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Abstract

This paper implements a procedure to evaluate time-varying bank interest rate adjustments over a sample period which includes changes in industry structure, market and credit conditions and varying episodes of monetary policy. The model draws attention to the pivotal role of official rates and provides estimates of the equilibrium policy rate. The misalignment of actual official rates and their changing sensitivity to banking conditions is identified. Results are also provided for the variation in intermediation margins and pass-throughs as well as the interactions between lending and borrowing behaviour over the years, including behaviour before, during and after the global financial crisis. The case studies are the US and Australian banking systems.

Keywords: bank interest rates; time-varying asymmetric adjustments; monetary interest rate policy.

JEL classification: C32; E43;G21.

1 Introduction

The pivotal role of official interest rates in the determination of bank rates is well-known. For monetary policy to be effective, official interest rate changes need to be transmitted quickly to other rates, and the ensuing levels and spreads need to be of magnitudes that produce changes in real expenditure. Consequently, knowledge about the size (i.e., how much of the policy change in the official cash rate is passed on), as well as the speed of transmission (i.e., how quickly the policy change is passed on) is important for implementing informed monetary policy. This has sparked an empirical literature on estimating the pass-throughs of policy changes and these studies are important because, as shown in Kobayashi (2008), incomplete pass-throughs imply a reduction in social welfare.[1]

The empirical analysis is not straightforward. While bank rates, in general follow policy changes, bank rates also change in response to market conditions, independently of changes in official target rates. A case in point is the recent hikes in bank rates during the tight credit conditions associated with the global financial crisis (GFC) of 2008/09. These changes, in turn, have implications for central bank monetary policy given their typical reliance on interest rate changes to manage the economy (especially inflationary pressures). Thus, studies of adjustments in bank rates need to allow for feedbacks from bank rates to official target rates. This is not simply a question of applying appropriate econometric techniques to obtain unbiased estimates, it is also a question of allowing for credit conditions to influence banking behavior as well as to shape monetary policy.

The empirical analysis is further complicated by the fact that there have been many changes in the financial system. Banks in the world have been progressively deregulated; monetary policies have undergone changes from a focus on the money supply to a focus on interest rates; financial systems have been subjected to a range of innovations and the economic environment of many nations has changed following the growth of emerging nations such as

[1] This article also contains a review of the recent studies on interest rate pass-through for the Euro area.

China and India. In short, studies of adjustments in bank rates need to also allow bank behavior to be asymmetric and to evolve over time in response to changes in industry structure, monetary policy and shocks (see for example, a review by Berger, Demirguc-Kunt, Levine and Haubrich (2004) who found that concentration and competition had an influence on bank performance).

A number of studies have attempted to address these issues. For example, Mizen and Hofmann (2002) extended earlier work by Hannan and Berger (1991) and Neumark and Sharpe (1992) to allow for asymmetry and nonlinearity in the adjustment processes and applied it to study the case of UK retail bank and building societies' rates over the 1985-1999 period. Lim (2001) applied an asymmetric vector error-correction model to test for asymmetric speeds and sizes of adjustment in response to tightening and loosening of policy for the case of Australian rates over the period 1984-2000, while Espinosa-Vega and Rebucci (2003) applied a standard error correction model to investigate the pass-through of money interest rates to retail banking rates for a number of countries including Chile, the United States, Canada, Australia and New Zealand. More recently, Groppp, Sorenson, and Lichtenberger (2007) explored the behavior of changes in bank spreads over the period 1994 to 2002 and, in particular, allowed for asymmetric responses to monetary policy innovations. Leuvenstein, Sorensen and Rixtel (2008) found that competition implies significantly lower loan spreads and larger deposit spreads in the Euro area during the period 1994-2004. Finally, Gambacorta (2008) examined a panel of Italian banking rates for the period 1993-2001 and suggested that heterogeneity in the pass-throughs reflect liquidity, capitalization and relationship lending issues, but only in the short run.

The aim of this paper is to contribute to this empirical literature in three ways. The first contribution is to shed light on how the pass-through coefficients and the intermediation margins changed as the global financial crisis emerged. The studies to date have not included data that covered the most recent financial crisis whereas this study spans a sample period which includes a long growth cycle, the maturing of the inflation targeting form of monetary policy, as well as financial episodes such as the recent credit constraints associated with the propagation of the global credit crisis. A study of banking behavior pre, during and post crisis would add to our understanding about whether and if so, how banking behavior sowed the seeds of a crisis (in addition to those identified by Hagen and Ho (2007), namely: slowdown in GDP, lower real interest rates, extremely high inflation, large fiscal deficits and over valued exchange rates).

The second contribution is to allow for endogeneity in the official rates. While this may not have been such an issue in past studies, the emergence of the credit crisis has highlighted the need to allow for feedbacks. To this end, the banking model of Freixas and Rochet (1997) is adopted. This competitive economic model of bank behavior treats the determination of deposit, loan and money rates simultaneously and would be an improvement over previous partial studies of bank interest rate behavior.[2] The equilibrium model pins down the relationship between the rates and it is then transformed into a multivariate error-correction form to capture the interplay of long-run optimizing behavior and short-run adjustments. More importantly the methodology expands on earlier studies by relaxing the restriction that bank adjustments to borrowing and lending rate disequilibria are determined by reference to a single deterministic indicator variable. The relaxation of this restriction allows for the derivation of a time-varying equilibrium reference rate. Comparing actual official rates with this time-varying equilibrium rate would then provide a measure of both the period and quantum of historic misalignment.

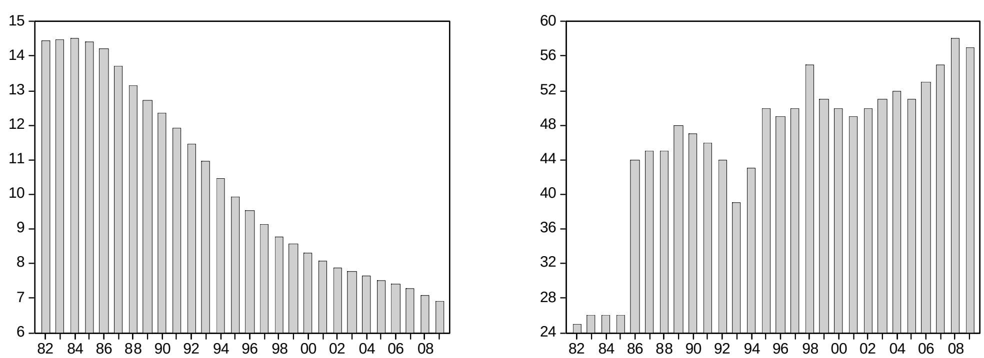
The third contribution is to compare two banking systems - the case of the US and the case of Australia and is partly motivated by Schaeck, Cihak and Wolfe (2009) who found that more competitive banking systems are less likely to experience systemic crisis. The US and Australian banking systems are interesting case studies because, while both financial systems are well-developed, the former system is populated by many banks and exhibits a strong regional aspect (see DeYoung, 2007 for a survey of the evolution of US banking industry), whereas the Australian system is better described as an

[2] Notably Scholnick (1996) and Heffernan (1997) who have examined the deposit side separately from the loan side. Partial analysis is not desirable as, a priori, the borrowing and lending decisions of banks are interdependent.

oligopolistic system dominated by four major nationwide banks. Moreover, over the period 1982-2009, the number of US banks has declined from about 14,000 to 8000,[3] whereas the number of Australian banks has grown from 26 to 55 banks[4] (see Figure 1). For the US market based system, the change in the number of banks reflects greater consolidation activity and an increase in the number of failures (over 100 banks failed during the global financial crisis). In contrast, the growth in the number of banks in Australia reflects the deregulation of the financial system in the early 1980s. With deregulation, the Australian system was opened to foreign banks (16 upon initial deregulation). Over the years, changes in the Australian banking sector have included non-bank deposit taking institutions becoming banks, and the acquisition of several mid-size and smaller banks by their larger counterparts.

Figure 1: Number of banks between 1982 and 2009

United States (thousands) | Australia



Source:http://www.fdic.gov/bank/statistical/stats/2009jun/fdic.html

Source:http://www.apra.gov.au/

[3] Some statistics about the US system are available on the Federal Deposit Insurance Corporation website: http://www.fdic.gov/bank/statistical/stats/2009jun/fdic.html

[4] Australia has adopted a 'four pillars' banking policy that prevents mergers among the four major Australian banks. Information about Australian banking performance can be found on the website of the Australian Prudential Regulatory Authority: http://www.apra.gov.au/.

The paper is organized as follows. The banking model is described in section 2 and the econometric model with time-varying parameters is set out in section 3. Results and discussion for the two case studies follow in Section 4. Concluding remarks are in Section 5.

2 Bank Interest Rate Setting Behavior

The empirical analysis is based on the imperfect competition banking model of Freixas and Rochet (1997). For convenience of exposition and completeness of the paper, the key derivations and equations in Freixas and Rochet (1997) are reproduced here. Consider a banking sector with N banks (indexed by $n = 1, ..., N$). Each bank has on the liability side - deposits D_n, and on the asset side - interbank[5] balances M_n, and loans L_n so that the balance sheet identity is:

$$D_n = L_n + M_n, \qquad n = 1, ...N \tag{1}$$

Let each bank face the same cost function $C(D, L)$, assumed linear for simplicity:

$$C(D, L) = \gamma_D D + \gamma_L L, \quad n = 1, ...N \tag{2}$$

where γ_L and γ_D are the marginal costs with respect to deposits and loans respectively.

Now, define the equilibrium loan and deposit rates as r_L^* and r_D^* respectively. Let the banking sector face a downward sloping aggregate demand for loans $L(r_L)$ and an upward sloping aggregate supply of deposits $D(r_D)$; this can be expressed in inverse form as $r_L(L)$ and $r_D(D)$ respectively.

In this imperfectly competitive banking model of Freixas and Rochet, the interbank rate, r_M is assumed to be exogenously determined. The Cournot equilibrium of the banking sector will be N-tuple vectors $(D_n^*, L_n^*)_{n=1,...N}$ with unique equilibrium conditions, $L_n^* = \frac{L^*}{N}$ and $D_n^* = \frac{D^*}{N}$ obtained by letting the nth bank maximize its profits, taking the volume of deposits and loans

[5] Freixas and Rochet (1997) suggest that cash balances be modelled as a proportion of deposits. Since this assumption does not alter the basic model, it has been omitted here.

of other banks as given. Defining the nth bank's profit function as

$$\Pi_n = r_L(L_n + \sum_{m \neq n} L_m^*)L_n + r_M(D_n - L_n) - r_D(D_n + \sum_{m \neq n} D_m^*)D_n - C(D_n, L_n), \tag{3}$$

yields the first order conditions

$$\frac{\partial \Pi_n}{\partial L_n^*} = r_L'(L^*)L_n^* + r_L(L^*) - r_M - \gamma_L = 0, \tag{4}$$

$$\frac{\partial \Pi_n}{\partial D_n^*} = r_M - r_D'(D^*)D_n^* - r_D(D^*) - \gamma_D = 0. \tag{5}$$

Solving the first order conditions then gives the banking sector's optimal loan and deposit rates as

$$r_L^* = -r_L'(L^*)\frac{L^*}{N} + r_M + \gamma_L, \tag{6}$$

$$r_D^* = -r_D'(D^*)\frac{D^*}{N} + r_M - \gamma_D. \tag{7}$$

where the $*$ denotes the optimal values. Equations (6) and (7) describe the equilibrium relationships between the rates, given the exogeneity of r_M and they show the positive response of both r_L^* and r_D^* to r_M. Moreover, they show that in a perfectly competitive banking sector ($N = \infty$), the loan intermediation margin ($r_L^* - r_M$) equals its marginal cost γ_L while the deposit intermediation margin ($r_D^* - r_M$) is equal to the negative of its marginal cost $-\gamma_D$. However, as the banking sector becomes oligopolistic (N becomes small) and approaches the monopoly case ($N = 1$), the size of the loan intermediation margin increases (since $r_L' < 0$) while the deposit intermediation margin decreases (since $r_D' > 0$).

Equations (8) and (9) constitute the two fundamental (i.e., the long-run cointegrating) relationships sought in the empirical analysis which, for later reference, is rewritten as:

$$r_L^* = \beta_0^l + \beta_1^l r_M, \tag{8}$$

$$r_D^* = \beta_0^d + \beta_1^d r_M, \tag{9}$$

where

$$\beta_0^l = \gamma_L - r_L'(L^*)\frac{L^*}{N},$$

$$\beta_0^d = -\gamma_D - r_D'(D^*)\frac{D^*}{N},$$

$$\beta_1^l = \beta_1^d = 1.$$

In the simplest case, both slope coefficients (the pass-throughs) are expected to be unity, while the intercept terms β_0^l, and β_0^d may be viewed as deposit and loan intermediation margins. A priori, $\beta_0^l > 0$ while $\beta_0^d < 0$ as loan spreads $(r_L - r_M)$ are typically positive while deposit spreads $(r_D - r_M)$ are typically negative.[6]

3 The Econometric Model

The proposed econometric framework includes the fundamental relationships expounded in the theory section, but allows for the endogeneity and identification of the reference rate as well as for time-varying behavior in both the size and speed of bank interest rate adjustments to monetary policy. The endogeneity and identification of the reference rate is an important empirical consideration as it has implications for the independence of monetary policy while the capacity for stochastic time-variation allows us to capture observed asymmetric behavior as well as structural change in the financial system over time.

The econometric model of the trivariate set of interest rates under study,

[6] This relationship has been tested in recent times. For example, in the last 18 months, bank deposit rates in Australia have often exceeded policy rates as banks have sought to increase their cash reserves.

r_t^m, r_t^l, and r_t^d, is specified as a trivariate vector error correction model:

$$\Delta r_t^m = \delta_{0t} + \delta_{1t} r_{t-1}^m + \alpha_{1t}^m c_t^l + \alpha_{2t}^m c_t^d + e_t^m, \tag{10}$$

$$\Delta r_t^l = \delta_{0t} + \delta_{1t} r_{t-1}^m + \alpha_{1t}^l c_t^l + \alpha_{2t}^l c_t^d + e_t^l, \tag{11}$$

$$\Delta r_t^d = \delta_{0t} + \delta_{1t} r_{t-1}^m + \alpha_{1t}^d c_t^l + \alpha_{2t}^d c_t^d + e_t^d, \tag{12}$$

where

$$c_t^l = r_{t-1}^l - \beta_{0t}^l - \beta_{1t}^l r_{t-1}^m,$$

$$c_t^d = r_{t-1}^d - \beta_{0t}^d - \beta_{1t}^d r_{t-1}^m.$$

The terms c_t^l and c_t^d are measures of disequilibrium based on the relationships identified in the banking model. Following standard practice, actual changes are modelled as proportions of the disequilibrium gaps. In this system of equations, $\{\beta_{1t}^l, \beta_{1t}^d\}$ represent the pass-throughs in response to a change in the official rate, r^m. The intercept terms $\{\beta_{0t}^l, \beta_{0t}^d\}$ are the intermediation margins while the $\{\alpha_{1t}^m, \alpha_{2t}^m, \alpha_{1t}^l, \alpha_{2t}^l, \alpha_{1t}^d, \alpha_{2t}^d\}$ are the error-correction terms and measure the speeds of adjustment to the disequilibrium gaps. The coefficients are all time-varying so that banks may inter-temporally adjust their response to interest rate disequilibria and the disequilibria themselves may also exhibit inter-temporal sensitivity to the target rate and other information through the time varying parameters.[7]

The model also includes the terms δ_{0t} and $\delta_{1t} r_{t-1}^m$. These terms are necessary for two reasons. The first, is to cover the case when the reference rate is strictly exogenous, so that when $\alpha_{1t}^m = \alpha_{2t}^m = 0 \quad \forall t$; the data generating process for r_t^m becomes $r_t^m = \delta_{0t} + (1 + \delta_{1t}) r_{t-1}^m + e_t^m$.[8] The second

[7] The system has been set up assuming the existence of two cointegrating vectors. However, two identifying restrictions are needed and it is useful to select identifying restrictions that facilitate an economic interpretation of the cointegrating vector. For a discussion of the identification of long run cointegrating vectors and related testing, see Ericsson and Irons (1994). In this case, consistent with the model specified in Section 2, the cointegrating vectors are normalised on r^l and r^d; that is the zero restrictions are on r^d in the first cointegrating vector and on r^l in the second cointegrating vector.

[8] This is a generalisation of the basic short-rate model $dr(t) = \delta_0(t, r(t))dt + \sigma(t, r(t))\, dB(t)$, where B is a Wiener process (Cox, Ingersoll and Ross, 1985; Hull and White, 1990).

reason is to ensure that the system is uniquely identified. In equilibrium, when $\Delta r^m = \Delta r^l = \Delta r^d = 0$, the system collapses to: $r^l = \beta_0^l + \beta_1^l r_M$ and $r^d = \beta_0^d + \beta_1^d r^m$. Thus, $c^l = c^d = 0$ and this yields an equilibrium reference rate: $r^{m*} = -\delta_0/\delta_1$.

For estimation purposes, the three pivotal equations in the model are rewritten as:

$$\begin{aligned}\Delta r_t^m &= \alpha_{1t}^m r_{t-1}^l + \alpha_{2t}^m r_{t-1}^d - \left(\alpha_{1t}^m \beta_{0t}^l + \alpha_{2t}^m \beta_{0t}^d - \delta_{0t}\right) \\ &\quad - \left(\alpha_{1t}^m \beta_{1t-1}^l + \alpha_{2t}^m \beta_{1t}^d - \delta_{1t}\right) r_{t-1}^m + e_t^m,\end{aligned} \tag{13}$$

$$\begin{aligned}\Delta r_t^l &= \alpha_{1t}^l r_{t-1}^l + \alpha_{2t}^l r_{t-1}^d - \left(\alpha_{1t}^l \beta_{0t}^l + \alpha_{2t}^l \beta_{0t}^d - \delta_{0,t}\right) \\ &\quad - \left(\alpha_{1t}^l \beta_{1t-1}^l + \alpha_{2t}^l \beta_{1t-1}^d - \delta_{1t}\right) r_{t-1}^m + e_t^l,\end{aligned} \tag{14}$$

This allows the model to be estimated as:

$$\Delta r_t^m = \alpha_{1t}^m r_{t-1}^l + \alpha_{2t}^m r_{t-1}^d - \theta_{1t}^m - \theta_{2t}^m r_{t-1}^m + e_t^m, \tag{15}$$

$$\Delta r_t^l = \alpha_{1t}^l r_{t-1}^l + \alpha_{2t}^l r_{t-1}^d - \theta_{1t}^l - \theta_{2t}^l r_{t-1}^m + e_t^l, \tag{16}$$

$$\Delta r_t^d = \alpha_{1t}^d r_{t-1}^l + \alpha_{2t}^d r_{t-1}^d - \theta_{1t}^d - \theta_{2t}^d r_{t-1}^m + e_t^d. \tag{17}$$

The errors $e_t = \begin{bmatrix} e_t^m & e_t^l & e_t^d \end{bmatrix}' \,\tilde{}\, MVN\left(0, \Sigma_t\right)$, where $\Sigma_t = diag\left(\begin{bmatrix} h_{mt} & h_{lt} & h_{dt} \end{bmatrix}'\right)$. The volatility of each error term is modelled as the first-order ARCH process $h_{jt} = \omega_j + \psi_j e_{jt-1}^2$, for $j = m, l, d$. The time-varying parameters are also specified as first-order stochastic processes of the form:

$$\alpha_{kt}^j = \alpha_{k,t-1}^j + \varepsilon_{kt}^j \tag{18}$$

$$\theta_{kt}^j = \theta_{kt-1}^j + \nu_{kt}^j \tag{19}$$

where $\varepsilon_{kt}^j \,\tilde{}\, iidN\left(0, \sigma_{\varepsilon k}^j\right)$, $v_{kt}^j \,\tilde{}\, iidN\left(0, \sigma_{vk}^j\right)$ for $j = m, l, d$ and $k = 1, 2$.

The estimation process involves the maximization of:

$$\begin{aligned} Max \ln L(\Psi) &\propto -\frac{1}{2}\sum_t \left(\ln\left|P_{t|t-1}\right| + e'_{t|t-1}P^{-1}_{t|t-1}e_{t|t-1}\right) \\ \Psi &= \{\alpha_1^j, \alpha_2^j, \theta_1^j, \theta_2^j, \omega_j, \psi_j, \sigma_1^j, \sigma_2^j, h_1^j, h_2^j\} \end{aligned} \tag{20}$$

where the one-step ahead error $e_{t|t-1}$ and its corresponding variance $P_{t|t-1}$ are obtained using the Kalman filter. Since the time-varying parameters are unobserved, the e_t^2 is undetermined. In this respect, the approach of King, Sentana, and Wadhwani (1994) is followed and the e_t^2 is replaced with its conditional expectation.

Given estimates of $\{\alpha_{1t}^m,\ \alpha_{2t}^m,\ \alpha_{1t}^l,\ \alpha_{2t}^l,\ \alpha_{1t}^d,\ \alpha_{2t}^d\}$ and $\{\theta_{1t}^m,\ \theta_{2t}^m,\ \theta_{1t}^l,\ \theta_{2t}^l,\ \theta_{1t}^d,\ \theta_{2t}^d\}$, estimates of $\{\beta_{0t}^l,\ \beta_{0t}^d,\ \beta_{1t}^l,\ \beta_{0t}^d,\ \delta_{0t},\ \delta_{1t}\}$ for each time period may be obtained using the following projections:

$$\begin{bmatrix} \alpha_{1t}^m & \alpha_{2t}^m & 0 & 0 & -1 & 0 \\ 0 & 0 & \alpha_{1t}^m & \alpha_{2t}^m & 0 & -1 \\ \alpha_{1t}^l & \alpha_{2t}^l & 0 & 0 & -1 & 0 \\ 0 & 0 & \alpha_{1t}^l & \alpha_{2t}^l & 0 & -1 \\ \alpha_{1t}^d & \alpha_{2t}^d & 0 & 0 & -1 & 0 \\ 0 & 0 & \alpha_{1t}^d & \alpha_{2t}^d & 0 & -1 \end{bmatrix} \begin{bmatrix} \beta_{0t}^l \\ \beta_{0t}^d \\ \beta_{1t}^l \\ \beta_{1t}^d \\ \delta_{0t} \\ \delta_{1t} \end{bmatrix} = \begin{bmatrix} \theta_{1t}^m \\ \theta_{2t}^m \\ \theta_{1t}^l \\ \theta_{2t}^l \\ \theta_{1t}^d \\ \theta_{2t}^d \end{bmatrix}. \tag{21}$$

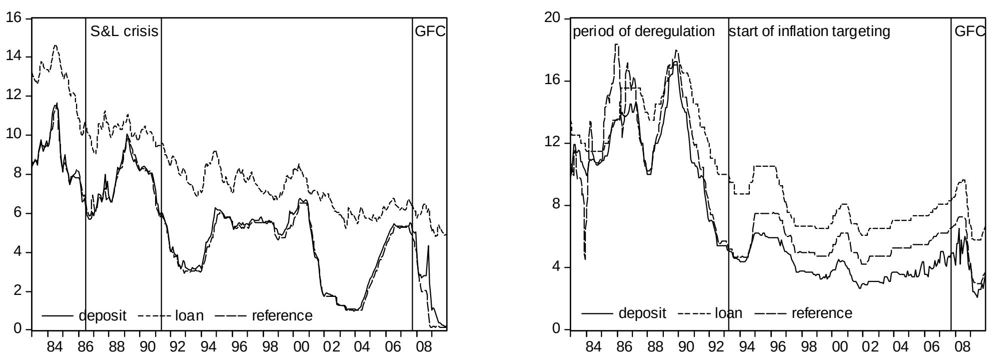
The equilibrium policy rates over time $r_t^{m*} = -\delta_{0t}/\delta_{1t}$ can then be computed and compared with actual official rates.

4 Empirical Results

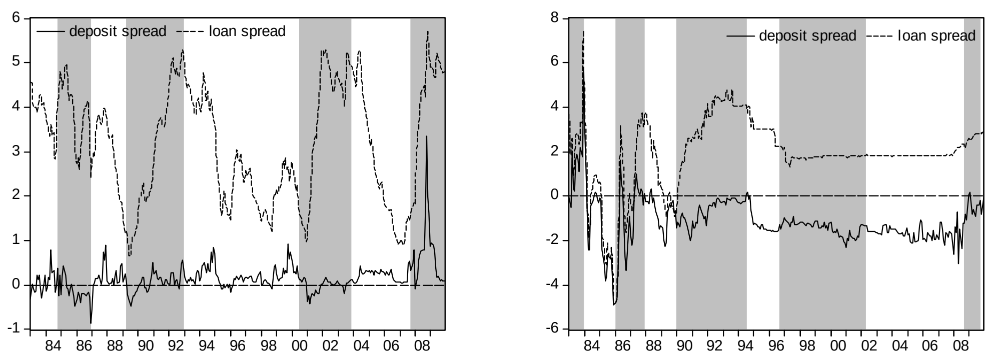
The empirical analysis consists of two case studies - the case of the United States (US) and the case of Australia (AUS). The US loan rate (r_t^l) is represented by the contract interest rate on 30-year, fixed-rate conventional home mortgage commitments while the deposit rate (r_t^d) is represented by the average rate on 3-month negotiable certificates of deposit (secondary market), quoted on an investment basis. The policy rate (r_t^m) is the Federal funds effective rate.[9] The Australian deposit rate is represented by the 3-month bank deposit rate and the loan rate is represented by the standard variable bank home loan rate (because unlike the US, more Australian mortgage holders take up the variable home loan rate option). The reference rate is the official cash rate.[10]

Figure 2: Deposit rate, loan rate and reference rate between 1982 and 2009

United States Australia



Deposit and Loan Spreads
(shaded areas are periods of monetary easing)



[9]Source: http://www.federalreserve.gov/releases/h15/data/Monthly. Related series were also used in the empirical analysis, but the qualitative results were not affected.

[10]Source: the interbank rate in the Reserve Bank of Australia Statistical Bulletins, various issues. Prior to 1995, this rate was the money market rate as the Reserve Bank operated its open market operations through authorised short-term money market dealers. Following a re-organisation of the payments and settlements system, the interbank rate became the official cash rate.

Figure 2 shows the behavior of the monthly rates from 1982:03-2009:12 for the US and AUS including the spreads between the rates $(r_t^l - r_t^m)$ and $(r_t^d - r_t^m)$ as they provide an indication of the values for β_{0t}^l and β_{0t}^d when $\beta_{1t}^l = \beta_{1t}^d = 1 \ \forall t$. The macroeconomic environment over the years for both economies can be broadly described as: the 1980s where economies recovered from an era of high inflation associated with the oil supply shocks in 1973 and 1979; the 1990s where inflation was brought down from double-digit numbers (especially in Australia by an explicit inflation targeting monetary policy) but where there were also periods of low growth (notably in the 1990-1992 years), and the 2000s where developing global savings and investment imbalances and excessive risk-taking resulted in a period of credit crisis (popularly coined as the 'global financial crisis').

In terms of the banking sector, the US experienced two severe crises in the Savings and Loan crisis and the GFC. The Savings and Loan crisis of the 1980s was spurred by inadequate deregulation, risky mortgage loan activity and speculative bank investments in real estate and commercial loans. These developments led to the failure of over 1000 banks, plummeting real estate prices in Texas (the hub of the crisis) and a taxpayer-funded bailout. A spate of mergers and consolidations also took place (predominantly the result of deregulation allowing banks to undertake non-traditional activities such as underwriting and selling insurance and securities). A remarkably similar crisis emerged in the late 2000s, dubbed the GFC, driven by speculative loans and veiled financial instruments, and marked by large scale taxpayer-funded bailouts.

Following on from both deregulation and the fallout associated with the two major financial crises, the US banking sector has changed from one populated by many small local institutions to one containing a smaller number of large nationwide banks. The opposite took place in Australia, as regulatory developments resulted in an increase in the number of institutions. The 1980s deregulation of the banking sector introducing competition from foreign banks and resulting in an immediate and sustained jump in the number of banks competing in the banking sector (from 25 in 1985 to over 40 a year later). Deregulation in the 1980s and 1990s also saw an increase in the types of financial products that deposit taking institutions such as credit unions and building societies were authorised to provide. Notwithstanding greater bank numbers, however, the Australian banking sector remains dominated by four large nationwide banks competing in a relatively risk-averse oligopolistic environment; the Reserve Bank of Australia estimated that only around 1 per cent of domestic mortgages (as at mid-2008) were non-conforming, relative to about 12 per cent for the United States (Reserve Bank of Australia, 2008).

With respect to the rates themselves, it is evident that for the US, until 2008, there was a close relationship between deposit and reference rates, with $r^d - r^m$ close to zero. In 2008, however, significant (positive) deviations between the deposit and interbank rates were observed amid the GFC. The figure also shows that mortgage rates always exceeded the deposit and interbank rates, with $(r^l - r^m)$ exhibiting some cyclical characteristics with peaks occuring during periods of monetary easing.

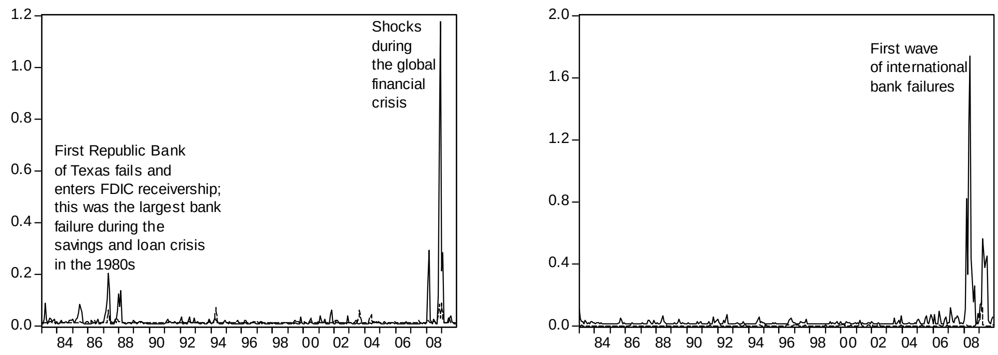
For Australia, the relationships between the rates up to the late 1980s were highly variable reflecting the uncertainty in the banking system when traditional deposit-taking institutions (the banks) were subject to increasing competition from non-bank financial institutions like building societies and credit unions. As the system became progressively deregulated in the face of financial innovation, the banking system (esp. since 1990) became more stable and rates began to move in tandem. Certainly, since the adoption of inflation targeting in 1993, loan margins have remained consistently positive while deposit margins have remained consistently negative (with the exception of the GFC). Similar to the US, loan spreads seem to be particularly high during the recession period around the 1990s and during the recent period of slow growth and monetary easing associated with the credit crisis.

4.1 Shocks to the Banking Sector

The econometric model has been specified to allow for time-varying volatility in the shock process. Figure 3 shows the estimated variance of the shocks affecting the banking system over the sample period. It is clear that the effects of the global financial crisis from mid-2007 were historically unprecedented.

Figure 3: Volatility of shocks to the banking system

United States Australia



Much has been written about the chronology of events leading up to and during the crisis, including the policy responses.[11] The collapse of the subprime market in the US has been identified as the main trigger and in September 2008, as house prices in the US fell and defaults and foreclosures escalated, the effect of the credit squeeze was felt around the world. Volatility in the deposit side of the financial system was overwhelmingly greater than in the loan markets, reflecting to a large extent the bank panics sweeping the system.[12]

The empirical analysis identified two waves - the first was around early 2008 and is directly associated with the financial credit crisis which had a significant impact on a small open economy like Australia. The second wave is in late 2008 and reflects the aftermath of the financial crisis when it turned into an economic crisis with real effects on economic activity and employment. Although Australia was also affected by this shock, the volatility was smaller reflecting in part domestic measures to prevent a recession.

[11] For a detailed timeline of events in the US and international responses to the crisis, see http://newyorkfed.org/research/global_economy/policyresponses.html.

[12] For a study of why some bank stocks performed better during the credit crisis see Beltratti and Stulz (2009).

4.2 Underlying relationships: β^l_{1t}, β^d_{1t}, β^l_{0t}, β^d_{0t}

Figure 4 shows the evolution of the coefficients in the deposit and loan cointegrating equations; the top panel shows the 'slope'-coefficients (β_{1t} and β_{2t}), namely the evolution of the pass-throughs, while the bottom panel shows the 'intercept'-terms (β^l_{0t} and β^d_{0t}), namely the evolution of the costs of intermediation.

For the US, the deposit rates are more aligned to changes in the policy rate (coefficients close to one) although the relationship has exacerbated since July 2007. The results suggest that the lending behaviour of US banks is weakly aligned with changes to the official reference rate (federal funds rate). In contrast, in the Australian system, policy changes are only partially passed through to both rates. A particularly interesting point to note is that while the pass throughs rose, in late 2008, with the onset of monetary easing as a result of the credit crisis, it was no more than in the slow growth years in the early 1990s and moreover, the pass-throughs fell in late 2009 when the stance of monetary policy changed from easing to tightening and official rates were increased.

Overall, there is evidence suggesting that falls in official rates were passed through by more than rises in official rates (esp. for Australia). This is most obvious in the early 1990s during the period of monetary easing associated with declining economic growth, and around 2008 during the global financial crisis.

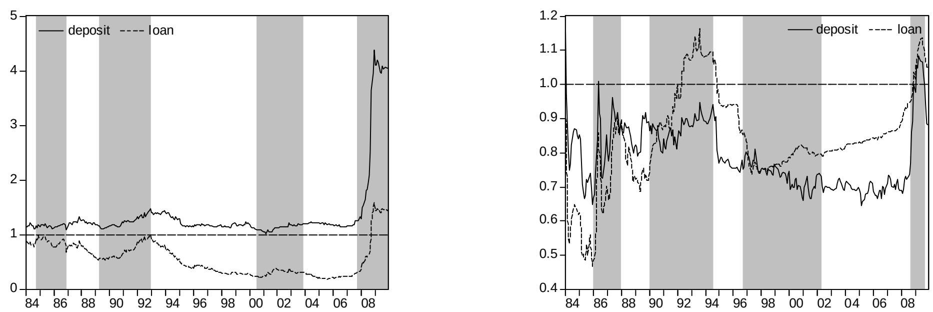
As expected for the US banking system, the intermediation margins for loans were positive while those for deposits were negative. In the US case, the deposit intermediation margins rose sharply in late 2007, indicating a sharp rise in the cost of raising funds. It fell subsequently as the Federal Reserve stepped in, but US banks kept deposit margins close to zero.

In the Australian case, the loan intermediation margins fell as the number of banks in the system increased. Likewise the deposit intermediation margin approached zero except that the trajectory was from above rather than below zero reflecting the fact that the banking system evolved from a regulated system with interest rate controls. With the onset of the credit crisis, the

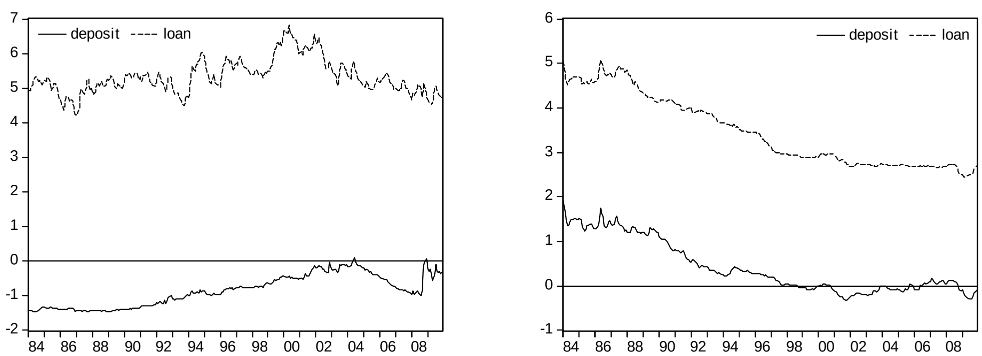
Figure 4: Pass-Throughs

United States Australia

Pass-throughs, (β_{1t} and β_{2t})



Intermediation Margins, (β_{0t}^{l} and β_{0t}^{d})



fall in the loan margin was due to serious difficulties in lending, but the management of the credit shock was helped by the fall in official rates (and associated regulatory and fiscal supports) as the drop in margins on the loan side was accompanied by large falls in deposit rates. Note again, how the intermediation margins have since reverted back to pre-crisis levels.

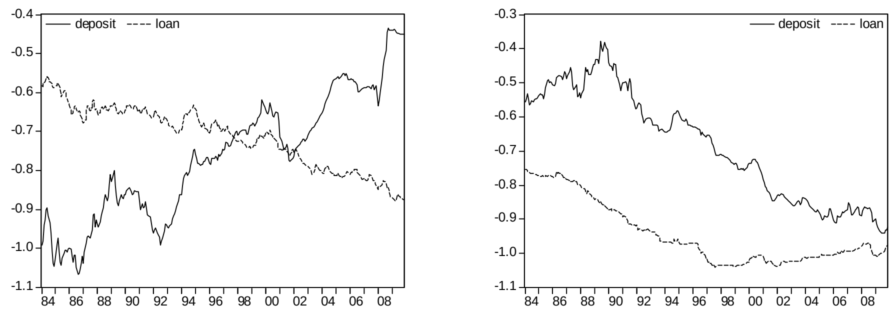
4.3 Adjustments to Disequilibria: $\alpha_{1t}^{l}, \alpha_{2t}^{l}, \alpha_{1t}^{d}, \alpha_{2t}^{d}$

The adjustments of loan and deposit rates to fundamental disequilibria (via $\alpha_{1t}^{l}, \alpha_{2t}^{l}, \alpha_{1t}^{d}, \alpha_{2t}^{d}$) are shown in Figure 5. The top panels show their own adjustments - loan to loan disequilibrium and deposit to deposit disequilibrium - while the bottom panels show the cross adjustments - loan to deposit disequilibrium and deposit to loan disequilibrium. As expected, the signs of $\{\alpha_{1t}^{l}, \alpha_{2t}^{d}\}$, representing the sensitivity of changes in the lending and deposit rates to disequilibria in the long-run lending and deposit equations, are negative. This implies that if lending or deposit rates are above their equilibrium levels at some time t, a post time-t correction will take place pushing the relevant rate down (and vice-versa). The cross effects, however, are positive.

Figure 5: Adjustments to Own Disequilibrium

United States Australia

Adjustments to Own Disequilibrium, $(\alpha_{1t}^{l}, \alpha_{2t}^{d})$



Adjustments to Cross Disequilibrium, $(\alpha_{2t}^{l}, \alpha_{1t}^{d})$

For the US, the rate of adjustment to own disequilibria declined for the lending rate (from about –0.60 to -0.89) and incresed for the deposit rate (from about -1.0 to -0.5). In terms of interactions, the results show that reactions of deposit rates to the mortgage side of the balance sheet have hardly changed over the sample period but the reaction of the mortgage rate to changes in the deposit rate has become less important over time (although there has been a pick up in sensitivity since the late 1990s, the effects are small). In other words, lending behavior is increasingly divorced from borrowing behavior, and borrowing is becoming less sensitive to its own disequilibria.

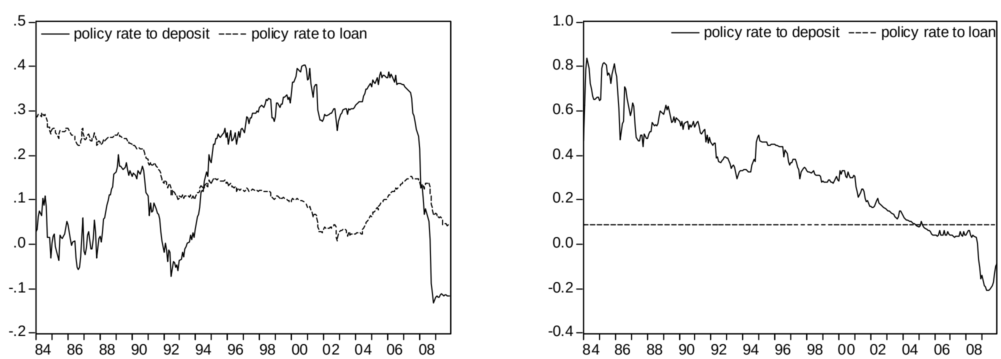
For Australia, Figure 5 shows that both the lending and deposit rates are exhibiting faster adjustments to their own disequilibria (with error correction coefficients around -1). But while deposit rates have increased its response to the loan side of the balance sheet, loan rates have become less sensitive to the borrowing side. This suggests that, like the US case, lending behavior is increasingly divorced from borrowing behavior but, unlike the US, borrowing is more sensitive to its own disequilibria as well as more sensitive to lending rate disequilibria.

4.4 Role of the Reference Rate $r_t^{m*} = -\delta_{0t}/\delta_{1t}$

Figure 6 shows the evolution of α_{1t}^m , α_{2t}^m. As noted earlier, values of α_{1t}^m and α_{2t}^m close to zero imply that official rates may be treated as weakly exogenously determined variables.

Figure 6: Reactions of the Official Rate

United States | Australia



For Australia, it would appear that since the adoption of inflation targeting in 1993, and up to mid 2007, monetary policy had become progressively more independent of circumstances in the banking sector. In contrast, the federal funds rate shows more sensitivity to disequilibria in the banking sector (with greater sensitivity to deposit disequibrium than loan disequilibrium) suggesting a more reactive stance of policy. Since the onset of the crisis, the relationship of both reference rates to deposit disequilibrium has plummeted suggesting that both official rates have been acting to bring about a fall in the cost of funds. Note again, for the Australian case, the recent turn-around in the reaction of the policy rate as the central bank reversed its policy from easing to tightening.

Figure 7: Official Rate(actual) , implied equilibrium and deviations between actual and implied equilibrium
United States Australia
(shaded areas are periods of monetary easing)

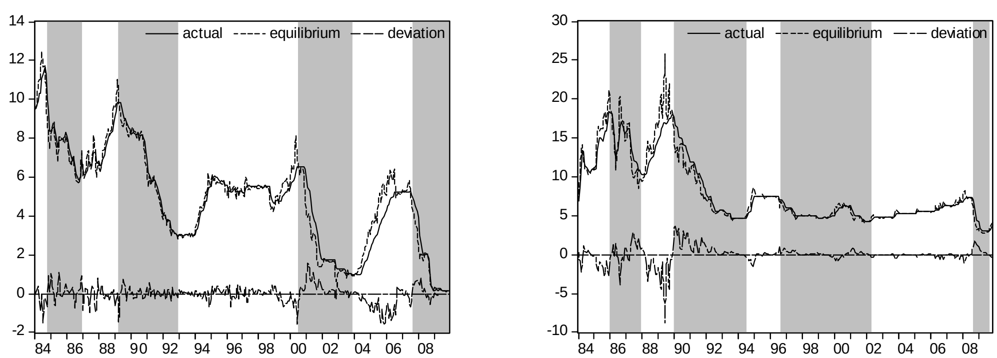


Figure 7 shows the implied equilibrium reference rate, $-\delta_{0t}/\delta_{1t}$, the actual official rates and the deviations of actual from implied equilibrium over the years. The significant result for the US is that deviations were persistently low over quite a few years (roughly 2003 to 2006) meaning that the actual federal funds rate was seriously misaligned. - too low for too long. Over the 2000-2001 years, the federal funds target rate was lowered from around 6 per cent to about 1 per cent to soften the negative wealth implications associated with the dot com collapse and with the September 2001 terrorist attack. The results here support the view that the US official rate was kept too low for too long in the early 2000s and that this may have helped create an environment of easy credit prior to the global financial crisis.

In contrast, for Australia there was no persistent misalignment in the 2000s although it was clear that the official rate was too high at the beginning of the recent financial crisis; a situation that was quickly remedied by the central bank which cut the official rate from 7.25 per cent in March 2008 to 4.25 per cent by December 2008.

5 Concluding Remarks

The aim of the paper was to examine the interactions of bank and official rates over time. To this end, a structural framework which contained an equilibrium model of banking was adopted to allow for interactions between the asset and liability side of the balance sheet and also between bank and official rates. The model was estimated with time-varying parameters to capture the evolution of interest rate behavior. The methodology also permitted the identification of an implied equilibrium reference rate commensurate with equilibrium conditions in the banking sector. The case studies are the United States and Australian banking systems and the sample period included changes in industry structure, market and credit conditions and varying episodes of monetary policy. The empirical analysis yielded three results.

The first result pertained to the nature of riskiness experienced by the banking systems since the early 1980s. The results showed that the banking systems were subjected to two waves of high volatility shocks in the noughties and they were historically unprecedented, especially for a small open economy like Australia. The first wave was more of a financial crisis following the collapse of the sub-prime market in the US, while the second wave was more likely economic in nature following the negative real effects on activity as financial activities were seriously curtailed.

The second set of results shed light on the changing nature of the fundamental relationships between bank rates and official rates over three decades. Pass-throughs tended to be higher on the deposit side for the US, but higher on the loan-side for Australian banks. Prior to the global financial crisis, the results also showed that intermediation margins fell when the number of banks increased in Australia, but the situation is less straightforward for the US case. The results also highlighted the evolving tendency of both US and Australian banks to change loan rates with less consideration paid to changes in deposit rates in recent years but, unlike the US case, Australian borrowing rates are more sensitive to their own disequilibria as well as more sensitive to lending rate disequilibria.

This leads to the third set of results concerning the role of official rates; specifically, their reaction to banking sector behavior and their degree of misalignment relative to their respective equilibrium rates. For the US, the results showed that the federal funds rate was reactive to changes in the US banking system and that it was quite sensitive to deposit conditions before the crisis. Furthermore, the analysis identified the period between 2003-06 when the federal funds rate was too low for too long relative to the implied equilibrium rate. For Australia, the results showed that prior to the global financial crisis the Reserve Bank of Australia was changing its cash rate quite independently of banking behavior (and presumably more in line with macroeconomic objectives) and that, moreover, official rates moved in line with the equilibrium policy rate, with the exception of the period prior to the crisis when they exceeded the equilibrium rate.

In conclusion, this paper has proposed an economic framework and an econometric methodology to study the changing relationship between bank and official rates for two banking systems - the US system which has seen a decline in the number of banks, and the Australian system which has seen a marked increase in bank numbers. Overall the results were informative about the evolution of lending and borrowing behavior over three decades and importantly, provided useful information about the relationship between actual and equilibrium official rates.

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