices to decreases in long-term interest rates. Sutton (2002) also found that Increases in the growth rate of national income would be expected to lead over time to higher house prices. A 1% increase in the growth rate of GNP is associated with a rise in real house prices in the range of 1–4% after three years. Abelson, et al. (2005) developed a long-run equilibrium model and a short-run asymmetric error correction model to examine the changes in real house prices in Australia from 1970 to 2003. They found that real house prices are determined significantly by real disposable income, general inflation level as represented by the consumer price index, unemployment rate, real mortgage rates, equity prices and the available housing stock.

The supply of new housing is relatively inelastic in the short term (Draper, 2000). The reason is that there are time lags between changes in price and increases in the supply of new properties becoming available, or before other homeowners decide to put their properties onto the market. The long-term impact of time lags on price depends on the length of time to the supply response, which in turn is determined by the price elasticity of supply (DiPasquale, 1999). Follain, Leavens, and Velz (1993) created a model of the supply of multi-family housing for which permits are a function of rents, the capitalisation rate, the replacement cost per unit of rental housing, and permits are lagged. Their results suggested that the long-term rent elasticity is between 3.0 and 5.0.

There is growing literature on modelling the time series behaviour of house prices in Australia (Abelson, 1994; Bourassa and Hendershott, 1995; Bewley, Dvornak and Livera, 2004; Bodman and Crosby, 2004; Abelson and Chung, 2005; Abelson, Joyeux, Milunovich and Chung, 2005; Oster, 2005, Otto, 2006; and Karantonis and Ge, 2007). The next section presents an empirical study on house price determinants in Sydney.

3. A General form of housing price model

A reduced-form equation for the price function derived from the supply and demand functions for owner-occupied housing (DiPasquale and Wheaton, 1994) is used to examine the main drivers of house prices in Sydney for the last decade June 2004 – June 2014. To develop a reduced-form housing price model, the first step is to derive a demand equation. The determinants of the quantity of demand for housing can be summarised as demographic factors, housing-related elements and macroeconomic variables, in accordance with the literature review. Thus, the demand equation can be denoted as follows:

$Q_d = f(G, H, D, t)$ $(t = 1, 2, 3, \ldots n)$ (1)

$G = g(x_1, x_i, \ldots x_m, t)$ $(i = 1, 2, 3, \ldots m)$ (2)

$H = h(y_1, y_i, \ldots y_m, t)$ (3)

$D = d(z_1, z_i, \ldots z_m, t)$ (4)

Therefore, $Q_d = f(x_i, y_i, z_i, t)$ (5)

where

Q_d = aggregated quantity demand for new housing during period t

G = macroeconomic variables

H = housing-related variables

D = demographic variables

x_i = macroeconomic variables such as interest rates, household income, and unemployment rate

y_i = housing-related variables such as location of houses

z_i = demographic variables such as population, number of marriages and birth rates.

It is assumed that homeowners aim to maximise utility and that investors aim to maximise their profits (Reichert, 1990).

The second step is to derive a supply equation. The supply of housing is a function of housing prices, construction costs (including interest rates), material costs and labour costs, and land supply. The quantity-of-supply equation can be denoted as follows:

$Q_s = f(S, t)$ $(t = 1, 2, 3, \ldots n)$ (6)

$S = s(v_1, v_i, \ldots v_m, t)$ $(i = 1, 2, 3, \ldots m)$ (7)

$Q_s = f(v_i, t)$ (8)

where

Q_s = aggregated quantity of new supply during period t

S = supply variables

v_i = variables such as housing price, construction cost, and land supply.

Under an assumption of supply-demand equilibrium within the given period, i.e., $Q_d = Q_s$, the functions (5) and (8) give a reduced-form price function:

$P = f(Q_d, Q_s, t)$ $(t = 1, 2, 3, \ldots n)$ (9)

$P = f(x_i, y_i, z_i, v_i, t)$ $(i = 1, 2, 3, \ldots m)$ (10)

where

P = the price of houses sold during period t as a dependent variable.

x_i, y_i, z_i, v_i are the independent variables.

Assuming a generalised functional form with a multiplicative relationship gives:

$$P_t = \beta_0 x_{it}^{\beta_1} . y_{it}^{\beta_2} . z_{it}^{\beta_3} . v_{it}^{\beta_4} \quad (11)$$

The functional form in (Equation 11) can be converted into a linear equation suitable for estimation by standard multiple regression techniques expressed in logarithmic form. A one-period lagged autoregressive error term P_{t-1} is applied to the model. Thus, the multiple regression equation for housing price becomes:

$$P_t = \beta_0 + \beta_1 x_{it} + \beta_2 y_{it} + \beta_3 z_{it} + \beta_4 v_{it} + \beta_5 P_{t-1} + \varepsilon_t \quad (12)$$

where

$\beta_0 \ldots \beta_5$ represent the intercepts and the regression coefficients (or elasticities) associated with the respective explanatory variables

ε_t = a disturbance term for quarter t, where $\varepsilon_t \sim WN(0, \sigma^2)$.

4. Empirical study

The role of economic activity, population growth, mortgage rates and inflation were key drivers of the real growth rates of house prices in Australian capital cities for the period of 1986:2-2004:3 (Otto, 2006). This research focuses the Sydney house market for the period of March 1994 – June 2014. Time series data on house prices in Sydney was collected from the Australian Bureau of Statistics (ABS), Reserve Bank of Australia and the Real Estate Institute of Australia (REIA). This section discusses the main data used and estimated procedures applying the multiple regression analysis.

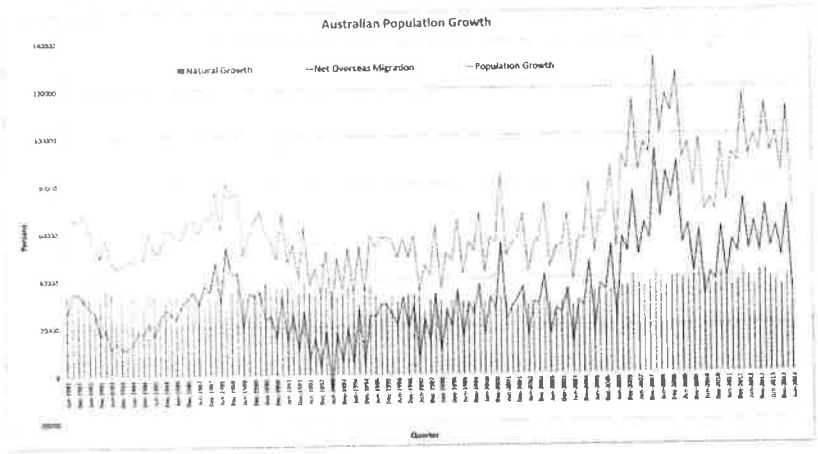
Population trends in Australia

There are around 23.5 million people as of March 2015 in Australia. The Australian population growth consists of natural growth and overseas migrations, which contributed approximately 42 per cent and 58 per cent respectively to total population growth for the year ended 30 June 2014. Figure 2 denotes the Australia population growth trend from June 1981 to June 2014. The natural increase indicates a relatively stable trend over the decade with around 32 thousand babies born per quarter. Average natural increases have added to 36 thousand per quarter since 2007. In contrast, the numbers of net overseas migration appear to present a cyclical pattern, which could be the effects of changing immigration policies (Carter, 2005). A strong increased of migrants were recorded for the years of 87/88, 00/01 and 06/08. Family Migration, Skilled Migration and Humanitarian Migration are the three major migration programs in Australia. The government has gradually shifted the balance of these programs by increasing the intake from the Skilled-migrants program. In 2013-14, the Skilled-migrants consisted of 67.7 per cent of the migration program (Australia Government, 2013).

Now South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS), Northern Territory (NT) and Australian Capital Territory (ACT) are the eight States and Territories of Australia. The majority of recent immigrants to Australia go to Australian eastern states such as NSW, VIC and QLD. According to the ABS (2014), there were total 212,695 net overseas migrants to Australia in the year 2013-14. These three States attracted 76.6 per cent of the net overseas migrants and only 23.4 per cent settled in other States and Territories.

The population in the New South Wales Australia has increased to around 7.5 million on June 2014 from around 5.9 million on June 1991 (ABS, 2014). There have been around 60,000 net overseas migration that come to live in the New South Wales each year. In the long term, these increases in population will increase the demand for housing and thus prices (Megbolugbe & Cho, 1993). Sydney is the state capital of New South Wales located on Australia's east coast and is considered a global cultural and economic centre (Kearney, 2014). At the time of the 2011 census, the population of Sydney was 4.39 million people of which 1.5 million of this total were born overseas. 42.5 per cent of the 1.5 million were born overseas are from England, China, India, New Zealand and Vietnam.

Figure 2: Australian population growth (June 1981 – June 2014)

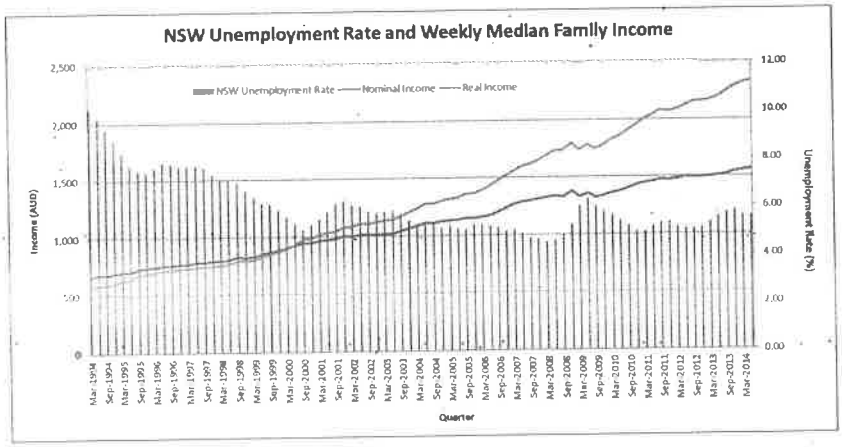


(Source: ABS Australia)

Family income and unemployment rate

The real income of households directly reflects their ability to spend. The higher the income, the greater the capacity to pay for higher the demand for houses thus prices. On March 1994, the median weekly family income was $665 and $1,553 on March 2014, increasing by a factor of 1.34 times over 20 years. However, real family income was rapidly increased comparing to the nominal. It was $570 on March 1994 and reached to $2,313, increasing by a factor of over three times over the last 20 years. Real median weekly family income was derived by deflating consumer price index (June 2000 = 100). The difference of the nominal and real median weekly family income was compared in Figure 3. In this study, median family income per week in the New South Wales was used as a proxy of income factors. The unemployment rate in NSW was high in 90s and gradually reduced to around 6 per cent over the last decade. The higher the unemployment rate implies less earnings for families and thus less the available money for housing, which will have negative impact on house prices.

Figure 3: NSW Median family weekly income and unemployment rate (March 1994 – June 2014)



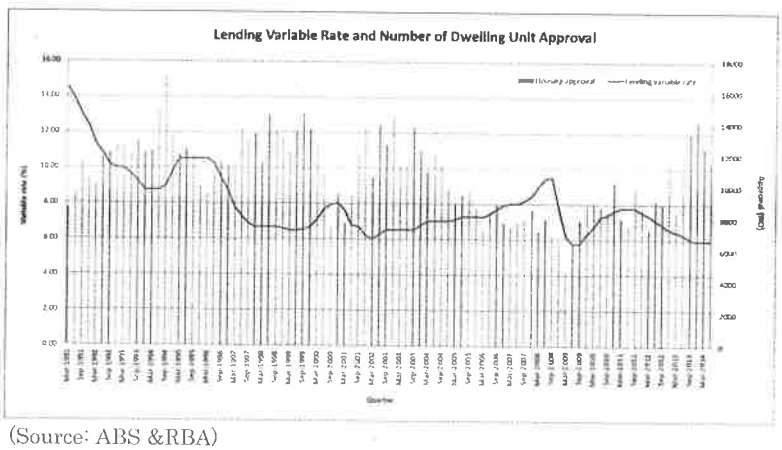
(Source: ABS and REIA)

Housing supply and lending rate

Most households are required to borrow money in order to access home ownership. The repayments are based on the loan amount with the term of the loan generally between 25 or 30 years for most of the households. It is expected that highermortgage rates imply higher burdens of repayments, housing becomes less affordable and thus have a reducing impact on house prices. The mortgage rate in Australia is affected by the cash rate set by the Reserve Bank of Australia. The higher the cash rate, the higher the mortgage rate. The mortgage rate in Australia was as high as of 14 per cent on June 1991 during a period of poor economic conditions and high unemployment rates. Financial deregulation accelerated lending competition among banks and financial institutions by reducing the security they required and lowering their rates. The standard variable lending rates for loans were around 6 to 8 per cent for a long period of time from February 1997 to October 2006. The global financial crisis pushed the rate upwards climbing up to the peak of 9.6 per cent in July 2008 and fell sharply to 5.75 per cent in April 2009 and 5.65 per cent in February 2015 as results of cash rate being dropped. The rate remains 5.5 per cent as historical low since December 2003. The lower the lending rate, the lower the cost of capital and the great the investment activities. Business and housing investment activities were encouraged which led to higher the demand for housing.

Figure 4 depicts lending rates for loan (line in blue) and the number of dwelling approval (bar chart in red) for the period of March 1991 to June 2014. Around 12 to 14 thousand housing units were approved for construction. However, there was a low approval rate, under 10,000 dwelling units, for the period of 2006 to 2012. This low approval rate could be as a result of higher costs for constructing dwelling units and the negative impacts of the global financial crisis. The numbers of approval units has recovered to the long term average position since 2013.

Figure 4: Lending variable rate and dwelling unit approval (March 1991 – June 2014)



(Source: ABS &RBA)

House prices are partially related to the shortage of supply (Janda, 2014). Scarcity of land, government planning system, and development approve process could the factors impact on supply houses. In addition, economic condition, construction costs and fund available for developers are other elements affect housing supply. In this study, the number of government approval will be used for model development. Since it takes

time for constructing houses, the correlation between house supply (number of lap-period) and house prices will be tested prior modelling.

Data and estimated procedure

The estimated procedure for deriving the house price models includes:

- Collecting time series data which includes both supply and demand sides factors;
- Data analysis which consists of data pre-processing and correlation analysis;
- Selecting variables and developing multiple regression models using SPSS software and stepwise function; and
- Verifying the developed models, analysing and interpreting the results.

Total 81 sets of quarterly time series data from March 1994 to June 2014 utilising data collected from various sources such as ABS, RBA and RIEA. The source and basic statistics of the collected data used for developing the regression models are shown in Table 1. Time series data for New South Wales are used as proxy because no time series data are available on population, overseas migration, earnings and housing supply for Sydney region. The median established house price in Sydney is the dependent variable.

Prior to developing the statistical model, all collected data was tested regarding their unit root applying Augmented Dickey-Fuller test using Eview software in order to check whether the time series variables are stationary using an autoregressive model. The unit root test identified that the collected time series data are stationary at 95 per cent, apart from median established house price, median family weekly income and net migration, which are stationary at first difference. Correlation between the dependent and independent variables was also tested. Table 2 shows the results of the tests which indicate that the changes of median established house price is positive correlated with housing supply and unemployment rate and negative correlated with mortgage lending rate and the change of net overseas migration.

Table 1: Data source and basic statistics

Data Source	Data Type	ADF	N	Minimum	Maximum	Mean	Std. Deviation
Median price of established houses for Sydney from REIA	Quarterly time series	1st difference (log)	81	-2.97	8.66	2.6045	2.41371
Population Change for New South Wales from ABS (2060843J)	Quarterly time series	1st difference (log)	81	-18.09	17.58	.1550	5.43320
Overseas migration to New South Wales from ABS data series (2060789F)	Quarterly time series	1st difference (log)	81	-19.19	22.32	.3175	7.15768
Median weekly family income for NSW from REIA	Quarterly time series	1st difference (log)	81	-3.50	5.89	1.7635	1.36155
Unemployment rate New South Wales from ABS data series (181576X)	Quarterly time series	stationary	81	4.48	9.84	6.0080	1.17715
Mortgage standard variable rate for housing loan from Reserve Bank of Australia data series	Quarterly time series	stationary	81	5.77	10.50	7.4705	1.24203
Total number of dwelling unit NSW building approval from ABS	Quarterly time series	stationary (log)	81	3.68	4.23	4.0154	.10670

Adjusted R-square, F-test and p-value were used to test the significance of the derived models. The higher the adjusted R-square, the better the model value. Variance Inflation Factor (VIF) is used to examine multicollinearity existence. If VIF is closed to 1, it can conclude that there is no multicollinearity issue for the studied variable. Durbin-Watson (DW) indicators were also considered in order to detect the presence of

autocorrelation in the residuals from the derived regression analysis. The models were significant at the .95 confidence level.

Table 2: Variable correlations

	MFINSW_C	LR	APPNSW_L	MEHPS_C	POPGNSW_LC	NOM_LC	UEMNSW
MFINSW_C	1						
LR	.283*	1					
APPNSW_L	.101	-.100	1				
MEHPS_C	.026	-.268*	.431**	1			
POPGNSW_LC	-.018	.055	-.066	-.203	1		
NOM_LC	.016	.068	-.039	-.259*	.811**	1	
UEMNSW	-.023	.372**	.554**	.267*	-.056	-.004	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

5. Model development and discussion of results

The models were built by analysing the past relationships between housing prices and independent determinants. The three models shown in Table 3 have statistically significant results recorded. The dependent variable of Model 1 is the median price of the established house price for Sydney. The data series has been transferred to log 10. At the significance level of 0.05, the adjusted R-square of 99.9 percent shows that the fluctuation in housing prices can be explained by the house price movements at the previous period and mortgage lending rate in the studied period. The model is considered to be a good fit to explain the housing price fluctuations. A one percent increase in the previous house prices during the given period is associated with a 0.983 per cent increase in housing prices during the same period. A one percent increase in mortgage lending during the given period is associated with a 0.004 percent decrease in housing prices during the same period.

Model 2 and 3 use the percent change of median price of established house for Sydney as a dependent variable. The mortgage lending rate indicates statistical significant in both models. The total dwelling unit approval for building houses shows the supply element contributing to house price changes. The supply of new housing is relatively inelastic in the short term. Model 2 had an adjusted R-square value of 0.262, slightly superior to Model 3, which was 0.184. In Model 2, a one percent change in the building approval for building houses during the given period is associated with a 9.076 percent change in housing price during the same period. The mortgage variable rate has a significant contribution in Model 2. A one percent decrease in the mortgage variable rate during the given period is associated with a 0.413 percent change in the median house price during the same period. The changes of net overseas migration also play a role in contributing house price changes. A one percent change of net overseas migration during the given period is associated with 0.077changes in the median house price during the same period.

Table 3: Regression results

Variables	Model 1	Model 2	Model 3
Dependent variables	MEHPS_L	MEHPS_LC	MRHPS_LC
Constant	0.087 (5.143)	-.30.730 (-3.405)	.087 (5.147)
MEHPS_1	0.983 (214.6)		.993 (214.6)
LR	-0.004 (-4.157)	-.413 (-2.197)	-.004 (-4.157)
NOM_LC		-.077 (-2.373)	
APPNSW_L		9.076 (4.153)	
Adjusted R2 Square	0.999	0.262	0.184
F-test	30504	10.451	10.022
Sig.	.000	.000	0.000
Sample	81	81	81

This paper have developed three multiple regression models to examine the main factors that contribute house price increases in Sydney market for the period of March 1994 to June 2014. The statistical results have provided evidences that house price performance in the last/previous period, mortgage lending rate, housing supply in term of unit approval for building houses and net overseas migration are the main factors that contribute to the house price fluctuation in Sydney for the last decade. Some of the findings from this research coincide with the findings of Otto (2006), who concluded that the role of economic activity, population growth, mortgage rates and inflation as key drivers of the real growth rates of house prices in Australian capital cities over the period of 1986:2 to 2004:3. The median weekly family income and unemployment rate have not shown statistical significant in the derived models. Those findings are different from Reichert (1990), Brown *et al.* (1997), Dieleman *et al.* (2000), Abelson (1997), and Voith (1999) which included household income. Household income has also been suggested as a main determinant of housing demand by Pain & Westaway (1997) and Megbolugbe *et al.*, (1991). The reason is that housing is an expensive product, it requires long-term commitment for repayment.

The developed models have suggested that mortgage variable rate was a factor that influenced house price appreciation in Sydney. For a mortgage size of 500,000 dollars, a 0.25 percent increases in mortgage interest rate could lead to an additional repayment of 1,250 dollars a year. This result agrees with the findings from Sutton (2002) and Abelson, *et al.*, (2005). However, the Interest rate was not statistically significant in the model for Hong Kong (Tse *et al.*, 1999). This could be that housing price was not affected by the change of interest rate in the short term, and thus it may be intrinsically affected by other variables.

Australia's population growth relies heavily on overseas migration. Net overseas migration was one of the variables derived in the developed models in Sydney housing market. Relative to other variables, it shows a weak impact on housing prices (recorded in Table 4). The finding is similar with Tse *et al.* (1999), i.e., a percentage change of

population was associated with a 0.0012 percent increase in housing price, using yearly data. The reason of such results could the length of the study as demographic factors have been demonstrated as important variables for housing price determination in the long term (Ho & Ganesan, 1998).

The variable 'total number of dwelling unit building approval 'was suggested by the developed models in this study as one of the important variables contributing to house price increases in Sydney. The shortage of housing supply in Australia was blamed for Australian's affordability crisis (Gurran and Phibbs, 2013). The National Housing Supply Council (Commonwealth of Australia, 2012) reported that there was a shortage of 228,000 dwellings in 2011 in Australia. The Council also projected that the housing shortfall will rise by around 141,000 in the five years to June 2016.

5. Conclusion

Based on the research findings, it can be concluded that house price increases in Sydney during the last decade were principally determined by the factors of mortgage interest rate, housing supply and population growth. Multiple regression analysis (MRA) is one of the methods applied to derive the main determinants. However, there are limitations of using MRA modelling because the variables are non-linear. Brown *et al.* (1997) indicated the problem of coefficient instability in the regression model as an economic system is itself unstable. One of the difficulties of using MRA is handling problems with multicollinearity and non-linearity among variables. Hence, it is difficult to perform such multi-attribute non-linear mappings using regression. Also, regression models lack the ability to learn by themselves, generalise solutions, and respond adequately to highly correlated, incomplete data (Shaw, 1992). Therefore, it is worthwhile to try Vector Autoregressive (VAR) or nonlinear models that may help to solve the problem of building in regression statistics.

References

Abelson, P. (1994), "House prices, costs and policies: an overview", *Economics Papers*, Vol. 13 No. 1, pp. 76-96.

Abelson, P. (1997), "House and land prices in Sydney from 1931 to 1989", *Urban Studies*, Vol. 34 No 9, pp. 1381-1400.

Abelson, P. and Chung, D. (2005), "The Real story of housing prices in Australia from 1970 to 2003", *The Australian Economic Review*, Vol. 38 No. 3, pp. 265-281.

Abelson, P., Joyeux, R., Milunovich G. and Chung, D. (2005), "Explaining house prices in Australia: 1970-2003", *The Economic Record*, Vol. 81, Special Issue, pp. 96-103.

Anas, A. and Eum, S. (1984), "Hedonic analysis of a housing market in disequilibrium", *Journal of Urban Economics*, Vol 15, pp. 87-106.

Arnott, R. (1987), "Economic theory and housing", in Mills, E.S. (ed), *Handbook of Regional and Urban Economics*, Vol. 2, New York: Elsevier Science Publishers, pp. 959-988.

Australian Bureau of Statistics (2014), "Residential property price indexes: Eight capital cities, Available at http://www.abs.gov.au/ausstats/abs@.nsf/mf/6416.0 (Accessed on 25 January 2015).

Bewley, R., Dvornak, N. and Livera, V. (2004), "House price spirals: where the buck starts", CommSec, Commonwealth Bank, Sydney.

Bodman, P. and Crosby, M. (2004), "Can macroeconomic factors explain high house prices in Australia?", *Australian Property Journal*, Vol. 38 No. 3, pp. 174-179.

Bourassa, S.C. and Hendershott, P.H. (1995), "Australian capital city real house prices, 1979-93", *Australian Economic Review*, 3rd quarter, pp. 16-26.

Brown, J.P., Song, H. and McGillivray, A. (1997), "Forecasting UK house prices: a time varying coefficient approach", *Economic Modelling*, Vol. 14, pp. 529-548.

Carter, T. (2005), "The influence of immigration on global city housing markets: The Canadian Perspective, *Urban Policy and Research*, Vol. 23 No. 3, pp. 265-286.

Commonwealth of Australia (2012), Housing supply and affordability – key indicators, 2012, National Housing Supply Council, ISBN 978-0-642-74817-1.

Demographia (2014), "10th Annual Demographia International Housing Affordability Survey: 2014 - Ratings for Metropolitan Markets: Australia, Canada, Hong Kong, Ireland, Japan, New Zealand, Singapore, United Kingdom, United States", Performance Urban Planning.

Dieleman, F.M., Clark, W.A.V. and Deurloo, M.C. (2000), "The geography of residential turnover in twenty-seven large US metropolitan housing markets, 1985-95", *Urban Studies*, Vol. 37 No 2, pp. 223-245.

DiPasquale, D. (1999), "Why don't we know more about housing supply?", *Journal of Real Estate Finance and Economics*, Vol. 18 No 1, pp. 9-23.

DiPasquale, D. and Wheaton, W.C. (1994), "Housing market dynamics and the future of housing prices", *Journal of Urban Economics*, Vol. 35, pp. 1-27.

Draper, D.A.G. (2000), "Rent control and the efficiency of the housing market", Available at: www.cpb.nl/nl/general/org/homepages/dagd/woning.pdf (Accessed 29 January 2015).

Follain, J.R., Leavens, D. and Velz, O.T. (1993), "Identifying the effects of tax reform on multifamily rental housing", *Journal of Urban Economics*, Vol. 34, pp. 275-298.

Goodman, A.C. (1988), "An econometric model of housing price, permanent income, tenure choice, and housing demand", *Journal of Urban Economics,* Vol. 23 No 3, pp. 327-353.

Goodman, A.C. (1990), "Demographics of individual housing demand", *Regional Science and Urban economics*, Vol. 20, pp. 83-102.

Gurran, N. and Phibbs, P. (2013), "Home truths: are planners really to blame for our housing "shortage"?", *The Conversation,* Available at http://theconversation.com/home-truths-are-planners-really-to-blame-for-our-housing-shortage-12723 (Accessed on 3 February 2015).

Gwartney, J.D., Stroup, R.L. and Sobel, R.S. (2000), *Economics – private and public choice*, New York: The Dryden Press.

Haurin, D.R. and Gill, H.L. (1987), "Effect of income variability on the demand for owner-occupied housing", *Journal of Urban Economics*, Vol. 22, pp. 136-150.

Helbling, T. and Terrones, M. (2003), "Real and financial effects of bursting asset price bubbles", *IMF World Economic Outlook*, Chapter II, April.

Ho, W.K.O. and Ganesan, S. (1998), "On land supply and the price of residential housing", *Netherlands Journal of Housing and the Built Environment*, Vol. 13 No 4, pp. 439-451.

Janda, M. (2014), "What housing supply shortage?", ABC Business, Posted 4 November 2014. Available at http://www.abc.net.au/news/2014-11-04/janda-what-housing-supply-shortage/5865096 (Accessed on 4 February 2015).

Karantonis, A. and Ge, X.J. (2007), "An empirical study of the determinants of Sydney's dwelling price", *Pacific Rim Property Research Journal,* Vol. 13 No 4, pp. 493-509.

Kearney, A.T. (2014), 2014 Global cities index and emerging cities outlook: global cities, present and future, AT Kearney Inc. Accessed on 30 March 2015.

Maclennan, D. (1982), *Housing economics - an applied approach*, London: Longman Group Limited.

Manning, C. (1989), "Explaining intercity home price differences", *Journal of Real Estate Finance and Economics*, Vol. 2, pp. 131-149.

Meen G.P. (1995), "Is housing good for the economy?", *Housing Studies*, Vol. 10 No 3, pp. 405-424.

Megbolugbe, I.F. and Cho, M. (1993), "An empirical analysis of metropolitan housing and mortgage markets", *Journal of Housing Research*, Vol. 4 No 2, pp. 191-210.

Megbolugbe, I.F., Marks, A.P. and Schwartz, M.B. (1991), "The economic theory of housing demand: a critical review", *The Journal of Real Estate Research*, Vol. 6 No 3, pp. 381-393

Muth, R.F. (1960), "The demand for non-farm housing", in Quigley, J.M. (ed) (1997), *The Economics of Housing*, Vol I, Northampton, MA: Edward Elgar Publishing, Inc.

Muth, R.F. and Goodman, A.C. (1989), *The economics of housing markets*, Chur, Switzerland: Harwood Academic Publishers.

Omar, A.A. and Ruddock, L. (2002), "The internal & external influence in housing markets", Available at: http://www.scri.salford.ac.uk/bf2002/pdf/omar.pdf School of Construction & Property Management, University of Salford, pp. 222-233

Oster, A. (2005), "House Prices – Drivers and Links to the Broader Economy: Rational or Irrational Exuberance," Shann Memorial Lecture, Economics Discussion Paper 25, University of Western Australia.

Otto, G. (2006), "The growth of house prices in Australian capital cities: What can economic fundamentals explain?", Centre for Applied Economic Research, Working Paper, School of Economics, University of New South Wales, (2006/10) ISSN 13 29 12 70, ISBN 0 7334 2364 7

Pain, N. and Westaway, P. (1997), "Modelling structural change in the UK housing market: a comparison of alternative house price models", *Economic Modelling*, Vol. 14, pp. 587-610

Potepan, M.J. (1994), "Intermetropolitan migration and housing prices: simultaneously determined?", *Journal of Housing Economics*, Vol. 3, pp. 77-91.

Pozdena, R.J. (1988), *The modern economics of housing*, Westport, CT: Quorum Books.

Rahman, M.M. (2015), "Australian housing market: causes and effects of rising price", School of Accounting, Economics and Finance, University of Southern Queensland, Toowoomba, QLD 4350, Australia. Available at https://eprints.usq.edu.au/4614/2/Rahman_2008.pdf (Accessed on 1 February 2015)

Rahman, M.M., (2008), "Australian housing market: causes and effects of rising price", working paper/4614, School of Accounting, Economics and Finance, University of Southern Queensland, Australia. Available at https://eprints.usq.edu.au/4614/2/Rahman_2008.pdf (Accessed on 28 January 2015)

Reichert, A.K. (1990), "The impact of interest rates, income, and employment upon regional housing prices", *Journal of Real Estate and Economics*, Vol. 3, pp. 373-391

Rosen, S. (1979), "Wege-based indexes of urban quality of life" in Mieszkowski, P. and Straszheim, M. (eds), *Urban Economics*, Baltimore, MD: John Hopkins University Press

Shaw, J. (1992), "Neural network resource guide", *AI Expert*, Vol. 8 No 2, pp. 48-54.

Sutton, G.D., (2002), "Explaining changes in house prices", *BIS Quarterly Review*, September 2002 pp.46-55

Sven, R. and François, O.M. (2001), "Housing market dynamics: on the contribution of income shocks and credit constraints", Available at: http://epub.ub.uni-muenchen.de Discussion paper 2001-09, April, Department of Economics, University of Munich, (accessed on 28 January 2015).

Tse, R.Y.C., Ho, C.W. and Ganesan, S. (1999), "Matching housing supply and demand: an empirical study of Hong Kong market", *Construction Management and Economics*, Vol. 17, pp. 625-633

Turner, M. and Struyk, R. (1984), *Urban housing in the 1980s: markets and policies*, Washington, D.C.: The Urban Institute Press

Voith, R. (1999), "The suburban housing market: effects of city and suburban employment growth", *Real Estate Economics*, Vol. 21, pp. 621-667

Woodward, S.E. (1991), "Economists prejudices: why the Mankiw –Weil story is not credible", *Regional Science and Urban Economics*, Vol. 21, pp. 531-537

Zhu, H.B. (2003), "The importance of property markets for monetary policy and financial stability", *in IMF-BIS conference on Real Estate Indicators and Financial Stability,* 27-28 October, 2003, Washington DC. Available at http://bis.hasbeenforeclosed.com/publ/bppdf/bispap21c.pdf (Accessed on 30 January 2015).