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LIBOR and interest rate spread: sensitivities of the Australian housing market

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ABSTRACT

This paper analyses the margin between the Cash Rate Target and LIBOR, and its relationship with house price variation in Australia. The research spans 24 years utilising monthly data to analyse the relationship between Australian house price and LIBOR/CRT spreads. Data are drawn from several sources before the time series is sub-divided into splines forming different stages of the housing market cycle. Models are developed based upon differencing the data and employing ADF tests for stationarity and examination via an Autoregressive Distributed Lag approach and Error Correction Model based data series. Results show there are various macroeconomic, financial and lending short-run dynamics which impact on house prices. Cointegration is also evident, which shows the LIBOR rate to comprise both a shot-run and long-run relationship with house prices. The margin between the CRT and LIBOR is less significant and is only observed in the short-run. The various approaches clearly exhibit the dynamism inherent between the wider macroeconomic and financial environment, which serves to highlight that different drivers affect the housing market at differing magnitudes and at different times. Nonetheless, both the short-run and long-run findings show GDP and LIBOR to be proponents for understanding the sensitivity of house prices in Australia.

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Introduction

In the aftermath of the global financial crisis, much discussion has taken place relating to the rapid and sustained depression within housing markets, and reasons behind the failure to predict such a sudden and catastrophic deflation. In the lead up to the crash financial markets were geared towards profit, turnover and plentiful liquidity, while the potential for market meltdown was given little credence. Transformation of financial market conditions and the effects of such market fluctuations are often linked to the performance of the housing market, as observed by Case and Quigley (2008). While the role of macroeconomic variables is a path well-trodden in terms of observing the cyclic nature of property markets (Edelstein & Tsang, 2007; Tsatsaronis & Zhu, 2004; Wheaton, 1999), including the average level of interest rates (Ortalo-Magne & Rady, 2006), few studies have addressed the subtle, yet prominent indicator that is established through

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identification of the spread between national base rates of interest and LIBOR. Brooks and Tsolacos (1999) established that property markets are sensitive to unexpected inflation and the interest rate term spread, and the widely accepted view is that interest rate fluctuations result in traditionally inverse house price movements (Sutton, 2002).

This paper seeks to explore whether housing market performance in Australia is sensitive to interest rate spreads and builds upon research carried out on the UK housing market by Hinch, Berry, McGreal, and Grissom (2015) which found the margin between the Bank of England (BoE) base rate and LIBOR to be a significant predictor in terms of house price fluctuations. The purpose of this paper is to explore house price relationships over a long time-series to establish the significance and nature of macroeconomic and financial influences during and across discrete time periods within the housing cycle. To capture these effects the paper uses monthly data, prior to and during, the onset of the financial crisis. The timescale has been selected to end in 2009, as the aftermath and recovery period of the global crash are a period felt worthy of separate analysis in their own right. The post crisis period also reflects a significant change in market behaviour based upon the perceived causes of the financial crash and it is suggested that since the global crisis the entire financial system and interrelated processes have changed entirely, potentially attributable to a fresh lack of confidence in the solvency of borrowers since the crash. (Valadkhani, 2014).

Literature perspective: macroeconomic indicators and the Australian housing market

In Australia, as with many developed nations, property is widely accepted as the primary asset within the typical household, and over the last 25 years Australian house prices have become one of the most expensive in the world (Worthington, 2012). As such, any shocks or instability within housing market structures can in turn affect macroeconomic stability. This concept is well established by earlier studies (Adair et al., 1993; Brooks & Tsolacos, 1999) and built upon through studies such as Ling and Naranjo (1997) who examined the performance effects of exogenous factors over time, and later Leung (2004) who recognises the nexus between the macroeconomy and property markets. The relationship between property market behaviour and macroeconomic performance is therefore well established, however as Edelstein and Tsang (2007) argue, it is less well understood which factors are significant in their influence upon these markets. The property boom of the early/mid 2000s and the global market crash that followed sparked a renewed outlook on the interrelationships between house price and the macroeconomy, not just on a national basis, but also on a global scale. Wealth, income and financial market effects were identified by Case and Quigley (2008), while Shiller (2007) suggests that the perception of property as a sound investment is perpetuated by the psychology of previous price rises, causing speculative bubbles to be created. Shiller also notes that the recent crash was unprecedented, both in terms of its impact and global reach.

Ortalo-Magne and Rady (2006) identify income and interest rates as major influences upon the price of housing while Egert and Mihaljek (2007) concluded that a strong positive relationship existed between per capita GDP and house prices.

Indeed, McQuinn and O'Reilly (2008) claimed that the influence of interest rates as a determinant of house price is "virtually uncontested" in their study of Irish house price. Debelle (2004) considers that unemployment, through the creation of debt problems within households, increases the possibility of default therefore causing an increase in the number of repossessions, and a downward movement in property prices.

The significance of unemployment as a factor influencing property markets is also supported by Abelson, Joyeux, Milunovich, and Chung (2005) who concluded in relation to a longitudinal study of the Australian market that, in the long term, real house prices are driven by income, unemployment, mortgage rates, equity prices and CPI. They observed that between 1970 and 2003 there were four house price booms, and that between these booms the house prices tended to fall. The study also indicated a strong inverse relationship between house prices and mortgage rates, a relationship further supported by Otto (2007) who analysed the influence of a number of economic factors on house prices in Australia's capital cities and found that factors such as unemployment, inflation, population, equities and mortgage rates were significant drivers. Otto concludes that mortgage rates have become increasingly significant determinants of house price and this, it is suggested, can be explained by larger loan sizes and fewer fixed price mortgages.

In their study of regional house prices in New Zealand, Fraser and McAlevey (2015) suggest that housing markets are susceptible to shocks to key macroeconomic variables, and state that interest rate and GDP shocks have particular significance in terms of the potential effects upon national and local house prices in New Zealand, although the extent of the response to shocks varies between locations. They also highlight the significance of immigration as a key socioeconomic factor, stating that house prices are impacted by high immigration levels from new immigrants and also from returning New Zealanders, and state that affordability issues in the market are a potential outcome. Rahman (2010) also analysed several socioeconomic factors causing rising house prices in Australia and concluded that interest rates, investment, economic outlook, financial regulation, land supply, the planning system, taxes, levies and charges, demographics, economic growth and wealth effect all play a vital role in influencing housing prices. Land supply was also investigated by Costello and Rowley (2010) who tested the possibility that property supply can be increased by releasing more land, therefore reducing overall prices through market forces, in turn increasing affordability within existing housing stock. The study revealed a weak relationship between supply of land and house price increases and concluded that housing affordability (and therefore house price relationships with the macroeconomy) are more integrated than just the single aspect of land release.

Less common is the utilisation of spreads as a measurement tool, although the use of such methods can add significantly to the exploratory value of research. Hinch et al. (2015) investigated the relationships between property price and the margin between the Bank of England base rate and LIBOR in the UK. With data taken over a 24-year timescale the study employed time series analysis divided into discrete time periods, referred to as splines, to establish the relationships between financial, housing and macroeconomic variables. The study showed that the BoE/LIBOR margin had a significant strong positive effect on UK house price where variation between LIBOR and BoE base rate is reduced, however where greater variation exists the margin has little effect with LIBOR shown as the significant driver. In addition to the predictive assets of the BoE base/LIBOR margin the study also highlighted the significance of unemployment as a strong negative influence upon UK house price. Moreover, the use of LIBOR along with other financial and macroeconomic measures is extremely relevant when considered with the influence of these operations upon the housing sector in the cycles preceding the recession, and further substantiated by the recognised influence upon the global recession experienced in many market economics since 2008/2009. In a recent paper deRoos, Liu, Quan, and Ukhov (2014) describe the advantage of using credit spreads for undertaking analysis, rejecting the use of mortgage rates given their observed similarities and co-linearity issues with property sectors.

Data and methodology

Drawing upon the literature, this study employs three groups of variables, which are widely accepted financial, housing and macroeconomic drivers of house prices (Table 1). To maximise the timescale and fully capture cyclical effects, data are considered from January 1986[1] through to December 2009 which is predicated on two aspects. First, as LIBOR is the focus of the paper, it is based upon the availability of LIBOR (AUD) data. Second, we are interested in examining whether LIBOR spreads are associated with house price change, and if this was a predictor of the housing market boom leading up to the global financial crisis. The data were drawn from a number of different sources spanning official government statistics and banking sources.

Descriptive statistics

The descriptive statistics for the variables can be observed in Table 2. The Cash Rate Target (CRT) statistics exhibit a similar picture to that of the LIBOR. Both show similar levels of (positive) skewness (1.335 and 1.338) respectively over the 24-year period analysed. Indeed, both display relatively similar spreads and the measures of central tendency are corresponding (Table 2). In respect of the CRT/LIBOR margin, this can be observed in Figure 1. Initial inception in January 1986 shows a period of severe volatility, characterised with high peaks and troughs. From 1990 to 1992, the margin remains negative, perhaps suggesting limited opportunity for lending and borrowing. Between 1992 and mid-1996 the CRT and LIBOR spread turns positive with two spikes observed in early and late 1994. This trend is noteworthy and remains relatively subdued, reverting around zero. More notably, the margin is positive from 2003 onwards trending incrementally until a sudden spike in mid-2007 corresponding directly with the wider market trends preceding the onset of the global financial crisis. In terms of descriptive statistics, the CRT/LIBOR margin reveals a marginal positive skewness (1.056) with the mean (0.11), median (0.08) and mode (0.04) all comparatively close. The Statistics relating to the bank accepted bill rate, ASX All Ordinary share Index and price of gold all display positive skewness over the defined periods, with the dispersion and central tendency of these variables not indicating any anomalistic behaviours in the data.

With respect to the housing and lending data, Median house price data display different behaviour to that of the financial variables. Skewness for the Australian median house price is only moderately positive (.582), with a mean of $232,739 and

Table 1. Variable descriptions.

Variable	Description	Abb.	Source
Cash Rate Target	The overnight rate charged on loans between financial intermediaries set by the RBA.	CRT	Reserve Bank of Australia (RBA)
3 Month LIBOR	The 3-month LIBOR (AUD) interest rate is the average interest rate at which a selection of banks in London are prepared to lend to one another in Australian Dollars with a maturity of 3 months.	LIBOR	British Bankers Association (BBA)
Bank Accepted Bill Rate (90 day)	The 90-day bank bill futures and options product is Australia's benchmark indicator for short term interest rates.	90 Day	RBA
CRT and LIBOR Margin	Spread between the Cash Rate Target and the 3-month LIBOR rate	CRT/LIBOR	Author calculations
ASX All Ordinaries Index	Monthly ASX ordinary share prices, the oldest index of shares in Australia, comprised of 500 companies' common shares from the ASE.	ASX	Australian Securities Exchange (ASE) Bloomberg
Median House Price	Median house price derived from the REIA in quarterly format and disaggregated in to monthly.	MHP	Real Estate Institute of Australia
Housing Loan Rate	Australian Variable Housing Loan Rate influenced by the CRT set by the RBA.	HLR	Australian Bureau of Statistics (ABS)
No. of FTB Loans	Monthly number of loans granted to first time buyers as recorded by the ABS.	FTB L	ABS
Value of FTB Loans	Monthly value of loans grated to first time buyers as recorded by the ABS.	FTB V	ABS
Total number of Loans	Monthly number of all loans granted to home buyers as recorded by the ABS.	Total L	ABS
Total Value of Loans	Monthly value of all loans granted to home buyers as recorded by the ABS.	Value L	ABS
Consumer Price Index	Australian Consumer Price Index.	CPI	ABS
Gross Domestic Product	Australian Gross Domestic Product.	GDP	ABS
Unemployment	Monthly unemployment statistics as referenced by the Australian Labour Force Survey recorded by the ABS.	Unemp	ABS

Table 2. Descriptive statistics for variables.

Variable	Minimum	Maximum	Mean	Std. Dev.
Cash Rate Target	3.000	18.900	7.722	4.124
3 Month LIBOR	3.368	18.233	7.829	4.065
CRT/LIBOR margin	−1.456	2.734	0.107	0.414
Bank Accepted Bills (90 day)	3.100	18.970	7.827	4.076
ASX All Ordinary shares	1051	6698	2826	1332
Median House Price	73,217	514,599	232,739	129,410
Variable Housing Loan Rate	5.80	17.00	9.69	3.43
No. of Loans (FTB)	5286	19,043	8584	2752
Value of Loans (FTB)	357,034	3,810,797	1,236,763	909,182
Total Number of Loans	18,864	73,903	42,934	13,459
Total Value of Loans	731,077	17,941,712	6,464,920	4,827,034
CPI	73.26	169.50	123.26	24.85
GDP	123,278	330,391	206,801	56,509
Unemployment	446,637	933,122	649,250	126,134

large standard deviation of 129,410 reflecting quite a large variance. Housing loan rate data displays similar behaviour to that of the median house price, with a moderately positive skewness. In terms of central tendency, the data shows a mean and median figure of 9.69 and 8.30 respectively and evidence of no significant outliers. Both FTB

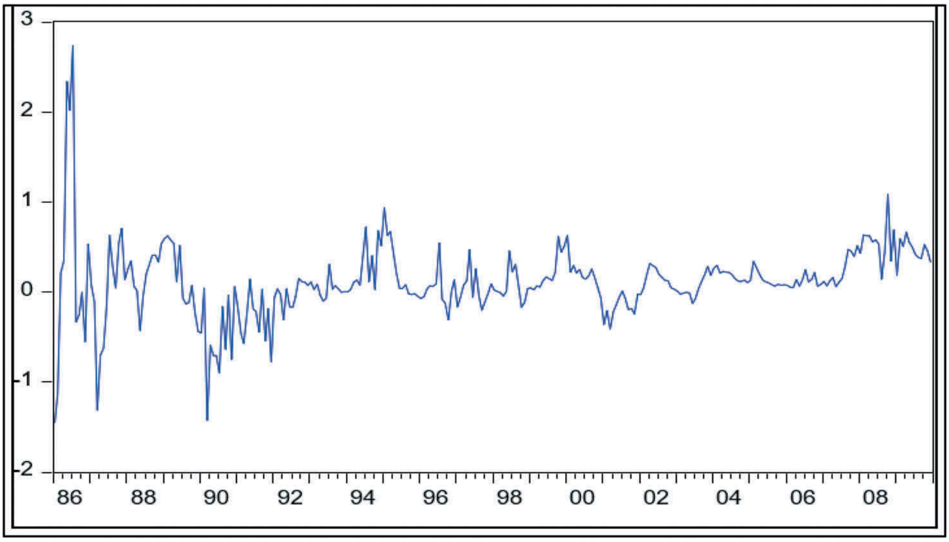

Figure 1. CRT/LIBOR margin.

number of loans and value of loans distribution indicators as a moderately positive skewness and a leptokurtic kurtosis. Statistics illustrating the total number of loans and total value of loans display positive skewness and a platykurtic kurtosis. Central tendency measures show no significant issues with the data. In terms of the CPI, GDP and unemployment data, as expected, these show moderate levels of skewness.

Methods: correlation and regression analysis

Correlation analysis is undertaken to examine the relationships between the variable subset offering initial inspection of the trends and linearity. Moreover, this step also serves to highlight instances of collinearity between the variables and justification for model inclusion purposes. Given that standard economic theory does not suggest an appropriate functional form to be used in hedonic price equations, there is limited theoretical guidance for the choice of functional form, as it represents an equilibrium price schedule (McCord, McCord, Davis, Haran, & MacIntyre, 2017). In line with other property studies, we transform the property price dependent variable into its logarithmic state and employ a semi-log functional form model. The semi-log specification is as follows:

$$Iny_t = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_n x_n \ldots + \varepsilon \qquad (1)$$

where, In(y) is the dependent variable (log of sale price), $x_1 \ldots x_n$ are the independent variables; β_0 the intercept with $\beta_1 \ldots \beta_n$ the parameters to be estimated; with ε the error term.

ARDL model

The rationale for undertaking an ARDL model pertains to the fact that price effects do not occur instantaneously but are spread, or distributed, over future time periods, which introduces a lagged effect into the effects on house prices. Algebraically, this

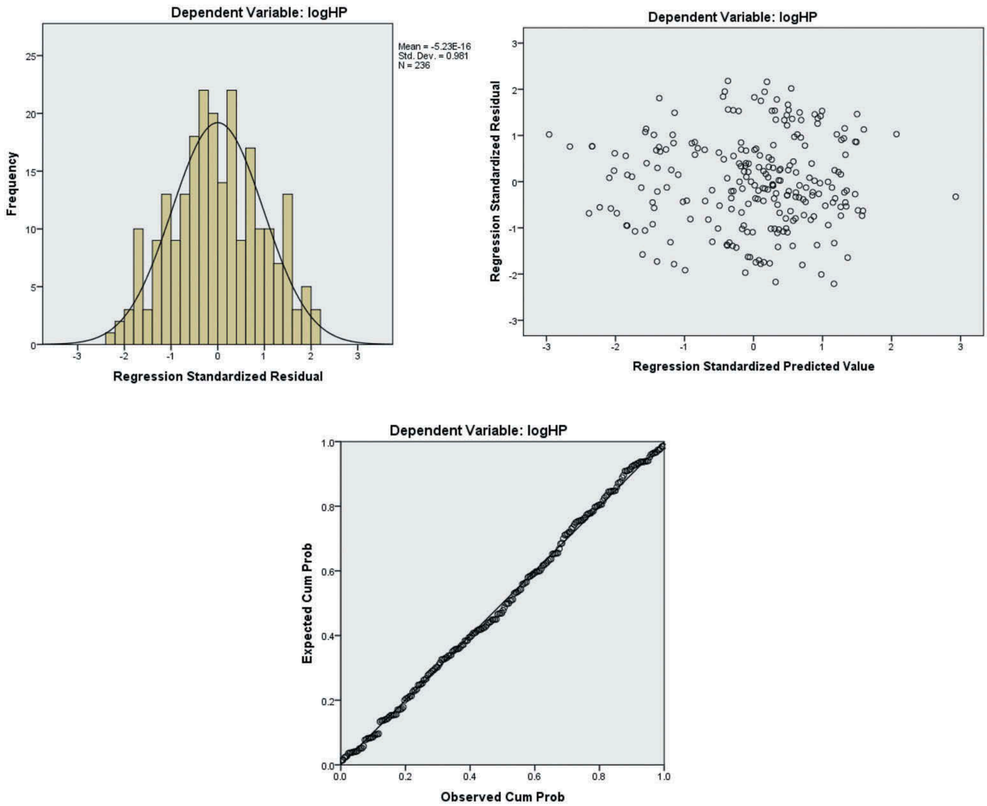

Figure 2. Regression model stability tests.

lag effect can be represented as a change in variable x_t has an effect upon economic outcomes y_t, y_{t+1}, y_{t+2}, or, y_t is affected by the values of x_t, x_{t-1}, x_{t-2} etc. In this paper, median current house prices, y_t, depend on wider market capital, financial and economic appropriations, x_t, as well as the appropriations in the previous n periods. The first specification is that the (finite) ARDL model (p, q), with an additive error term, is specified as:

$$Y_t = \gamma_{0j} + \sum_{i=1}^{p} \delta_j Y_{t-1} + \sum_{i=0}^{p} \beta_j' X_{t-i} + \varepsilon_{jt} \tag{2}$$

where Y_t' is a vector and the variables in (X_t') are allowed to be purely $I(0)$ or $I(1)$ or co-integrated; β and δ are coefficients; γ is the constant; j = 1, ….., k; p,q are the optimal lag orders; ε_{jt} is a vector of the error terms – unobservable zero mean white noise vector process (serially uncorrelated or independent). The dependent variable is a function of its lagged values, the current and lagged values of the other exogenous variables in the model (Almon, 1965). The lag lengths for p, q, may not necessarily be the same with p lags used for the dependent variable, and q lags used for the exogenous variables. Given that the distributed lag weights reflect the fact that it measures the effect of changes in past appropriations, Δx_{t-1}, on expected current expenditures, $\Delta \mathrm{E}(y_t)$, all other things held constant (Shiller, 1973). In its basic form, an ARDL regression model and bounds test for cointegration for the house prices and exogenous variables in this paper takes the form:

$$\Delta LnHousePrice = \alpha_{01} + b_{11}HousePrice_{t-1} + b_{21}LIBOR_{t-i} + b_{31}\frac{CRT}{LIBOR_{t-i}} + \ldots b_{n1}\beta_{t-i} + \sum\nolimits_{i=1}^{p} \alpha_{1j}\Delta HousePrice_{t-i} + \sum\nolimits_{i=1}^{q1} \alpha_{2j}\Delta LIBOR_{t-i} + \sum\nolimits_{i=1}^{q2} \alpha_{3j}\frac{\Delta CRT}{LIBOR_{t-i}} + \ldots \sum\nolimits_{i=1}^{qn} \alpha_{nj}\beta_{t-i} + \varepsilon_{1t} \quad (3)$$

where the Hypothesis is: $H_0 : b_{1j} = b_{2j} = b_{3j} = \ldots b_{7j} = 0$, (where j = 1,2,3...7)

$$H_1 : b_{1j} \neq b_{2j} \neq b_{3j} \neq \ldots b_{7j} \neq 0$$

Correlation findings

Consistent with approaches undertaken in previous research on the UK housing market (Hinch et al., 2015), the LIBOR spreads coupled with macroeconomic influences are measured on house price performance. As highlighted in the methodology section, initial analysis is concerned with correlation, and tests for potential multicollinearity between the variables. In terms of the raw data, examination of the financial variables correlation matrix (Appendix X) reveals a high number of significant relationships, at the 5 and 1% level. Closer inspection reveals that the CRT has a virtually collinear association with both LIBOR (0.995) and the bank accepted bill rate (0.997), each significant at 1% level. A negative relationship is observed between the CRT and ASX (−0.533), and the CRT/LIBOR Margin (−0.192), again both significant at 1%. The price of gold has a weak negative correlation with the CRT (−0.126, p <0.05).

Scrutiny of the housing variables again reveals a number of significant relationships. The median house price exhibits a relatively strong inverse relationship with the variable housing loan rate (−0.670, p <0.01), signifying that decreases in loan rates increase house prices. This finding is consistent with the supposition that house prices are inversely related to the cost of borrowing; as one increases the other decreases. Positive and significant correlation is observed between the median house price and each of the remaining housing variables, with FTB number of loans (0.664) and total number of loans (0.873) showing strong relationships and the FTB value of loans (.916) and total value of loans (0.975) displaying collinearity and a deterministic relationship. In terms of the macroeconomic variables employed within this study, significant relationships are also observed, the CPI is suggestive of collinearity with GDP (0.972) and unemployment exhibits a highly significant relationship with each of the other variables at a low to medium inverse level, with CPI (−0.313), and GDP (−0.464).

The house price coefficient displays a positive near perfect relationship with both GDP (0.981, p <0.001), the total value of loans (0.975, p <0.001), the consumer price index and to a lesser degree the value of FTB loans (0.916, p <0.001) and the stock index (ASX = 0.911, p <0.01). Both the housing lending rate and unemployment show negative associations, which explain 67 and 49.2% of the variation in house prices, suggesting that as unemployment in the economy and the interest level on housing loans decreases, house prices increase. Interestingly, the level of association between the CRT and LIBOR with house prices is negative, explaining 57.8 and 56.3%, respectively, and suggesting that as these rates decrease house prices increase. The spread between the CRT/LIBOR however exhibits a low but positive relationship with house prices (0.234, $p < 0.05$).

In light of the elevated levels of correlations observed, and given this is a time series study, first difference operators are employed to account for temporal dimensions within the data trends. Accordingly, the logarithmic of the house price variable is also applied as in line with existing house price studies to account for a more normally distributed dependent variable. The difference (change) correlation analysis is exhibited in Appendix X. The results show a number of the values to retain a collinear degree of association, such as the LIBOR-90 Day Bill rate (0.848, $p < 0.01$) and Total V -Total L (0.991, $p < 0.001$), thus variables with a high association (>0.70) were purged from further analysis. As a consequence, eight exogenous variables (LIBOR, CRT/LIBOR, Gold Price, FTB Loans, Total loans, Unemployment, CPI, GDP) are carried forward into the modelling exercises.

When accounting for first differencing amongst the relationships, house prices reveal a high degree of divergence from the initial raw data estimation and more partial effects. In terms of the lending environment, FTB loans and FTB loans by value only display a slight negative association (−0.135 and −0.093). This is also similar for the wider number of loans and value, which show even smaller negative relationships of 5.1 and 3.4% respectively. GDP shows a medium positive level of association of 33.1%. With reference to CRT and LIBOR, the correlations are positive signalling a 10.1 and 17.8% level of association, with the CRT/LIBOR margin exhibiting a negative 2.8% level of association. These results are interesting as they are inverse to the original relationships presented in the previous correlation analysis. This suggests that there are weaker relationships evident regarding the changes in price variations between the market parameters.

The ADF test

The descriptive statistics coupled with the evident elevated correlations between a number of the variable subset which subsequently reduced when accounting for first differencing naturally warrants investigation as to the stationarity of the data. Initial inspection of the raw data (at levels) can be observed in Appendix 2. The findings show that a number of the variables appear to not conform to the principle of stationarity, displaying non-stationarity and symbolising that possible upward and downward trends are evident. The Augmented Dickey Fueller test was undertaken to investigate for the presence of a unit root and non-stationarity within the sample times series data, which reveals several of the data exhibit upward and downward trends. The analysis reveals that the null hypothesis cannot be rejected across a number of the parameters illustrating that there is stationarity present within the data series (Table 3). The LIBOR rate, Gold price, FTB loans, Total number of loans, Unemployment, CPI, GDP and BA 90 day bills variables are all integrated at an order of 1 ($I(1)$) with the CRT/LIBOR spread variable integrated at $I(0)$ with house prices $I(2)$. Accordingly, the

Table 3. ADF Test for stationarity.

Variable	Diff.	ADF test	Critical values 1% level	5% level	10% level
House prices	Levels	1.38,111	−3.45,332	−2.87,155	−2.57,217
	1st Diff	−2.44,589	−3.45,332	−2.87,155	−2.57,217
	2nd Diff	−20.49,111	−3.45,332	−2.87,155	−2.57,217
LIBOR	Levels	−2.473,715	−3.45,323	−2.87,151	−2.57,215
	1st Diff	−5.776,679	−3.45,323	−2.87,151	−2.57,215
CRT/LIBOR	Levels	−6.853,595	−3.45,307	−2.87,144	−2.57,212
FTB Loans	Levels	−1.185,791	−3.45,426	−2.87,196	−2.5724
	1st Diff	−6.434,291	−3.45,426	−2.87,196	−2.5724
Total loans	Levels	−1.340,328	−3.45,426	−2.87,196	−2.5724
	1st Diff	−5.487,628	−3.45,426	−2.87,196	−2.5724
Unemployment	Levels	−2.189,175	−3.45,348	−2.87,162	−2.57,221
	1st Diff	−4.795,184	−3.4534	−2.87,158	−2.57,219
CPI	Levels	−0.62,539	−3.45,332	−2.87,155	−2.57,217
	1st Diff	−4.47,897	−3.45,332	−2.87,155	−2.57,217
GDP	Levels	1.111,622	−3.45,409	−2.87,188	−2.57,235
	1st Diff	−3.822,777	−3.45,409	−2.87,188	−2.57,235

*MacKinnon (1996) one-sided p-values. Different model forms were tested for both intercept, intercept plus trend, and none. The intercept model is applied. ***denotes 1% level; **5% level; *10% level.

Table 4. Regression model on stationary data.

	β	t	Tolerance	VIF
(Constant)	3.139	11.126***		
LIBOR	0.464	0.751	0.752	1.331
CRT LIBOR Margin	0.739	1.930**	0.966	1.035
FTB Loans	−0.001	−1.786*	0.320	3.127
Total loans	−0.00002589	−0.433	0.305	3.274
Unemployment	0.00007.292	0.687	0.897	1.115
CPI	−85.099	−1.170	0.961	1.041
GDP	40.531	3.931***	0.836	1.196
R^2	0.180			
Adj. R^2	0.147			
F-stat	5.508***			
Durbin-Watson	1.643			
n	288			

***denotes significant at the 1% level; **5% level; *10% level.

data is subsequently transformed into its stationary sense (integrated all to the same order) for the regression-based analysis.

Regression analysis

The regression model run on the stationary data can be observed in Table 4. The model Adjusted R^2 value signifies that the predictors only explain 14.7% of the price variation. Nonetheless, the model coefficients display three variables to be statistically significant, namely GDP (t = 3.931, p <0.01), FTB loans (t = −1.786, p <0.10) and the CRT/LIBOR margin (t = 1.930, p <0.05).

The model collinearity results reveal limited variance inflation within the predictors with the diagnostic tests also showing the model residuals to be relatively normally distributed as evidenced in the standardised residual histogram and scatterplot of

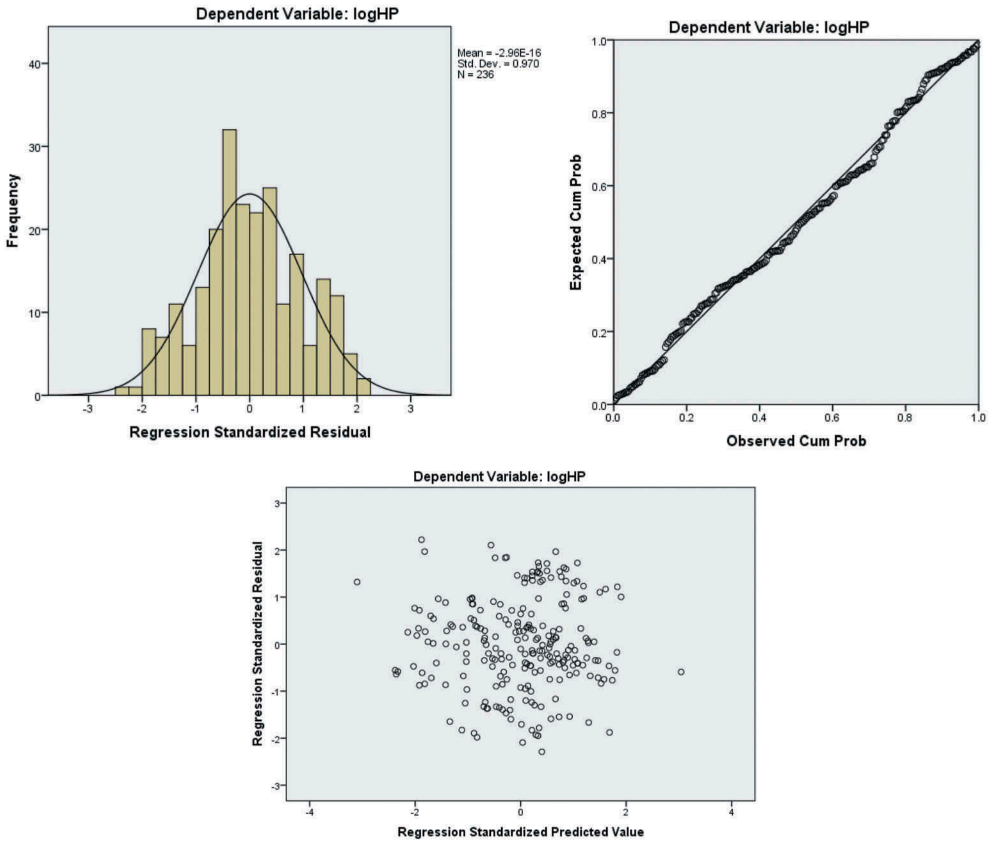

Figure 3. Regression model stability tests.

predicted value and residuals and normal P-P plot of the regression standardised residuals (Figure 3).

The DW statistic of 1.643 indicates a small level of positive autocorrelation. In light of this, and given the initial nature of the time-trends evident in the data, as observed in the ADF tests, the analysis is further dissected into temporal regimes (splines) to investigate the relationships between the financial and economic variables on house prices accounting for temporal breaks in the time series to establish whether specific periods comprise a differential (partial) and significant effect. According to Grissom and DeLisle (1999), when analysing time series data spline analysis yields investigative advantages over standard linear regression modelling. This is particularly relevant when the time period to be examined is long, as this can impact on the underpinning data structure thereby reducing the level of explanation (R^2) where the model continues past significant events in the time-series. With spline analysis, the relevance of identifiable independent variables is captured within shorter specific time slices, permitting a more accurate analysis of the relationships between the dependent variable and independent variables.

Spline analysis is applied to the data initially using dummy variables over predetermined time periods as constructed by periods of economic significance (political, economic and financial events) within Australia to create distinctive regimes based upon these discrete time periods. Notably, only one period of official recession (1990 to 1991) falls within the timescale of the data series. In addition, the data is further partitioned based on the discrete time periods effectively creating a separate model for each time slice. As a consequence, the time series has been divided into six periods of significance. Spline one is January 1986 to December 1989 which represents the start of the study and LIBOR inception through to the end of the last quarter of 1989. Spline two is January 1990 to December 1993 reflective of the deep recessionary period. Also during this period, in August 1990, the first Gulf War began. Spline three is January 1994 to December 1996, spline four is January 1997 to December 2001. Spline five is January 2002 to December 2006 and spline six is January 2007 to December 2009, the end of the study timescale. This period encompasses the beginning of the international credit crisis and subsequent global recession.

In addition, an Autoregressive Distributed Lag (ARDL) model is analysed to examine the dynamic nature, characteristics and relationships between the variables. While accounting for stationarity in the initial regression model, it is important to recognise that changes in the explanatory variables may have behavioural implications beyond the time period in which it occurred. Indeed, changes in LIBOR or economic variables not only affect house prices at one point in time, t, but also at times $t + 1$, $t + 2 \ldots t + n$. Moreover, changes in macroprudential, monetary and fiscal policy can also take longer to infiltrate into market prices and behaviour, thus it may take up to 6 months for any policy effects to manifest through the economy or within the financial realm such as mortgage lending. Therefore, we test for the presence of long-run relationships between house prices and the financial and economic data. The ARDL approach is selected as it can test for cointegration and estimate long-run and short-run dynamics, when the variables in question may include a mixture of stationary and non-stationary time-series.

Spline analysis

The initial spline model incorporating the time period dummies yields an Adjusted R^2 of 0.147, which is marginally higher than the un-segmented model $R^2 = 0.18$, thus suggesting that the inclusion of spline dummies improves, albeit nominally the overall explanatory power of the first difference model (Table 5). The model reveals the LIBOR to be statistically insignificant. Nonetheless, it reveals the CRT/LIBOR margin to be statistically significant ($t = 1.937$, $p < 0.05$) along with FTB loans which displays a negative coefficient sign. The level of GDP is also positive and significant at the 1% level. Only the spline period (Jan1994 -Dec1996) is significant.

The model collinearity results reveal limited variance inflation within the predictors with the diagnostic tests also showing the models residuals to be relatively normally distributed as evidenced in the standardised residual histogram and scatterplot of predicted value and residuals and normal P-P plot of the regression-standardised residuals (Figure 4). The Durbin-Watson statistic also falls within the acceptable range for stability.

Separate discrete Spline models are further constructed to examine the influence of the parameters on house prices to establish which predictors are driving house price change within each distinctive regime. The findings show some interesting market

Table 5. Spline model coefficients.

	β	t	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	3.258	7.771***		
LIBOR	0.228	0.373	0.732	1.366
CRT-LIBOR margin	0.678	1.937**	0.964	1.038
FTB Loans	−0.001	−1.989**	0.318	3.148
Total loans	−1.396E-05	−0.239	0.302	3.308
Unemp.	9.602E-06	0.904	0.855	1.170
CPI	−46.260	−0.502	0.571	1.751
GDP	40.496	4.004***	0.829	1.207
S2(Jan1990–Dec1993)	−0.611	−0.853	0.439	2.278
S3(Jan1994–Dec1996)	−1.419	−2.393**	0.626	1.598
S4(Jan1997–Dec2001)	−0.622	−1.010	0.705	1.419
S5(Jan2002–Dec2006)	0.217	0.406	0.614	1.629
S6(Jan2007–Dec2009)	0.977	1.544	0.669	1.495
R^2	0.235			
Adj. R^2	0.187			
F-stat	4.852***			
Durbin-Watson	1.765			
n	288			

*Spline 1(S1) is the Hold-out time period; ***denotes 1% level; **5% level.

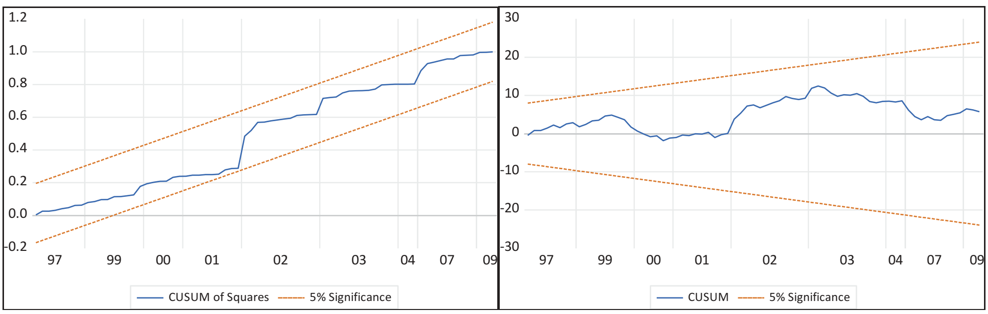

Figure 4. CUSUM of squares and CUSUM tests.

dynamics in operation. The first spline period model shows a relatively poor Adjusted R^2 of 5.1% and exhibits that no predictors are statistically significant. Spline two displays a slightly higher level of explanation, nonetheless, it only shows the volume of total loans in the market to be statistically significant at the 5% level. A noteworthy finding for the third spline model is that the LIBOR coefficient is a statistically significant parameter (t = −4.598, p <0.05) and the only significant variable in this period. For the fourth spline, two variables appear significant, namely the GDP variable and 90 day bill rate (Table 6) which also comprises the highest level of Adjusted R^2 of 34.7%. Both the spline periods five (Jan 2002–Dec 2006) and six (Jan 2007–Dec 2009) show low levels of model predictability and no significant coefficients; a surprising result given the boom-bust nature of these two periods.

Autoregressive distributed lag model

The ARDL model is examined using the Akaike Information criterion for model selection, encompassing the dynamic regressors with 6 lags and 6 lags for the

Table 6. Distinct Spline models.

	Spline 1	Spline 2	Spline 3	Spline 4	Spline 5	Spline 6
Variable	β	β	β	β	β	β
(Constant)	5.832	2.612	3.189	2.371	3.514	3.959
	(2.527***)	(3.765***)	(2.950***)	(4.588***)	(4.027***)	(2.889***)
LIBOR	0.612	1.447	**−4.598**	2.532	4.040	−2.028
	(0.626)	(0.904)	**(−1.950**)**	(1.067)	(0.584)	(−0.607)
CRT-LIBOR Margin	0.913	−0.103	−0.414	2.458	9.108	0.711
	(1.202)	(−0.085)	(−0.190)	(0.937)	(1.285)	(0.255)
FTB loans	a	a	0.002	0.000	−0.001	0.000
			(1.046)	(−0.632)	(−0.979)	(−0.430)
Total loans	−0.0000123	**−0.002**	0.000	0.000	8.486E-06	1.530E-05
	(−0.116)	**(−2.054**)**	(−1.412)	(0.718)	(0.049)	(0.087)
Unemployment	4.073E-05	−0.0000763	1.642E-05	1.369E-05	1.314E-05	1.772E-06
	(1.121)	(−0.472)	(0.491)	(0.599)	(0.412)	(0.052)
CPI	−531.023	3.570	−186.617	155.936	−101.077	35.718
	(−1.508)	(0.245)	(−0.513)	(1.014)	(−0.313)	(0.079)
GDP	40.049	−32.192	41.466	**124.881**	22.055	51.634
	(1.657)	(−0.172)	(1.215)	**(5.188***)**	(0.793)	(1.539)
R^2	.252	.250	.467	.392	.316	.262
Adj. R^2	.051	.096	.119	.347	.085	.085
F-stat	1.244	1.435	1.434	3.896***	1.518	0.749
Durbin-Watson	1.785	1.472	2.112	1.611	1.901	1.970
n	288	288	288	288	288	288

NB. t-statistic values in parenthesis. ***denotes 1% level, **5% level and *10% level. a. demotes a value of zero for raw data.

dependent (1986, M6 – 2009 M12) due to the application of monthly data. The ARDL model displays the short-run casual effects between the regressors. The results exhibit a lagged house price effect until the third period, significant at the 1% level. Interestingly, the 3-month LIBOR displays a statistically significant positive (albeit diminutive) effect at the contemporaneous level (10% level) and negative effect at the 3-month lag (5% level) but shows no significance at the negative 1 or 2 period lags (Table 7). With regards to the CRT/LIBOR spread, the ADRL estimation shows statistical significance at the 10% level at the 1 month lag. In terms of the economy indicators, both CPI and GDP are significant at the 1% level at the contemporaneous level and up to a 2 period lag. Other notable findings show the volume of total loans to be significant at the contemporaneous period (0) and 3 period lag (p <0.10), with Unemployment coefficient revealing a statistical relationship at the 4 period lag. The results suggest that the dynamism within and between the market characteristics are acting at varying speeds of adjustment and there is a presence of short-run causal movements in a number of the financial and economic indictors which are comprising an effect on changes in house prices.

Regarding the long-run estimation and cointegrating relationships, the coefficient estimates, as observed in Table 8, are examined using the *F*-statistic Bounds Test. To test for cointegration, the *null* hypothesis is that there is no levels relationship. As evidenced, the *F*-statistic results for the bounds test of cointegration using an unrestricted constant and no trend signifies the *F*-statistic value ($F = 4.607$) to be above the $I(0)$ and $I(1)$ bound thresholds of significance indicating that there are long-run cointegrating relationships evident between the dependent and predictors, signalling both short-run causal and long-run relationships are present.

Table 7. ARDL model (AIC).

Variable	Coefficient	Std. Error	t-Statistic
LogHP(−1)	0.836,768	0.105,900	7.901,467***
LogHP (−2)	−0.463,736	0.150,355	−3.084263***
LogHP(−3)	0.455,527	0.140,586	3.240,199***
LogHP(−4)	−0.144,617	0.128,063	−1.129,264
LIBOR	0.548,330	0.309,994	1.768,838*
LIBOR(−1)	−0.743,156	0.541,456	−1.372,512
LIBOR(−2)	0.807,579	0.533,028	1.515,078
LIBOR(−3)	−0.666,986	0.328,792	−2.028592**
CRT-LIBOR	−0.615,895	0.353,403	−1.742,753*
GDP	0.000132	2.57E-05	5.137,168***
GDP(−1)	−0.000267	5.10E-05	−5.225,873***
GDP(−2)	0.000124	4.42E-05	2.811,501***
GDP(−3)	8.76E-05	5.29E-05	1.655,494
GDP(−4)	−0.000134	6.64E-05	−2.020302**
GDP(−5)	5.73E-05	3.43E-05	1.671,725*
FTB Loans	−0.000144	8.81E-05	−1.635,660
FTB Loans (−1)	0.000129	7.37E-05	1.751,581*
FTB Loans (−2)	0.000106	6.38E-05	1.664,547
FTB Loans (−3)	−0.000107	6.55E-05	−1.637,275
FTB Loans (−4)	−0.000121	7.67E-05	−1.570,745
Total Loans	1.31E-05	1.84E-05	0.711,957
Unemp	1.17E-06	4.12E-06	0.283,681
Unemp (−1)	−8.06E-06	4.41E-06	−1.826,175*
Unemp (−2)	1.25E-05	4.60E-06	2.717,774**
Unemp (−3)	−1.48E-06	4.83E-06	−0.306,703
Unemp (−4)	4.34E-06	3.98E-06	1.088555
CPI	−0.008608	0.032522	−0.264,680
(Constant)	6.336,495	2.026569	3.126,711***
R-squared	0.908,280		
Adjusted R-squared	0.865,650		
S.E. of regression	0.452,553		
Sum squared resid	14.54,110		
Log likelihood	−45.19,703		
F-statistic	21.30,602		
Prob(F-statistic)	0.000000		
Durbin-Watson stat	2.003448		

* p-values and any subsequent tests do not account for model selection.
Dependent: Log(HP). Maximum dependent lags: 6 (Automatic selection).
Number of models evaluated: 4,941,258. ***denotes significance at the 1% level; **5% level; *10% level.

Table 8. ARDL long-run form and F-bounds test.

Test Statistic	Value	Sig.	*I*(0)	*I*(1)
			Asymptotic: n = 1000	
F-statistic	4.60,787	10%	2.03	3.13
k	7	5%	2.32	3.5
		2.5%	2.6	3.84
		1%	2.96	4.26
Sample Size	283		Finite Sample: n = 80	
		10%	2.129	3.289
		5%	2.476	3.746
		1%	3.233	4.76

Null Hypothesis: No levels relationship. Both the AIC and Hannan-Quinn criterion yield the same outcome.

Further examination of the long-run effects in the unrestricted constant (no trend) test (Table 9) shows the CRT/LIBOR margin to be significant at the 10% level, marginally just outside the 5% boundary, and unemployment at the 5% level inferring long-run

Table 9. Error correction term, residual value from the long-run equation.

Variable	Coefficient	Std. Error	t-Statistic
LIBOR	−0.111,326	0.089922	−1.238,030
CRT-LIBOR	−1.264,284	0.726,635	−1.839,916*
GDP	7.06E-07	2.64E-05	0.026751
FTB Loans	1.63E-05	7.59E-05	0.214,983
Total Loans	2.69E-05	3.76E-05	0.714,183
Unemp	−5.82E-06	2.34E-06	−2.483,761**
CPI	−0.017670	0.067397	−0.262,181

**denotes significant at the 5% level; *10% level.

Table 10. ARDL error correction regression.

Variable	Coefficient	Std. Error	t-Statistic
(Constant)	6.336,495	1.215,119	5.214,713***
D(LogHP(−1))	0.323,917	0.112,274	2.885,046***
D(LogHP(−2))	0.299,647	0.108,423	2.763,684***
D(LogHP(−3))	−0.164,088	0.112,928	−1.453,038
D(LogHP(−4))	0.291,439	0.091511	3.184,732***
D(LIBOR)	0.548,330	0.261,683	2.095402**
D(LIBOR(−1))	−0.140,593	0.313,575	−0.448,355
D(LIBOR (−2))	0.666,986	0.275,064	2.424,841**
D(GDP)	0.000132	2.18E-05	6.042690***
D(GDP(−1))	−0.000135	2.76E-05	−4.885,583***
D(GDP(−2))	−1.09E-05	2.34E-05	−0.463,893
D(GDP(−3))	7.67E-05	3.55E-05	2.163,001**
D(GDP(−4))	−5.73E-05	2.94E-05	−1.952,375**
D(FTB Loans)	−0.000144	5.89E-05	−2.447,282**
D(FTB Loans (−1))	−2.29E-05	5.98E-05	−0.382,019
D(FTB Loans (−2))	8.33E-05	5.57E-05	1.496,508
D(FTB Loans (−3))	−2.39E-05	5.88E-05	−0.406,664
D(FTB Loans (−4))	−0.000144	6.05E-05	−2.385,888**
D(Unemp)	1.17E-06	3.60E-06	0.324,389
D(Unemp (−1))	−4.06E-06	3.96E-06	−1.025131
D(Unemp (−2))	8.43E-06	4.06E-06	2.078810**
D(Unemp (−3))	6.95E-06	3.65E-06	1.903,803*
D(Unemp (−4))	1.13E-05	3.50E-06	3.221,661***
CointEq(−1)*	−0.487,149	0.093461	−5.212,324***
R-squared	0.772,747		
Adjusted R-squared	0.696,997		
S.E. of regression	0.431,769		
Sum squared resid	14.54,110		
Log likelihood	−45.19,703		
F-statistic	10.20,117		
Prob(F-statistic)	0.000000		
Durbin-Watson stat	2.003448		

***denotes significance at the 1% level; **5% level; *10% level.

causal effects (relationships), or in the long-run it appears that unemployment and CRT/LIBOR margin have significant effects on house prices.

Indeed, scrutiny of the ARDL Error Correction regression (Table 10) reveals the EC cointegrating equation value to be negative (–0.4871) which shows long-run reversion to equilibrium, or the speed of adjustment is 48.71% inferring the presence of the long-run causal relationships (t = −5.21, p <0.01). This shows that evidence of a long-run causal relationship is present given the significance of the ECT. The short-run coefficients signify that the first, second and fourth lag of house prices reveals a causal relationship at the 1% level. For LIBOR, both the first and third lags are significant at the 5% level with GDP significant up to four lags with the exception of lag two. FTB loans are significant at levels and only at the fourth lag term inferring that the previous quarter supply of FTB loan activity and contemporaneous level feeds into and determines current house prices. Unemployment displays a short-run causal relationship up to a four period lag.

In terms of model diagnostics and model stability, the residual diagnostics (Normality test) reveal that they are normally distributed and confirmed by the Jarque-Bera statistic. Serial correlation is further tested using the Breusch-Godfrey Serial Correlation LM Test. The F-statistic (1.5982, p >.05) denotes that we cannot reject the null hypothesis and that there is no serial correlation up to 4 lags (Appendix III). In addition, both the CUSUM and CUSUMSQ tests based on the recursive residuals are examined to detect structural (variance) changes in the model. The recursive tests for model stability fall within the 5% confidence bands inferring that the model does not suffer from any deviation of variance and hence no structural breaks are present.

With the presence of cointegration (and cointegrating equations), an Error Correction Model (ECM) is undertaken to examine the short-run dynamic parameters through estimation of the ECM associated with the long-run estimates; that the exogenous variables comprise a causal impact upon house prices. The ECM is represented as follows:

$$\Delta LnHousePrice = \alpha_0 \sum_{i=1}^{p} \alpha_{1j}\Delta HousePrice_{t-i} + \sum_{i=1}^{q1} \alpha_{2j}\Delta LIBOR_{t-i} + \sum_{i=1}^{q2} \alpha_{3j}\frac{\Delta CRT}{LIBOR_{t-i}} + \ldots \sum_{i=1}^{qn} \alpha_{nj}\beta_{t-i} + \lambda ECT_{t-i}\varepsilon_t$$

where λECT_{t-i}explains the long-run equation with $\lambda = (1 - \sum_{i=1}^{p} \delta_i)$, speed of adjustment parameter with a negative sign; $ECT = (InHousePrice_{t-i} - \theta X_t)$, the error correction term; $\theta = \frac{\sum_{i=0}^{q} \beta_i}{\alpha}$, is the long-run parameter; $\alpha_{1i}, \alpha_{1i}, \alpha_{1i}$ are the short-run dynamic coefficients of the models long-run equilibrium.

Table 11. Error correction term model.

Variable	Coefficient	t-Statistic
(Constant)	0.000225	7.549,396***
D(LIBOR(−3))	9.09E-05	1.948,025**
D(CRTLIBOR(−3))	−6.66E-05	−1.258,110
D(GDP(−3))	−2.36E-08	−5.050818***
D(FTBLOANS(−3))	2.23E-08	0.800,192
D(TOTLOANS(−3))	−1.98E-09	−0.362,741
D(CPI(−3))	3.74E-05	0.544,751
D(UNEMP(−3))	−4.67E-10	−0.442,490
ECM(−3)	−0.030621	−3.910,925***
R-squared	0.151,611	
Adjusted R-squared	0.126,750	
S.E. of regression	0.000304	
Sum squared resid	2.52E-05	
Log likelihood	1888.613	
F-statistic	6.098313	
Prob(F-statistic)	0.000000	
Durbin-Watson	1.655,671	

***Denotes significance at the 1% level; **5% level.

Table 12. Granger causality at various lags.

	4 Lags	3 Lags	2 Lags	1 lag
Null Hypothesis: > "does not"				
LIBOR > Granger Cause LogHP	0.49,567	1.23,914	2.36,429*	2.63,552*
LogHP > Granger Cause LIBOR	0.42,195	0.34,412	0.16,244	1.47,746
CRT-LIBOR > Granger Cause LogHP	0.48,912	0.74,774	1.14,901	0.14,144
LogHP > Granger Cause CRT-LIBOR	1.49,829	0.81,171	0.25,757	0.00306
GDP > Granger Cause LogHP	9.02966***	11.2369***	9.05058***	7.94,584***
LogHP > Granger Cause GDP	0.87,010	1.68,858	1.68,964	8.49,250***
FTB Loans > Granger Cause LogHP	2.32,739**	4.06135***	5.13,770***	9.07842***
LogHP > Granger Cause FTB Loans	3.32,644**	2.92,667**	1.22,684	0.50,481
Total Loans > Granger Cause LogHP	4.18,006***	8.16,970***	10.3535***	15.8446***
LogHP > Granger Cause Total Loans	3.32,315**	3.69,536**	0.84,128	0.31,616
Unemp > Granger Cause LogHP	4.13,852***	6.88,750***	5.65,113***	5.97,250**
LogHP > Granger Cause Unemp	0.41,789	0.17,555	0.54,311	0.22,377
CPI > Granger Cause LogHP	2.24,535	7.85,609***	8.16,683***	9.83,223***
LogHP > Granger Cause CPI	1.39,057	0.44,500	0.21,741	4.46,932**

> denotes "does not" ***1% level; **5% level; *10% level. 4 lags = 128 obs., 3 lags = 140 obs., 2 lags = 162, 1 lag = 184 obs. Results based on the F-statistic.

The ECM is specified to obtain the residuals of the long-run model in conjunction with the short-run estimations. The Error Correction coefficient shows that there is a correction (3%) in the previous errors in the subsequent periods, which is statistically significant at the 1% level (Table 11). Overall, the findings show that Australian house prices are affected by both short-run dynamic coefficients and when adjusting for the long-run equilibrium through the error correction. Pertinently, GDP is a statistically significant driver of house prices, with LIBOR also demonstrating an effect at the 5% level of significance.

Granger causality

Finally, the dynamism is tested between the parameter estimates using Granger causality at a number of various lag structures. The results show some interesting causal dynamics in operation between the house prices and the financial and macroeconomic indicators. The 3-month LIBOR exhibits a unidirectional statistically significant ($p < 0.10$) effect on house prices at both the one and two period lag (Table 12). The reverse causality is not evident which suggests that in the short-term LIBOR causes house price change, but house price changes do not cause LIBOR changes. When considering the CRT/LIBOR margin this significance does not hold true indicating that the spread between the base lending rate and LIBOR does not comprise any effect in the short-run. The GDP parameter shows a consistent representation across all four lags with house prices showing only a bi-directional feedback at the one period lag. This suggests that the level of GDP within the economy drives house price change – an *a priori* assumption. The lack of the reciprocal relationship evident infers that there is a much more pronounced effect only evident at the 1-month lag. The total number of loans and level of FTB loans show more bi-directional feedback loops between the wider lending environment and house prices. The loans clearly show a 4-month causal effect; however, house prices only show a 3-month signal, perhaps reflective of the slight lagged effect of statistics which feed into market sentiment.

Conclusion

The LIBOR is a key determinant for assessing financial liquidity and measuring the fragility of confidence between financial behemoths. As a determinant of the cost of borrowing, LIBOR and more specifically the spread between base interest rates or cash rates and LIBOR are envisaged to be key signals for determining movement in house prices over both the short-term and long-term impacting on the stability of the housing market. This paper has attempted to analyse the effects of LIBOR in the Australian context, assessing its relationship as a determinant for house price movements.

Initial model exploration signalled GDP, FTB loans and the CRT/LIBOR margin to be significant explanatory variables for house prices over the period 1986–2009. Further model refinements employing both spline analysis to garner a more temporal understanding of the dynamism between house price movements and the development of an ARDL model to examine the dynamic nature, characteristics and relationships between the variables investigating their lagged effects were undertaken. The initial spline model, while marginally increasing the explanation, further reinforced the original model findings exhibiting the CRT/LIBOR margin, GDP and FTB loans to be significant. When compartmentalising the spline analysis into discrete spline (temporal) models, the results showed much more variation in the predictor subset for affecting house price change. For a number of the discrete models, only one dimension of the market appeared to be significant, with FTB loans significant for the spline period two with LIBOR and GDP significant for time periods three and four respectively. Surprisingly, a number of the discrete spline models demonstrated no significant parameter estimates, particularly for the two spline periods leading up to the GFC. While surprising, this perhaps is explained more by the departing of house prices away from standard endogenous fundamentals typically perceived to be driving market developments.

Interestingly, when considering the change in house prices relative to the wider market characteristics, the regression models show poor explanation, inferring other dynamics are operational and perhaps driving the house price developments outside of normal market fundamentals. Moreover, this may also be a consequence of the price appreciation being driven by more euphoric behaviour, herd mentality and irrational exuberance. Indeed, this is evident in the ARDL findings, which revealed house prices to be a function of their lags and more short-term adjustment effects suggesting that they are self-perpetuating. The short-run casual effects between the regressors clearly showed the 3-month LIBOR to comprise some sort of significant effect across a 4-month lag with the CRT/LIBOR spread only showing a one month lagged relationship. These effects were also evident with the wider economic and lending environment indicators inferring that short-term drivers and the associated dynamism (albeit complex) are acting as key determinants of house price changes.

Importantly, the presence of cointegration shows a deeper connection in the long-run between some market features. The results detected evidence of initial long-run signs between CRT/LIBOR, Unemployment and house prices. These were further scrutinised through the ARDL Error-Correction framework, which showed LIBOR, GDP, FTB loan and Unemployment coefficients to be statistically significant short-run determinants with the presence of the long-run cointegrating equation. Further testing through the specification of the error correction term to control for the relationships revealed both GDP and LIBOR to be significant. Overall, the sensitivity of Australian house prices to the wider macroeconomic and financial environment clearly exhibit short-run lagged effects, which feed quickly into house prices. Nonetheless, the findings do infer a more long-run connection with both GDP and LIBOR, which remain generally significant predictors throughout the different approaches undertaken.

Note

1. Commencement date for analysis relates to the availability of monthly information for key datasets.

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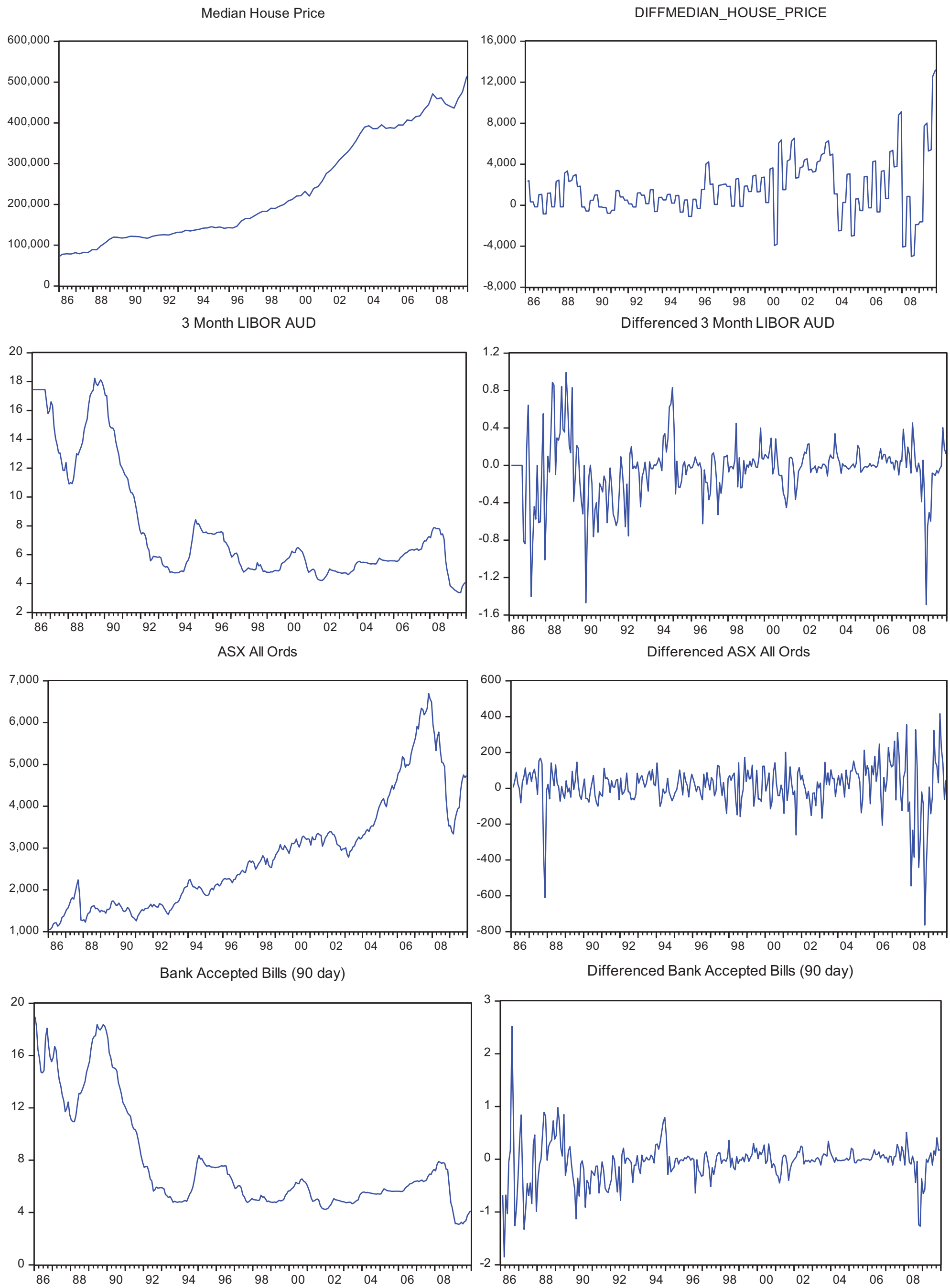
Appendix I. Correlation matrix (Raw data)

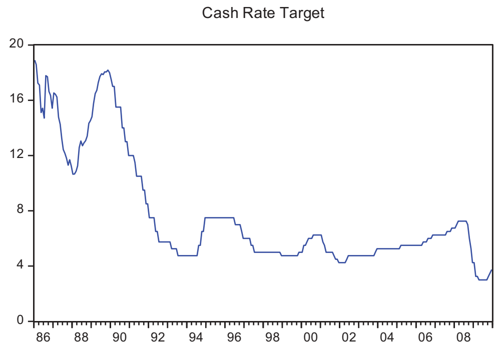
	CRT	LIBOR	CRT-LIBOR	90 day	ASX	Gold	MHP	HLR	FTB L	FTB V	Total L	Total V	CPI	GDP	Unem
CRT	1.000														
LIBOR	0.995	1.000													
CRT-LIBOR	−0.191	−0.092	1.000												
90 Day	0.997	0.996	−0.156	1.000											
ASX	−0.533	−0.519	0.214	−0.517	1.000										
Gold	−0.126	−0.099	0.282	−0.109	0.608	1.000									
MHP	−0.578	−0.563	0.237	−0.567	0.911	0.648	1.000								
HLR	0.945	0.941	−0.167	0.942	−0.622	−0.118	−0.670	1.000							
FTB L	−0.707	−0.696	0.212	−0.704	0.643	0.478	0.664	−0.727	1.000						
FTB V	−0.578	−0.560	0.264	−0.570	0.853	0.742	0.916	−0.648	0.852	1.000					
Total L	−0.738	−0.725	0.228	−0.726	0.848	0.473	0.873	−0.788	0.809	0.862	1.000				
Total V	−0.594	−0.577	0.251	−0.582	0.915	0.681	0.975	−0.674	0.756	0.956	0.927	1.000			
CPI	−0.723	−0.714	0.194	−0.715	0.887	0.576	0.956	−0.773	0.749	0.903	0.884	0.939	1.000		
GDP	−0.618	−0.602	0.244	−0.607	0.924	0.648	0.981	−0.706	0.713	0.932	0.864	0.962	0.972	1.000	
Unemp.	−0.293	−0.312	−0.142	−0.310	−0.505	−0.377	−0.492	−0.097	0.008	−0.366	−0.253	−0.440	−0.313	−0.464	1.000

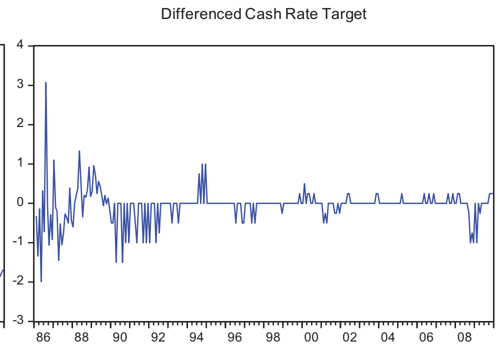
Appendix II. Correlation matrix (Differenced data)

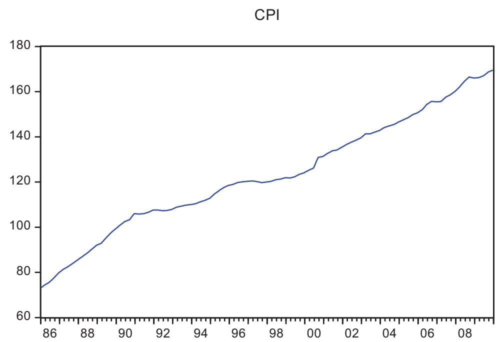
	CRT	LIBOR	CRT-LIBOR	90 day	ASX	Gold	MHP	HLR	FTB L	FTB V	Total L	Total V	CPI	GDP	Unem
CRT	1.000														
LIBOR	0.659	1.000													
CRT-LIBOR	0.039	0.128	1.000												
90 Day	0.733	0.848	0.095	1.000											
ASX	0.032	−0.068	−0.046	−0.008	1.000										
Gold	0.040	0.058	−0.009	0.072	0.043	1.000									
MHP	0.101	0.178	−0.028	0.135	−0.060	0.055	1.000								
HLR	0.513	0.444	0.087	0.454	0.180	0.036	0.078	1.000							
FTB L	−0.092	−0.088	0.020	−0.074	−0.005	−0.015	−0.135	−0.100	1.000						
FTB V	−0.054	−0.069	0.021	−0.067	−0.006	−0.023	−0.093	−0.068	0.955	1.000					
Total L	−0.038	−0.003	−0.015	−0.027	0.034	0.019	−0.051	−0.025	0.657	0.653	1.000				
Total V	−0.041	−0.003	−0.012	−0.031	0.032	0.005	−0.034	−0.024	0.647	0.652	0.991	1.000			
CPI	0.122	0.148	0.075	0.141	0.016	−0.011	−0.117	0.191	0.016	−0.028	−0.027	−0.034	1.000		
GDP	0.020	0.087	0.010	0.061	−0.079	0.031	0.331	0.039	−0.125	−0.104	−0.182	−0.164	0.041	1.000	
Unemp.	−0.216	−0.194	0.048	−0.187	−0.012	0.032	−0.099	−0.216	0.114	0.082	0.095	0.091	−0.030	−0.061	1.000

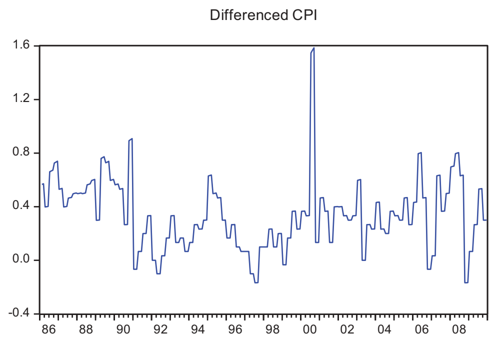
Appendix III. Differencing of data

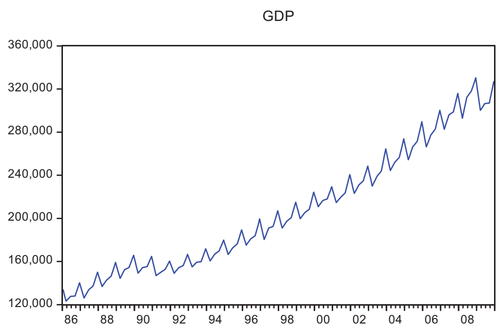


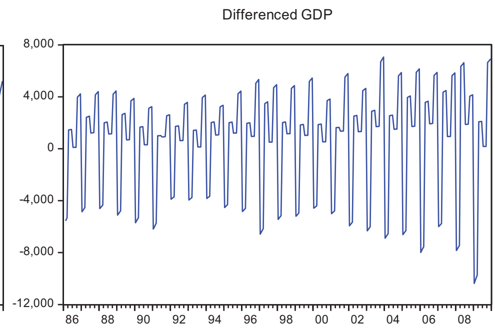

Cash Rate Target
20
16
12
8
4
0
86 88 90 92 94 96 98 00 02 04 06 08

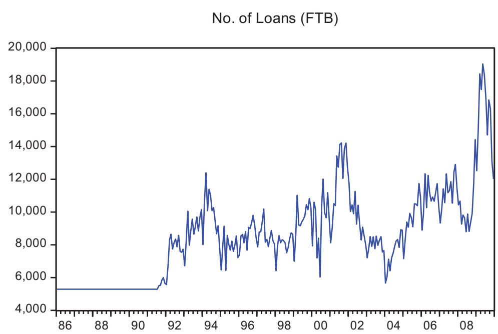

Differenced Cash Rate Target
4
3
2
1
0
-1
-2
-3
86 88 90 92 94 96 98 00 02 04 06 08

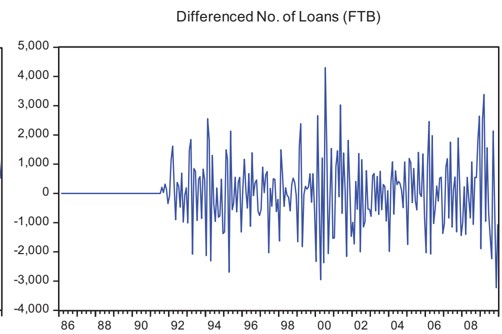

CPI
180
160
140
120
100
80
60
86 88 90 92 94 96 98 00 02 04 06 08

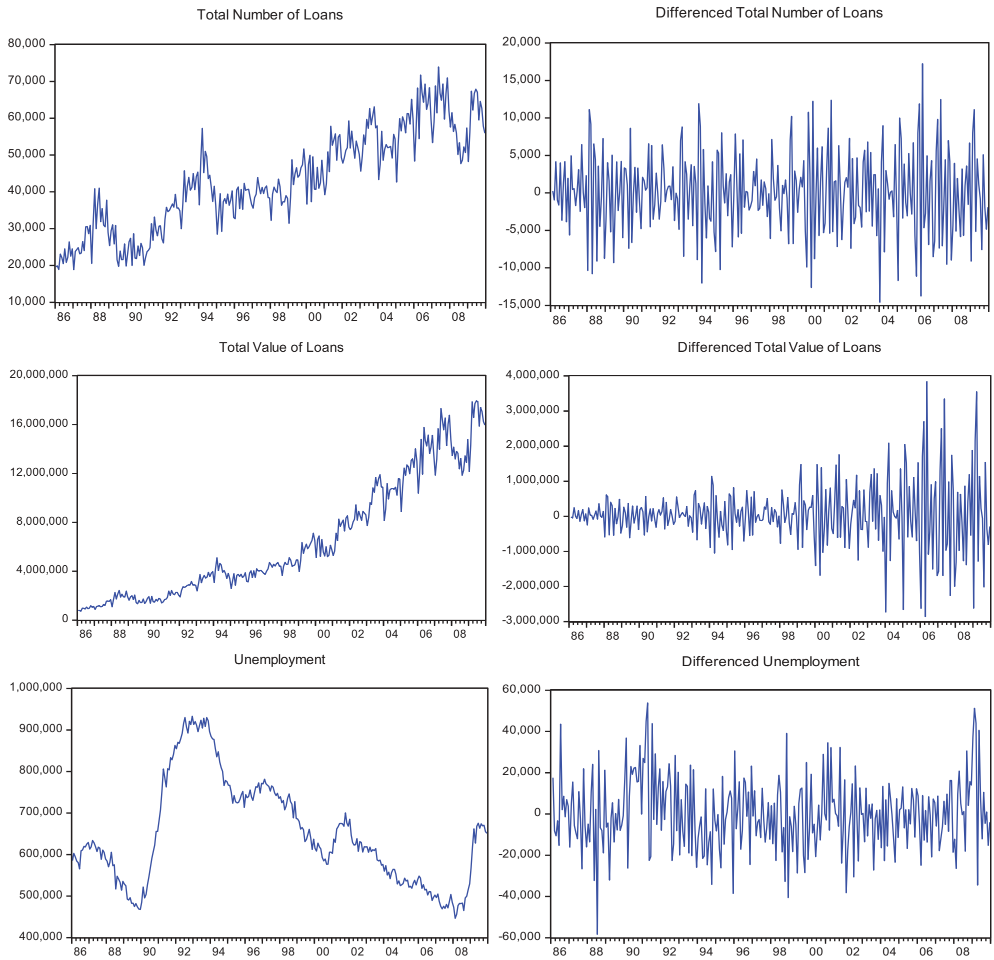

Differenced CPI
1.6
1.2
0.8
0.4
0.0
-0.4
86 88 90 92 94 96 98 00 02 04 06 08


GDP
360,000
320,000
280,000
240,000
200,000
160,000
120,000
86 88 90 92 94 96 98 00 02 04 06 08


Differenced GDP
8,000
4,000
0
-4,000
-8,000
-12,000
86 88 90 92 94 96 98 00 02 04 06 08


No. of Loans (FTB)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
86 88 90 92 94 96 98 00 02 04 06 08


Differenced No. of Loans (FTB)
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
86 88 90 92 94 96 98 00 02 04 06 08


Total Number of Loans
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
86 88 90 92 94 96 98 00 02 04 06 08
Differenced Total Number of Loans
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
86 88 90 92 94 96 98 00 02 04 06 08
Total Value of Loans
20,000,000
16,000,000
12,000,000
8,000,000
4,000,000
0
86 88 90 92 94 96 98 00 02 04 06 08
Differenced Total Value of Loans
4,000,000
3,000,000
2,000,000
1,000,000
0
-1,000,000
-2,000,000
-3,000,000
86 88 90 92 94 96 98 00 02 04 06 08
Unemployment
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
86 88 90 92 94 96 98 00 02 04 06 08
Differenced Unemployment
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
86 88 90 92 94 96 98 00 02 04 06 08

Appendix IV. Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.598,250	Prob. F(4,67)	0.1850
Obs*R-squared	9.146,174	Prob. Chi-Square(4)	0.0575

Null hypothesis: No serial correlation at up to 4 lags

Appendix V. Residual and Stability diagnostic tests