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Modelling Australia's Retail Mortgage Rate

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Abstract:
There is an ongoing controversy over whether banks' mortgage rates rise more readily than they fall due to their asymmetric responses to changes in the cash rate. This paper examines the dynamic interplay between the cash rate and the variable mortgage rate using monthly data in the post-1989 era. Unlike previous studies for Australia, our proposed threshold and asymmetric error-correction models account for both the amount and adjustment asymmetries. We found that rate rises have much larger and more instantaneous impact on the mortgage rate than rate cuts, suggesting an urgent need for monitoring the banks' lending behaviour in Australia.

JEL classification codes: C24, C58, E43 and E58.

Keywords: Banks' mortgage rates, Asymmetric and threshold error-correction models, Australia.

I Introduction

Examining the banks' asymmetric behaviour has been an important and ongoing empirical issue in macroeconomics and finance since the pioneering work of Eichengreen, Watson and Grossman (1985) in which they analysed the Bank of England's discount rate policy under the interwar gold standard (1925-31). They found that there was an asymmetry in the Bank's response to reserve gains and losses: the Bank increased its discount rate upon losing reserves but failed to reduce it upon gaining them. In the contemporary literature this phenomenon is referred to as Bacon's (1991) "rockets-and-feathers hypothesis". He argued that gasoline prices "shoot up like rockets" in response to positive rise in oil prices and "float down like feathers" in response to a fall. *Inter alia*, Hannan and Berger (1991) and Neumark and Sharpe (1992) are among earlier studies that have tested the rockets and feathers hypothesis in the context of the banking industry. Their thorough investigation suggests that, as compared to negative shocks, consumer deposit interest rates respond much slower to positive shocks.

In this paper we examine two specific issues. First, in overall terms, do mortgage-standard-variable rates respond asymmetrically to changes in the funding cost? If the cash rate changes, will the Bacon's (1991) "rockets-and-feathers hypothesis" be applicable in the context of Australia's mortgage rates? Second, when the cash rate, which is known as the federal funds rate in the US, increases by one per cent, on average, how much and how quickly does the standard-variable rate rises? If there exists a significant degree of asymmetric rate adjustments, one may then argue that financial institutions are profiteering from the Reserve Bank of Australia (RBA) rate changes. The second issue is of immense interest in the light of publicly held beliefs regarding the excessive banks' profiteering.

The cash rate is not the only factor that affects lenders behaviour. The response of individual lenders to changes in the funding cost is also influenced to varying degrees by a number of other factors such as the extent of securitisation and individual bank exposures to external sources. However, the cash rate has become increasingly politicised and the focus of much attention by media commentators and the public alike. This is not hard to understand as for many families, mortgage payments constitute a substantial part of their income and interest rate changes have a direct and appreciable effect on their standard of living. During periods of both increasing and decreasing rates, the media not only focuses on which lenders are raising or lowering their rates more quickly in response to the direction provided by the cash rate, but also the extent to which the change in the cash rate is passed on to borrowers.

Politicians of all persuasions in Australia have also long advised banks (particularly the Big 4) against increasing rates outside the RBA's cash rate.[1] For example, in December 2009, three of Australia's four largest banks caused outrage by raising rates more than the RBA, while in February 2010 former Prime Minister, Kevin Rudd, urged banks to follow a decision by the National Australia Bank to keep interest-rate adjustments within any official rate rise.[2] Banks have responded in a variety of ways, with some apparently justifying excessive rate rises outside the RBA cycle to the increased cost of funding and others taking advantage of a strategy of restraining rate rises to capture market share.[3] Particular groups of lenders (especially, credit unions and building societies, mortgage originators, and so on) have also used their varying responses to the cash rate for publicity purposes aimed at levering their 'consumer-friendly' credentials, especially against the major banks. This is not a new issue because about two decades ago Gittins (1991) also highlighted this same issue by stating that mortgage holders complained that banks did not fully pass on the rate cuts.

The asymmetric pass-through of funding costs into mortgage-interest rates are of paramount importance, as it raises serious competition issues in the banking sector. This issue is by no means Australia specific. Other developed countries are also facing the same dilemma. For instance, Corvoisier and Gropp (2002) and Bikker and Haaf (2002) have highlighted substantial differences across European countries in terms of the pass-through of monetary policy interest

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[1] ABC Radio, 'PM plays down bank rate rise chances,' 26 October 2007: http://www.digradio.com.au/news/stories/2007/10/26/2071270ABC.htm, ABC Radio, 'Costello warns banks against rates rises,' 23 October 2007, http://www.abc.net.au/news/stories/2007/10 /23/2068276.htm (both accessed 7 November 2011).

[2] Money, 'Kevin Rudd warns banks not to raise interest rates,' 2 February 2010, http://money.ninemsn.com.au/ (accessed on 5 November 2011)

[3] ABC Radio, 'Banks have grounds to raise home loan rates: Deloitte,' 2 November 2007, http://www.digradio.com.au/news/stories/2007/11/02/2080595.htm (accessed 7 November 2011.)

rate changes into money market rates. Bikker and Haaf examined banking-sector competition in 23 countries and discovered that competition is much weaker in local markets. A recent study found that the pass-through of official interest rate changes into mortgage rates in the Netherlands is only about half of the Euro-zone average (de Haan and Sterken, 2011). Prior to this, based on the Dutch data, Toolsema and Jacobs (2007) found convincing evidence that there is asymmetric pass-through of funding costs into mortgage-interest rates as banks tend to raise interest rates immediately once costs rise, while hesitating to lower their rates when costs drop.

There are numerous studies in the literature that found evidence of asymmetric pricing in the mortgage market (*e.g.* Allen *et al*., 1999; Haney, 1988; Hofmann and Mizen, 2004; and de Haan and Sterken, 2011). For example, Hofmann and Mizen (2004) examined the interplay between the 90-day deposit rate and the mortgage interest rate for seven banks in the UK. They found downward rigidity of the mortgage interest rate in the UK, the US and Dutch mortgage markets. The recent study by de Haan and Sterken (2011) provides further evidence for the asymmetric adjustment and its linkage with bank concentration or imperfect competition. Payne and Waters (2008) analysed the long-term interest rate pass through of the federal funds rate to the prime rate over the period February 1987-October 2005. They also found that the response of the prime rate to changes in the federal funds rate was asymmetric. By employing the Enders-Siklos (2001) momentum threshold autoregressive model, Payne (2007, 2006) found that the mortgage rates are cointegrated with the federal funds rate in the long run but with incomplete interest rate pass through in the short run.

Liu *et al.* (2008) conducted a similar study in the context of New Zealand and found complete long-run pass-through for most retail rates. However, similar to studies outlined above, they also found that the short-run pass-through of market interest rates to bank retail rates was mostly incomplete. In the context of Australia, using the data for the period 1990–2000, Lim (2001) examined the asymmetric adjustments between three Australian bank interest rates: a bank bill rate, a loan rate and a deposit rate. She uses a multivariate asymmetric error-correction model to capture the long- and short-run relationships between the levels of the rates and short-run relationships between the changes in the rates. Her empirical results indicate that “banks value their borrowing customers and tend to pass on decreases in the loan rates faster than they pass on increases” (Lim, 2001, p.146).[4] It should be noted that her results are in sharp contrast with previous similar studies in Australia and other countries including Lowe and Rohling (1992), Lowe (1992), Allen, Rutherford, and Wiley (1999), Arbatskaya and Baye (2004), Hofmann and Mizen (2004); Toolsema and Jacobs (2007), Payne (2007, 2006), Saadon, et al. (2008), Payne and Waters (2008), Allen and McVanel (2009), and de Haan and Sterken (2010). In an interesting article more recently Karamujic (2011) has used monthly data (June 1994 and March 2004) to examine the nature of seasonality in the mortgage interest rates of two major banks in Australia (i.e. National Australia Bank and Commonwealth Bank of Australia). Based on a structural time series modelling approach, he finds evidence of cyclicality and seasonal variations in the selected home loan interest rates.

This paper addresses an important policy issue not recently tackled in Australian context properly. Not only do we test for the two different types of possible asymmetries (i.e. the amount asymmetry and adjustment asymmetry), but we also use a sample period during which the RBA has conducted monetary policy by setting the desired interest rate on overnight loans in the money market. To the best of our knowledge, only a few previous studies such as Allen and McVanel (2009) and De Haan and Sterken (2011) have tested for both the amount and adjustment asymmetries in a short-run dynamic model for mortgage rates. The majority of previous studies have only tested for the adjustment asymmetry by using a Wald test in which two coefficients corresponding to positive and negative changes in the lagged error correction

[4] Using monthly data, Lim (2001) has tested only for the first order autocorrelation and the first order ARCH term (see Table 5, p.145).

terms were assumed to be equal (see for example Sarno and Thornton, 2003; Chong et al., 2006; Liu et al. 2008; Chong, 2010).

If the federal funds rate was not cointegrated with a particular lending rate, then the proposed asymmetric models in such studies would have become symmetric. However, in this paper we argue that even if the lending rate is not cointegrated with the federal funds rate, it is quite possible that short-run positive and negative changes in the federal funds rate may still exert different effects on the corresponding lending rate. In other words, the amount asymmetry should also be tested but within a dynamic framework. It should be noted that Lowe and Rohling (1992) proposed a simple asymmetric model which was used for testing the amount asymmetry. However, in their model only positive and negative changes in the federal funds rate at time *t* were allowed to impact on the lending rates (see Table 4 in Lowe and Rohling, 1992, p.25), whereas in our proposed models the amount asymmetry is tested allowing up to a 12-month lag.

This paper offers an analytical modelling framework to quantify and assess unjustified rate rises (if any), resulting in greater efficiency and transparency of the lending market. The results and policy implications of this paper increases our understanding of the lending market in Australia and are beneficial to all borrowers and various government and non-government decision-makers such as the ACCC (Australian Competition and Consumer Commission), which can play an important role in market efficiency and consumers' protection.

The rest of this paper is structured as follows. In Section II our threshold and asymmetric error-correction models are briefly discussed. Section III discusses the choice of our sample period, the descriptive statistics of the data employed followed by the results. Section IV presents the empirical results of the short- and long-run mortgage rate models. Section V provides some concluding remarks and the final section presents the agenda for future research.

II Theoretical Framework

The cash rate is the baseline for the other rates charged by Australian financial institutions for their various loans including mortgage rates (See Figure 1 in the next section). Based on a relationship between the cash rate (r_t) and the mortgage rate (i_t) in the long run we assume that $i_t = \beta r_t + \varepsilon_t$. In this equation β denotes the long-run pass through parameter to be estimated, and ε_t is the white noise error term.

Standard unit root tests, such as the Augmented Dicky-Fuller (ADF) test, the Kwiatskowski-Phillips-Schmidt-Shin (KPSS, 1992) test as well as the Lee and Strazicich (2003) test, which endogenously incorporate two structural breaks in the testing procedure, are used in the next section to ensure that our empirical results are not biased towards the erroneous non-rejection of the non-stationarity hypothesis. Since both i_t and r_t are I(1), in the next step the aim is to test if the mortgage rate is cointegrated with the cash rate although this seems obvious based on the graphical inspection of the data presented in the next section. If the two variables are cointegrated, then the stationary residuals resulting from $\varepsilon_t = i_t - \hat{\beta} r_t$ could form an error correction mechanism (*ECM*), representing the short-run deviation from the long-run equilibrium.

Standard cointegration tests (Johansen, 1995) implicitly assume a symmetric adjustment process but if the adjustment process is asymmetric or if the mortgage rate is sticky downwards, these tests can lead to misleading results. In other words, the Engle-Granger type tests with a linear adjustment procedure will be inappropriate when the dynamic adjustment of mortgage rates in fact exhibits a non-linear behaviour. One alternative is to use the threshold cointegration test proposed by Granger and Lee (1989) and Enders and Granger (1998) and Enders and Siklos (2001).

In a similar vein, we propose to estimate two short-run dynamic models: in equation (1) the asymmetric parameter associated with the lagged error correction component (or τ) is assumed to be equal to zero and in the second model (equation 2) this threshold parameter is data-determined. Thus:

$$\Phi_k(L)\Delta i_t = \xi_0 + \sum_{s=0}^{q}\lambda_s^{+}\Delta r_{t-s}^{+} + \sum_{s=0}^{q}\lambda_s^{-}\Delta r_{t-s}^{-} + v_t + \begin{cases} \omega^{+} ECM_{t-1}^{+} & \text{If } ECM_{t-1}^{+} > 0 \\ \omega^{-} ECM_{t-1}^{-} & \text{Otherwise} \end{cases} \quad (1)$$

$$\Phi_k(L)\Delta i_t = \xi_0 + \sum_{s=0}^{q}\lambda_s^{+}\Delta r_{t-s}^{+} + \sum_{s=0}^{q}\lambda_s^{-}\Delta r_{t-s}^{-} + v_t + \begin{cases} \theta^{+} ECM_{t-1}^{+} & \text{If } ECM_{t-1}^{+} > \tau \\ \theta^{-} ECM_{t-1}^{-} & \text{Otherwise} \end{cases} \quad (2)$$

where $\Phi_k(L) = (1-\rho_1 L - \rho_2 L^2 - ... - \rho_k L^k)$ represents a *k*-order polynomial lag operator (which is assumed to have no zero within or on the unit circle), *k* is the number of autoregressive terms, ω^{+}, ω^{-}, θ^{+} and θ^{-} are the error correction parameters, which are expected to be negative, $\hat{\varepsilon}_t = ECM_t$ and λ_s^{+} and λ_s^{-} are the short-run effects of positive and negative changes in the cash rate on the mortgage rate at time *t-s* (where *s* can range between 0 and 12), respectively. The superscripts + and – denote the positive part and negative part of the time series, respectively as defined below.

$$\Delta r_t^{+} = max\{\Delta r_t^{+}, 0\} \Rightarrow \Delta r_t^{+} = \Delta r_t \text{ if } \Delta r_t > 0 \text{ and } \Delta r_t^{+} = 0 \text{ if } \Delta r_t \le 0 \quad (3)$$

$$\Delta r_t^{-} = min\{\Delta r_t^{-}, 0\} \Rightarrow \Delta r_t^{-} = \Delta r_t \text{ if } \Delta r_t \le 0 \text{ and } \Delta r_t^{-} = 0 \text{ if } \Delta r_t > 0 \quad (4)$$

Δi_t^{+} and Δi_t^{-} are also defined similar to Δr_t^{+} and Δr_t^{-}. Equations (1) and (2) provide a more flexible model to capture any possible short- or long-run asymmetric effects of changes in the cash rate on the mortgage rate. This is the first study in which both the amount $(\lambda_s^{-}, \lambda_s^{+})$ and adjustment

[ω^{-}, ω^{+} (or θ^{-}, θ^{+})] asymmetry coefficients have been incorporated in a short-run dynamic model for mortgage rates.

In both equations (1) and (2) the magnitude of short-run coefficients (*i.e.* λ_s^{-} and λ_s^{+}) depends on whether changes in r_t are positive or negative. This means the short-run effects of rate rises on the mortgage rate are allowed to be different from those of rate cuts, an issue mot considered by previous studies. Unlike the asymmetric model formulated in equation (1), in the threshold model (equation 2), the parameter τ is assumed to be different from zero. Once the resulting residuals have been sorted in ascending or descending order, we conduct a grid search within the middle 85 per cent of the observations and select an optimum value of the threshold, which yields the lowest residual sum of squares.

Using equations (1) and (2), the Wald test can be employed to test two types of asymmetric adjustment processes: amount asymmetry and adjustment asymmetry. First, if the null hypothesis $\lambda_s^{+} = \lambda_s^{-}$ (for all *s* values) is rejected, then positive and negative short-run changes in the cash rate have asymmetric effects on mortgage interest rates. Accordingly, if $\lambda_s^{+} > \lambda_s^{-}$, then in the short-run dominant market participants pass through market-interest rate rises more than market-interest rate decreases.

Second, if the null hypotheses $\omega^{+} = \omega^{-}$ and $\theta^{+} = \theta^{-}$ are rejected, one can argue that the adjustment process toward the long-run equilibrium is also asymmetric and hence there is evidence of adjustment asymmetry. If $\left|\omega^{-}\right| > \left|\omega^{+}\right|$ or $\left|\theta^{-}\right| > \left|\theta^{+}\right|$, then a lagged negative disequilibrium between the actual interest rate and its equilibrium path results in a relatively swift error correction as compared to the case of a lagged positive disequilibrium. This can easily be justified as financial institutions prefer to increase the actual mortgage rate to its desired path immediately when $ECM_{t-1} < 0$ or $ECM_{t-1} < \tau$. On the other hand, when the lagged-actual mortgage rate is above the equilibrium path, banks may have less desire to lower their rate to its equilibrium path, causing the speed of adjustment to be more sluggish or sometime non existent. This means that in the case of adjustment asymmetry $|\omega^-| > |\omega^+|$ or $|\theta^-| > |\theta^+|$, depending on whether equation (1) or equation (2) is being used in the testing procedure. For a detail discussion of the distinction between amount and adjustment asymmetries in the literature see Chen et al, (2005), Bachmeier and Griffin (2003), Bettendorf et al. (2009), Allen and McVanel (2009) and De Haan and Sterken (2011).[5]

III Data

(i) Choice of the Sample Period 1989-2011

It should be noted that Australia's approach to monetary policy has undergone significant changes over time. From the mid-1970s until 1985, based on the assumption of a strong and persistent relationship between inflation and the supply of money, monetary policy was conducted by targeting the annual growth of M3. However, in 1985 this policy was abandoned because deregulation of the financial system made M3 a misleading guide to the stance of monetary policy (Grenville, 1990). From 1985 to 1988 a "checklist approach" was adopted, whereby a multitude of indicators such as, monetary aggregates, the GDP growth rate, the shape of the yield curve, exchange rates, and the unemployment rate were considered prior to the implementation of monetary policy. The checklist approach was also unsuccessful and finally discontinued in 1989 due to the impossibility of monitoring the above indicators which could provide contradictory policy signals.

Since 1989, the RBA has conducted monetary policy by setting the desired interest rate on overnight loans in the money market. This year has been considered as the starting point for our sample period. Through monetary policy transmission mechanism, changes in the cash rate are

[5] Apart from the recent two studies by Allen and McVanel (2009) and De Haan and Sterken (2011) all other studies are in the context of petrol prices.

ultimately reflected in the rates on all lending instruments in line with the desired policy intent. The cash rate in Australia is now considered the baseline for the rates paid by all borrowers, including mortgage-holding households. Figure 1 suggests that during our sample period, which consists of monthly data from April 1989 to October 2011, there is a very close relationship between the cash rate on one hand and mortgage rate and various types of money market instruments on the other.

[FIGURE 1 ABOUT HERE]

Brännäs and Ohlsson (1999) suggest that the detection of asymmetry depends on the sampling frequency of the series. They argue that the use of aggregated frequencies (*i.e.* annual) may obscure the nonlinearities or asymmetries that exist in a series. They found that "asymmetric monthly series may become symmetric when aggregated to quarterly or annual frequencies" (Brännäs and Ohlsson, 1999, p.341). Therefore, in this paper, we use monthly data to detect any discernable asymmetric behaviour not easily observable in the raw and aggregated data.[6]

(ii) Descriptive Statistics and the Unit Root Test Results

Table 1 presents the descriptive statistics and the unit root test results for all of the variables employed in this paper. During the sample period the average of the standard-variable rate was 8.79 per cent, ranging from a minimum of 5.75 in May 2009 to a maximum of 17.00 per cent in June 1989. As expected, the cash rate showed a slightly less variability than the aggregate mortgage rate, averaging only 6.51 per cent during the sample period. It should be noted that the cash rate (or the interbank-loan rate) exhibited greater variability in post-1989 period than in pre-1989 era. We also found that the cash rate was much less volatile than long-term rates. Similar results were found in the context of the US interest rates in the post-1985 financial deregulation

[6] As can be seen in our results presented in the next section, the effects of positive and negative changes in the cash rate on the mortgage rate appear to be exhausted within 1-2 months. Therefore, this confirms Brännäs and Ohlsson's point that the use of annual time series in lieu of monthly could have masked the existing nonlinearities or asymmetries in the series.

era. According to Watson (1999), the persistence of changes in short-term interest rates varies. Watson argues that “expectations theories of the term structure imply that such shifts in persistence will have a large effect on the variability of changes in the long-term rates but have little effect on the variability of changes in short rates” (Watson, 1999, p.90). Based on the reported Jarque-Bera statistic, the null hypothesis of normality is rejected at any conventional level for all series as their distributions are positively skewed and show a typical leptokurtic pattern with the kurtosis statistic exceeding well above 3.0.

An important step before undertaking our empirical investigation is to determine the time series properties of the data. This is an important issue since the use of non-stationary data in the absence of cointegration can result in spurious regression results. To this end, two unit root tests, i.e. the ADF test, and the Kwiatskowski-Phillips-Schmidt-Shin (KPSS) (Kwiatkowski et al. 1992) test, have been adopted to examine the stationarity, or otherwise, of the time series data. In this paper the lowest value of the Schwarz criterion (SC) has been used as a guide to determine the optimal lag length. Unlike the ADF test, the KPSS test has the null of stationarity, and the alternative indicates the existence of a unit root. In Table 1 we have also reported the results of the Lee and Strazicich (2003) test, which endogenously incorporates two structural breaks in the testing procedure. The resulting two break dates for r_t and i_t are shown by the vertical dotted lines and solid lines, respectively. Irrespective of which test is considered, it appears that both r_t and i_t are I(1) and the order of integration of the residuals obtained from $i_t = \beta r_t + \varepsilon_t$ is I(0). Hence, one can argue that r_t and i_t are cointegrated and this is easily backed up by the visual inspection of the graphs presented in Figure 2. Lowe (1995) also found similar results based on his sample period which ran from January 1986 to October 1994.

[TABLE 1 AND FIGURE 2 ABOUT HERE]

IV Empirical Results

A cursory look at Figure 2 reveals that during the entire sample period 1989-2011 there are four specific periods when both the mortgage rate and the cash rate witnessed a noticeable downward trend: January 1990-July 1994 (as a result of a recession), May 1996-January 2000 (as an outcome of the Asian financial crisis), January 2001-April 2002 (due to another recession) and September 2008-August 2009 (as a consequence of the recent global financial crisis). It is very interesting to observe the behaviour of the mortgage rate during these periods. As can be seen from Figure 2, while the cash rate was on a downward trajectory during these periods, the reduction in the mortgage rate was not of the same magnitude over time. As a result, the gap between these two rates became wider and wider when both rates were decreasing. This phenomenon is more noticeable in the first (January 1990-July 1994) and the last periods (September 2008-August 2009). It is also equally interesting to recognise that such behaviour was not exhibited at other times when the cash rate was on the rise. Attention is now directed to examine such an asymmetric behaviour using a more formal econometric approach.

(i) Estimated Threshold Error-Correction Models

In this section, we first use monthly data for the period April 1989-October 2011 to estimate the long-run relationship between the mortgage rate and the cash rate by the OLS method. The estimated results are as follows:

$$i_t = 1.252 r_t \Rightarrow ECM_{t-1} = i_{t-1} - 1.252 r_{t-1}$$
$$t: \quad (86.8) \qquad (6)$$
$$R^2 = 0.637 \qquad \text{ADF} = -4.316$$

The long-run pass through parameter is estimated at 1.252, which appears to be of consistent sign and order of magnitude and highly significant. This means that in the long run a 1 per cent rise in the cash rate by the RBA leads to a 1.252 per cent increase in the mortgage rate. We also tested the hypothesis that the long-run pass through parameter is equal to 1. Given $F(1{,}270)$=305 and p-value=0.00, such a hypothesis is definitely rejected. As discussed in the previous section, we adopt two dynamic error-correction models (*i.e.* equations 1 and 2). In the first short-run dynamic model (Model I) the threshold parameter (τ) is assumed zero. However, in Model II, which is based on equation (2), this parameter is determined endogenously by the data as explained in the previous section. More specifically, after sorting the resulting residuals (271 monthly observations during April 1989-October 2011) in ascending order, we searched within the middle 85 per cent of the observations and selected a value of the threshold which yielded the lowest residual sum of squares as an estimate of the optimal threshold. The lower and upper values in our grid search were 0.2262 and 1.9194, respectively, with an increment of 0.01 at each step leading to an optimal threshold value of 0.2462.

In terms of determining the optimal lag length (q) in equations (1) and (2), given that we are using monthly data, an upper band of 12 lags was allowed. Following the general-to-specific methodology, insignificant variables in equations (1) and (2) were omitted on the basis of a battery of maximum likelihood tests. We imposed joint-zero restrictions on explanatory variables in the unrestricted (general) model to obtain the most parsimonious and robust equation. The estimation results for both Model I and Model II have been presented in Table.[7]

[TABLE 2 AND FIGURE 3 ABOUT HERE]

According to Table 2, all the estimated coefficients are statistically significant at the 1 per cent level and have the expected theoretical signs, with the only exception being ECM^{+}_{t-1}. Both models also perform well in terms of goodness-of-fit statistics. The adjusted R^2 is as high as 0.64 and the overall F test rejects the null hypothesis at the one per cent level of significance. Furthermore, both estimated models pass a battery of diagnostic tests and show no sign of, serial

[7] We found that the cash rate is weakly exogenous with respect to the dependent variable. This justifies the use of the OLS method to estimate the short-run dynamics of the mortgage rate model based on an asymmetric version of the Engle-Granger two-step procedure. This is not counter-intuitive as the cash rate is directly controlled by the RBA as a policy variable. The weak erogeneity test results are available from the authors upon request.

correlation (see the Breusch-Godfrey LM tests), misspecification (see the Ramsey RESET test), heteroskedasticity (see the ARCH tests) and instability (see the Chow forecast tests in three different out of sample periods). The only diagnostic test that our models could not pass was the Jarque-Bera normality test of the residuals. This was unavoidable given the use of monthly data. Due to the persistence of interest rates in the post-1989 era, the estimated coefficients of AR(1), AR(6) and AR(9) are also statistically significant and the corresponding inverse roots of AR polynomials for both models are well within the unit circle (see Figure 3). As can be seen from Table 2, the estimated coefficients in both models I and II are very similar in terms of their magnitudes and statistical significance.

Ceteris paribus, if in the short run the cash rate increased, say by one per cent in a particular month, this would have immediately led to a rise of 1.158 per cent in the mortgage rate. On the other hand, a similar one per cent rate cut would have resulted in only 0.550 per cent fall at time *t* and a further 0.290 per cent at time *t-1*. The total short-run effect associated with the RBA's rate cut would then be only 0.80 per cent (0.55+0.29), whereas the corresponding effect for a rate rise would be 1.158 percent. This proffers support for the short-run applicability of the rockets-and-feathers hypothesis in the context of the mortgage market in Australia.

What about the adjustment asymmetry? Since in Table 2 $|\omega^-| > |\omega^+|$ and $|\theta^-| > |\theta^+|$, it is clear that whenever the actual mortgage rate is below its equilibrium path at time *t-1 (i.e.* $ECM_{t-1} < 0$), the mortgage rate has quickly been adjusted towards its equilibrium value with the estimated feedback coefficient of -0.176 per month. However, when the mortgage rate is above the equilibrium value or $ECM_{t-1} > 0$, such an adjustment does not take place as the corresponding *t* ratio for the feedback coefficient is highly insignificant (see the *t* ratio for the coefficient of ECM^+_{t-1} in Table 2). It appears that the Australian mortgage lenders enjoy charging above equilibrium rates when such a deviation from the equilibrium path occurs. Conversely, when their actual rates are below the market equilibrium (*i.e.* Model I) or less than a certain threshold (*i.e.* Model II where $\tau = 0.2462$), they relatively quickly correct the prevailing gap by raising their mortgage rates with a feedback coefficient of -0.17.

We have also formally tested the absence of both the amount asymmetry (*i.e.* the short-run asymmetry) and the adjustment asymmetry (*i.e.* the long-run asymmetry) using a Wald test and the results are presented in Table 3. The null hypotheses are rejected at the 1 per cent level of significance, irrespective of which model has been used in the testing procedure. Based on these results, one can argue that there is convincing evidence for the existence of both the amount asymmetry and the adjustment asymmetry. Our results are also consistent with previous studies. An overwhelming majority of previous studies suggest that there is a great deal of asymmetry in the short-run changes in mortgage rates. See for instance Heffernan (1997), Payne (2007, 2006), and Toolsema and Jacobs (2007), Saadon, et al. (2008) and Liu, et al. (2008) and de Haan and Sterken (2011).

[TABLE 3 ABOUT HERE]

Peltzman (2000) believes that various measures of imperfect competition, the existence of consumer search costs, inventory cost, inflation-related asymmetric menu costs, and input price volatility generally determine the extent of asymmetric changes in prices. More specifically in the context of banks' lending rates, previous studies have identified 5 explanations for the rigidity in the interest rate adjustment process: fixed menu cost, high switching cost, imperfect competition, asymmetric information, and interest rate regulation (see *inter alia* Hannan and Berger (1991; Scholnick, 1996; Chong et al., 2006; and Chong, 2010).

In the context of Australian mortgage rates, Lowe and Rohling (1992) provided a detailed account of the stickiness of various types of loan rates. They argued that the two most important explanations for the downward stickiness of the mortgage rates in Australia are switching costs and risk sharing. Switching costs (such as loan establishment fees, stamp duty, early repayment fees) associated with moving from one housing loan to another could be quite high. Lowe (1995) has attributed the incomplete pass-through parameter to the possibility that banks may smooth mortgage rates over the cycle so that the variability in borrowers' repayment burdens is reduced. It is also argued that "if borrowers are more risk averse than the shareholders of the bank, there exists an implicit risk insurance argument for the stickiness of interest rates" (Lowe and Rohling, 1992, p.11). If competition is not strong and customers' decisions are interest-rate inelastic, then changes in the cash rate may have relatively little impact on mortgage rates.

(ii) Policy Implications

Researchers from Australia and other countries which could be exposed to banks' asymmetric behaviour in setting the variable-mortgage rate may also find our proposed models and the results useful. This paper can assist mortgage holders and relevant government regulators to quantify the extent of the asymmetric behaviour exhibited by the banking industry as a whole. Borrowers are entitled to know why rate rises have been passed onto them faster than rate cuts and vice versa. This paper benefits all borrowers through a better understanding of mortgage rates and the regulators in enhancing transparency and competition in consumer lending.

The results presented in this paper reveal that there is a significant degree of market inefficiency and relatively larger incomplete interest rate pass through, requiring in turn a closer government monitoring and scrutiny. The paper shows how differently standard-variable interest rates have responded to rate rises and rate cuts set by the central bank in its pursuit of a contractionary or expansionary monetary policy. This paper contributes to the enhancement and effectiveness of government and private responses to pronounced and sometimes obvious rate fixings in the market— particularly when the market is subject to global and external shocks. Our results suggest that there is an urgent need for monitoring the lending institutions' behaviour in Australia.

V Conclusion

Banks' asymmetric behaviour in setting the mortgage rates is a major cause of concern. Like many other countries, mortgage interest payments constitute a significant proportion of consumer spending in Australia. However, little empirical work has been conducted regarding the dynamic effects of a change in the cash rate on Australia's retail mortgage rate. This paper is among the first comprehensive studies that have attempted to (i) model mortgage interest rates in Australia and (ii) trace out the dynamic asymmetric response of lenders to changes in the funding cost over time. Specifically, this paper attempts to rigorously test the robustness of the rockets-and-feathers hypothesis in Australian context. While this paper focuses on the residential mortgage market, our proposed framework can be adapted in other similar economies to model the intricacies associated with the dynamic interplay between other types of retail and wholesale interest rates, including those for credit cards, personal loans, and business loans.

Threshold and asymmetric error-correction models are used to examine monthly data from 1989 to 2011 and the sensitivity of our results to model specification. We found that rate rises are passed onto the consumer faster than rate cuts both in the short- and long-runs. The short-run effects of one per cent "rise" and "fall" in the cash rate on the mortgage rate are 1.158 per cent (occurred almost instantaneously) and 0.80 per cent (eventuated within 1-2 months), respectively. Our results indicate that the rockets-and-feathers hypothesis is applicable in Australia's home-loan market. In sum, we found that while ECM_{t-1}^{-} is statistically significant, ECM_{t-1}^{+} is not. One can thus conclude that when actual mortgage rates are below the market equilibrium value, Australian banks quickly fill the gap by raising their mortgage rates. Conversely, when actual mortgage rates are above the equilibrium path, the Australian mortgage lenders usually hesitate to lower their rates.

VI Agenda for Future Research

Where do we go from here? In this paper we have established that the rockets-and-feathers hypothesis is applicable at an aggregate level in Australia's mortgage market. On our agenda for future research, our aim will be to purchase consistently-defined weekly data for 110 bank and non-bank financial institutions from CANSTAR CANNEX (www.canstar.com.au). Such a disaggregated and weekly study (as emphasised by Brännäs and Ohlsson, 1999) can reveal in which bank or non-bank institutions interest rate pass-through is incomplete and the extent of the asymmetric adjustment is greater. We can then describe the main characteristics of such lending institutions. For example, are the leaders of rate rises mainly big banks, if so which one? Have such banks maintained similar position in the market throughout the sample period? One can identify the bank-specific opportunistic behaviour in the home loan market and reveal excessive profiteering by the parties involved due to market inefficiency or collusion. The results of such a large-scale project will enable us to identify the leaders and followers of mortgage rate changes. This type of information could provide consumers with more specific forward information about the expected dynamics and the extent of interest rate pass through and the expected "best bank to borrow". Mortgage holders will thus be more informed and able to borrow better, and regulators will be more adequately equipped in protecting consumers.

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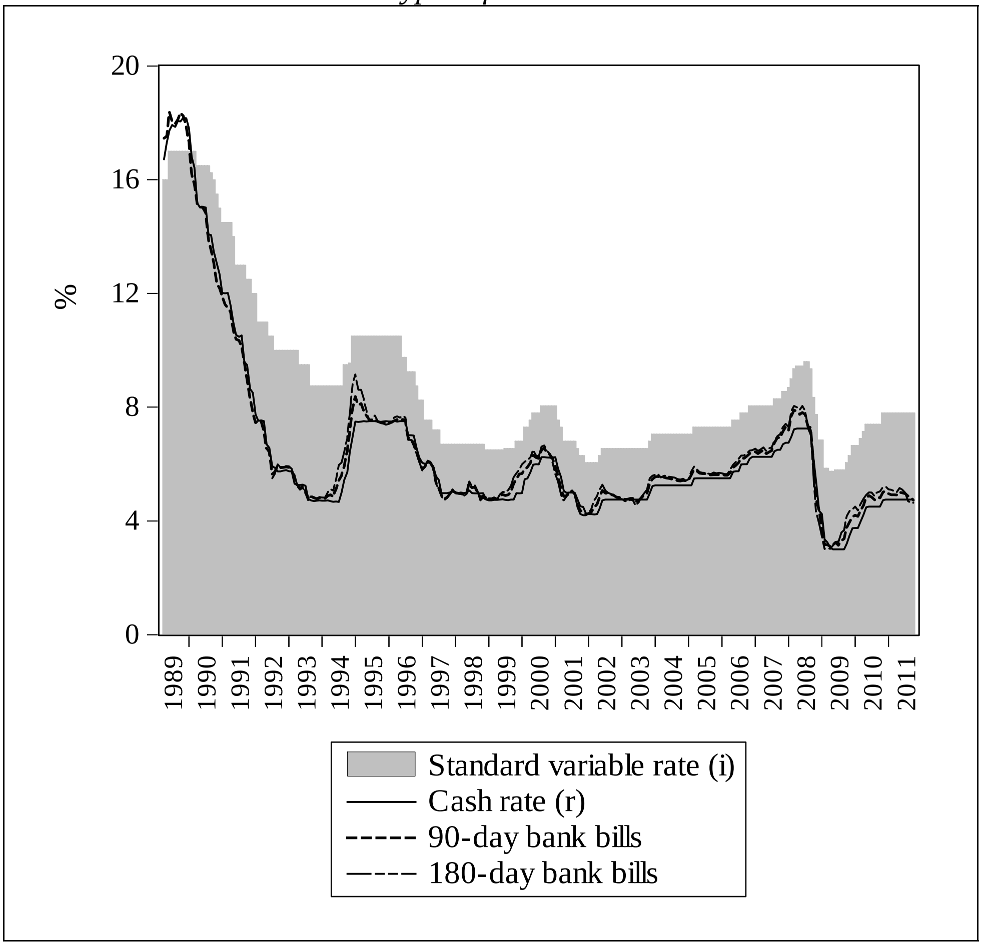
FIGURE 1

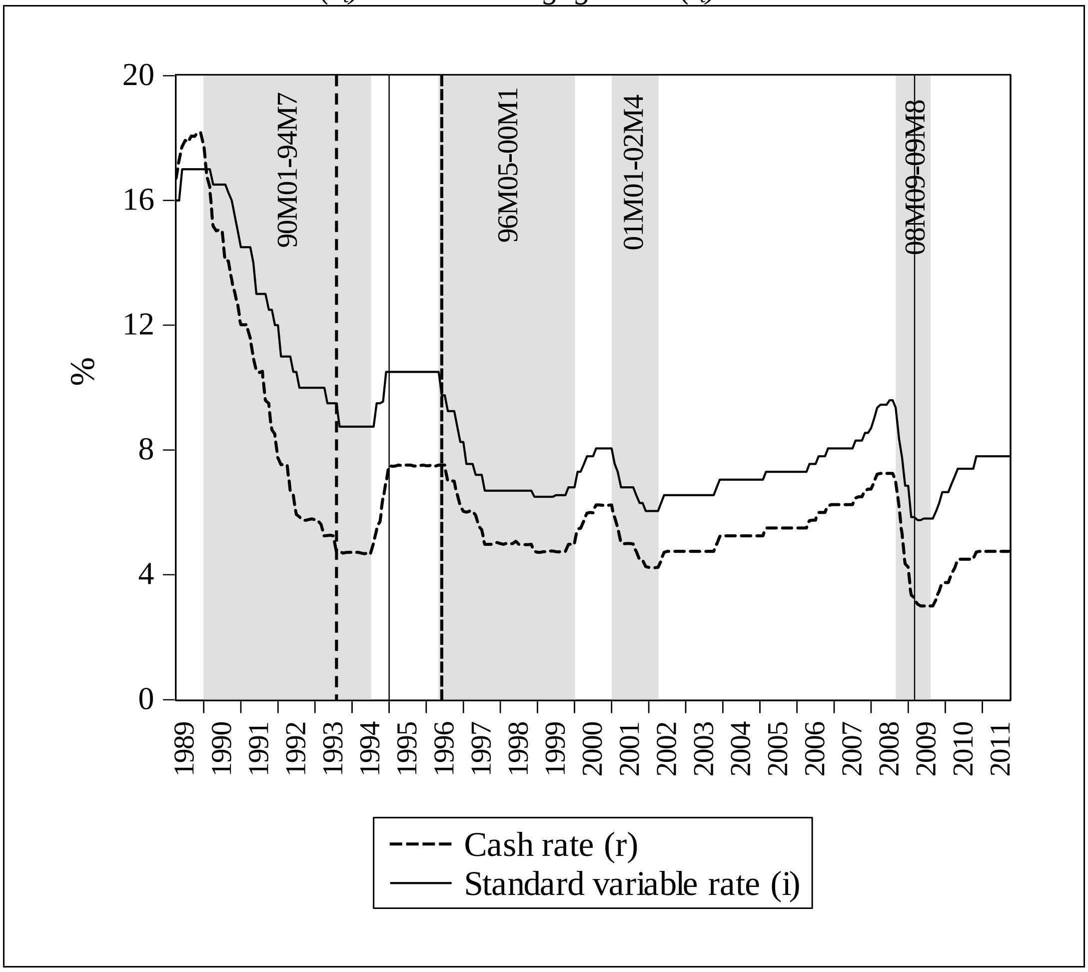
Cash Rate vs Other Types of Interest Rates 1989M4-2011M10



Source: The Reserve Bank of Australia (RBA, 2011).

FIGURE 2

The Cash Rate (r_t) and The Mortgage Rate (i_t) 1989M4-2011M10



Note: The endogenously-determined two break dates for r_t and i_t are shown by the vertical dotted lines and solid lines, respectively.

Source: The Reserve Bank of Australia (RBA, 2011).

FIGURE 3

Inverse Roots of AR Polynomials

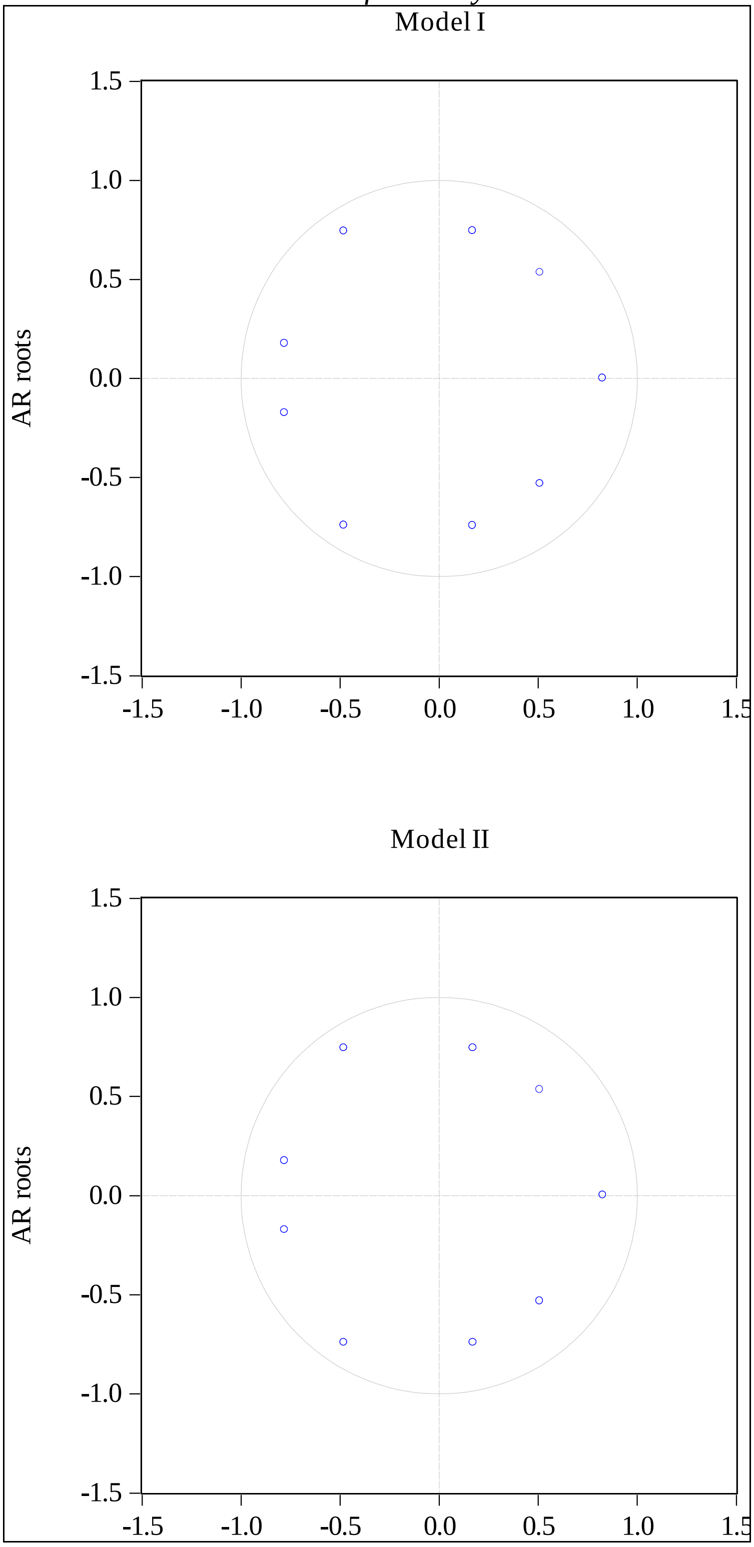


TABLE 1

Descriptive Statistics and Unit Root Test Results

Description	i_t	Δi_t	r_t	Δr_t	ECM_t
Mean	8.79	-0.03	6.51	-0.04	0.637
Maximum	17.00	1.00	18.18	0.72	3.529
Minimum	5.75	-1.00	3.00	-1.26	-5.758
Std. Dev.	2.86	0.24	3.20	0.25	1.599
Skewness	1.62	-1.06	2.33	-1.69	-1.976
Kurtosis	4.88	9.42	7.96	8.30	9.051
Jarque-Bera	159*	517*	523*	446*	590*
ADT test					
t stat.	-2.576	-8.315*	-2.426	-6.854*	-4.316*
Optimal lag	4	1	2	1	4
KPSS					
LM stat.	0.400*	0.041	0.274*	0.095	0.119
Bandwidth	12	9	12	10	12
Lee and Strazicich LM_τ test:					
t ratio	-2.950	-7.281*	-2.693	-6.856*	-6.617*
Optimal lag	6	6	6	1	8
$\hat{T}_B$	1993:8 2009:3	1993:08 1996:06	1995:01 2009:03	1992:03 1995:01	1994:10 2008:11

Notes: (1) * indicates that the corresponding null hypothesis is rejected at 1 per cent level of significance. (2) The choice between the crash model and the trend break model in the Lee and Strazicich (2003) test was based on the statistical significance of the corresponding parameters.

TABLE 2

Estimated Asymmetric Short-Run Dynamic Models For (Δi_t)

Variable	Model I (Equation 1)			Model II (Equation 2)		
	Coefficient	*t* ratio	*p*-value	Coefficient	*t* ratio	*p*-value
Intercept	-0.009	-0.6	0.55	-0.003	-0.2	0.85
Δr_t^+	1.158*	13.0	0.00	1.153*	13.0	0.00
Δr_t^-	0.550*	11.1	0.00	0.548*	11.1	0.00
Δr_{t-1}^-	0.290*	6.2	0.00	0.291*	6.2	0.00
ECM_{t-1}^+	-0.006	-0.5	0.58	-0.008	-0.8	0.40
ECM_{t-1}^-	-0.176*	-6.1	0.00	-0.175*	-6.2	0.00
D_t	-0.656*	-5.7	0.00	-0.653*	-5.7	0.00
AR(1)	-0.319*	-5.4	0.00	-0.317*	-5.3	0.00
AR(6)	0.218*	4.1	0.00	0.220*	4.1	0.00
AR(9)	0.130*	2.8	0.00	0.131*	2.9	0.00
Goodness of fit statistics:						
R^2	0.657			0.659		
$\bar{R}^2$	0.645			0.647		
Overall $F(7, 251)$	53.5*	0.00		53.9*		0.00
Akaike info criterion	-1.045			-1.050		
Schwarz criterion	-0.908			-0.913		
Hannan-Quinn criterion	-0.990			-0.995		
Diagnostic tests						
DW	1.932			1.932		
Serial correlation LM Test:						
2 lags	1.455		0.24	1.225		0.30
4 lags: $F(4,247)$	1.523		0.20	1.359		0.25
6 lags: $F(6,245)$	1.520		0.17	1.363		0.23
8 lags: $F(8,243)$	1.563		0.14	1.455		0.17
10 lags: $F(10, 241)$	1.280		0.24	1.191		0.30
Ramsey RESET: $F(1,250)$	1.695		0.19	2.257		0.13
Jarque-Bera: $\chi(2)$	535.9*		0.00	528.4*		0.00
Heteroskedasticity ARCH test:						
1 lag: $F(1,259)$	1.892		0.17	2.043		0.15
2 lags: $F(2,258)$	1.400		0.25	1.450		0.24
3 lags: $F(3,257)$	1.284		0.28	1.233		0.30
4 lags: $F(4,256)$	1.255		0.29	1.168		0.33
Chow forecast test:						
2007M01-2011M10: $F(58,193)$	0.774		0.87	0.806		0.83
2008M01-2011M10: $F(46,205)$	1.026		0.44	1.040		0.41
2009M01-2011M10: $F(34,217)$	0.651		0.93	0.661		0.93

Notes: (1) * indicates that the corresponding null hypothesis is rejected at 1 per cent level of significance. (2) EViews and WinRats software packages have been used in generating our results.

TABLE 3

Test Results For Amount Asymmetry and Adjustment Asymmetry

Null hypothesis	Model I		Model II	
	F statistics	*p*-value	*F* statistics	*p*-value
$\lambda_0^+ = \lambda_0^-$	*F*=(1,251)=33.04	0.00	*F*=(1,251)=32.74	0.00
$\lambda_0^+ = \lambda_0^- + \lambda_1^-$	*F*=(1,251)=8.99	0.00	*F*=(1, 251)=8.77	0.00
$\omega^+ = \omega^-$	*F*=(1,251)=33.23	0.00	—	—
$\theta^+ = \theta^-$	—	—	*F*=(1,251)=33.23	