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Abstract

The Colombian economy and financial system have coped reasonably well with the effects of the global financial crisis. Hence, "unconventional" policy measures have not been at the center of the policy decisions and discussions. Nominal short term interest rates have remained the main monetary policy tool and "Quantitative easing" measures have not been central in the policy response. The one "unconventional" monetary instrument used by the Central Bank in Colombia has been changes in reserve requirements (RR) on financial system deposits. Interestingly, they were adopted *before* the global financial crisis, as a reaction to domestic credit conditions. The effects of RR on interest rate and interest rate pass-through in an inflation targeting regime are not as straightforward as those under a monetary targeting regime. Conceptually, those effects depend on the degree of substitution between deposits and central bank credit as sources of funds for banks and on the extent to which RR changes affect the risks facing banks. The empirical results for Colombia suggest that RR are important long run determinants of business loan interest rates and have been effective in strengthening the pass-through from policy to deposit and lending interest rates.

Key Words: *Reserve Requirements, Inflation Targeting, Interest rate pass-through*

JEL Classification: *E51, E52, E58, G21.*

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1. Introduction

The Colombian economy and financial system have coped reasonably well with the effects of the global financial crisis. Hence, "unconventional" policy measures have not been at the center of the policy decisions and discussions.

Even though bank loans decelerated markedly in 2009, they are still growing in real terms and credit markets have not experienced the severe crunch that is hindering economic growth in other parts of the world. Deposit, loan, bond and interbank markets have not undergone any important disruption. This has been a consequence of the restrictions and prudential regulation that existed before 2006 or were introduced thereafter (Uribe, 2008a, 2008b and 2009). As a result, there has been little room for "unconventional" financial/monetary policy measures aimed at preserving liquidity in key markets, or at reactivating the credit channel for firms and households. For example, the collateral requirements and maturity of Central Bank credit facilities have remained basically unchanged since the onset of the crisis.

At the same time, annual CPI inflation has decreased significantly from 7.67% in December 2008 to 2% a year later. Unlike other countries, however, this reversion has not turned into deflation and the economic slowdown has been relatively moderate. Thus, nominal short term interest rates have not hit the zero bound and have remained the main monetary policy tool. "Quantitative easing" measures have not been central in the policy response.

Changes in reserve requirements (RR hereafter) on financial system deposits have been the one "unconventional" monetary instrument used by the Central Bank in Colombia. Interestingly, they were adopted *before* the global financial crisis, as a reaction to domestic credit conditions. Between the second semester of 2006 and the first half of 2007 the Colombian financial system produced a rapid expansion of loan supply, partially offsetting the monetary policy tightening pursued by the Central Bank to curb excessive expenditure growth and inflation. Marginal reserve requirements were then introduced in May 2007 to try to reinforce the transmission of policy interest rate increases and to limit credit growth. Towards the third quarter 2008 the economy started to show sings of a slowdown and, as uncertainty about the effects of the crisis increased the liquidity risk perception of financial intermediaries, some local lending interest rates rose in the fourth quarter of 2008. The Central Bank responded by reducing RR to enlarge the liquidity in the hands of banks.

What is the role of RR as a monetary policy tool in an inflation targeting regime, where the central bank stabilizes the short term interest rate? What were the effects of the changes in RR on the transmission of policy rate movements? Were the changes in RR effective in achieving the objectives that motivated them? This paper is an attempt to answer these questions. The next section provides the rationale for the use of RR as a monetary policy instrument in an inflation targeting regime, both theoretically and in the context of the Colombian economy over the past three years. Then the effects of RR changes are empirically examined. The final section concludes.

2. The Rationale for RR as Monetary Policy Tools in an Inflation Targeting Regime

a. Events in Colombian Credit Markets

Following a prolonged decline in sovereign risk premia and inflation, local Government bond long interest rates fell significantly between 2003 and 2005 (Graph 1). Colombian financial intermediaries had steadily increased their share of local public bonds in total assets since 2003 (Graph 2) and benefited substantially from the rising trend in public bond prices. By the first quarter of 2006, bond holdings represented about a third of banks´ assets, implying a large exposure to unhedged market risk (Vargas et al., 2006). These institutions sustained large losses in the second quarter of 2006, when a spike in global risk aversion caused a drop in the price of domestic public bonds.

In response, financial intermediaries reduced their exposure to market risk and abruptly shifted their asset portfolio away from Government bonds and into loans to firms and households (Graph 2). In doing so, they delayed or offset the tightening of monetary policy that the Central Bank had started in April 2006 to slow aggregate expenditure and prevent emerging inflationary pressures (Graph 3). While policy interest rates increased throughout 2006 and the first quarter of 2007, consumer, commercial and mortgage lending rates dropped or remained stable (Graphs 4 and 5). Only short term commercial bank treasury rates and prime lending rates increased along with the policy interest rate (Graph 6).

At the same time, average financial system credit real growth rates jumped from 15.2% in the first semester 2006 to 25.3% in the second semester of 2006 and 26.3% in the first half of 2007 (Graph 7). The behavior of prices and quantities in the loan markets suggested the effect of a supply shock generated by the shift in the bank asset portfolio. The near one-year delay in the transmission of policy rate hikes (Graphs 4 and 5) and the abrupt jump of loan growth raised concerns in the Central Bank about both price and financial stability. There was also apprehension about the quality of the new loans, especially in the consumer credit segment (Graph 8)[1].

Hence, it was deemed crucial to intervene in the credit markets to prevent excessive leverage of the private sector and control the credit risk of the financial system. Loan provisioning requirements were increased by the Financial Superintendency[2], while the Central Bank introduced marginal reserve requirements on domestic deposits in May 2007 (Table 1). Reserve requirements on foreign indebtedness were reactivated as a complementary measure.

[1] Consumer credit growth rates went from 29.4% on average in the second semester of 2005 to 37.5% in the first half of 2006, 42.2% in the second semester of 2006 and 39.5% in the first semester of 2007.

[2] A system to manage commercial loan credit risk (SARC) was introduced by the Financial Superintendency in July 2007. This system determines the loan provisioning requirements for commercial loans depending on each loan´s risk qualification. Since higher provisions were foreseen before implementation, the Superintendency required a gradual upward adjustment in provisions prior to the formal introduction of SARC. Something similar occurred with the adoption of an analogous system for consumer credit. The system was formally introduced in July 2008, but provisioning requirements were raised since June 2007.

In June 2007 RR and their remuneration were again modified to lump savings accounts and sight deposits in one group[3]. The rationale was that the distinction between these types of deposits in terms of liquidity had been blurred, so their RR should be leveled as well. A year later the Central Bank changed again the RR to sterilize part of the monetary expansion caused by a program of international reserve purchases. This time the marginal reserve requirements were eliminated, but the average levels were increased (Table 1).

In the last quarter of 2008, following the Lehman Bros. Bankruptcy, commercial bank treasury interest rates and prime lending rates rose (Graph 9). Interestingly, in the same period longer maturity loan rates (consumer and commercial) did not increase (Graph 10), suggesting that financial intermediaries were concerned mostly about liquidity and not credit risk at the time. A bank liquidity gap indicator shows a slight deterioration in the same period (Graph 11)[4]. The Central Bank then acted preemptively, allowing the currency to depreciate with minimal intervention in the FX market and reducing RR to ensure the availability of local currency liquidity (Table 1). Finally, remuneration of RR was reduced in January 2009 and eliminated altogether in July 2009.

In sum, RR have been used in Colombia since May 2007 to enhance the transmission of policy interest rates and curb credit growth, to sterilize FX purchases by the Central Bank and to guarantee the provision of liquidity in periods of potential turmoil. Among these objectives, the first one deserves especial attention, for RR had been used in the past in Colombia as a monetary policy tool under financially-repressed, monetary targeting regimes. Their use in an inflation targeting (IT) regime where the Central Bank stabilizes the interest rate in the short term had no precedent in the country.

b. Reserve Requirements in an Inflation Targeting Regime

In a monetary targeting regime, an increase in RR causes a rise in base money demand and, given the money supply, pushes up short term interest rates. In a regime that stabilizes short term interest rates, such as the conventional IT strategy, the central bank will provide the additional money demand implied by larger RR, so that short term interest rates do not change. Thus, the effects of RR in such a regime are not as straightforward as those under a monetary targeting regime.

In an IT regime RR may affect directly market interest rates and the pass-through from the policy interest rate to those interest rates. In both cases, the results would depend on the degree of substitution between central bank credit and deposits, as is explained in what follows.

(i) Direct Effects of RR on Market Interest Rates

One effect stems from the fact that RR constitute a tax on financial intermediation. Therefore, higher RR are reflected in larger interest rate spreads. However, as long as central bank credit is a close substitute of deposits as a source of funds for the banks, higher RR will produce a fall in deposit interest rates, leaving lending rates unchanged.

[3] The existing regime remunerated RR on savings accounts and CDs.

[4] Liquidity Gap Indicator = (Liquid Liabilities-Liquid Assets) / Illiquid assets. Liquid assets include domestic Government bonds whose prices fell during the Lehman crisis. This may help explain the observed increase in the indicator.

Intuitively, a step up in RR makes deposits more expensive, reduces bank demand for deposits and increases bank demand for central bank credit. If the interest rate on the latter (the policy rate) is constant, the marginal cost of funds for the banks does not change and neither does the lending interest rate. In contrast, the fall in bank demand for deposits reduces their interest rate.

A key assumption in the foregoing analysis is the high degree of substitution between deposits and central bank credit as sources of funds for the banks. If that is not the case, a rise in RR will not be fully accommodated with a larger use of central bank credit. Thus, both bank supply of loans and demand for deposits will be affected, and so will be lending and deposit rates.

Betancourt and Vargas (2009) show that in the presence of interest rate risk and risk averse banks, central bank credit and deposits are not perfect substitutes. In this case, an increase in RR in an interest rate-smoothing monetary regime raises lending rates and has an ambiguous effect on deposit rates. Intuitively, higher RR make deposits more expensive and tend to reduce bank demand for deposits and increase bank demand for central bank credit. Nevertheless, a larger reliance on term central bank credit adds to interest rate risk when the latter has shorter maturities than loans. The increased risk reduces the perceived benefits of loans for risk averse banks, restricts loan supply and drives lending interest rates up.

The net effect on bank demand for deposits is uncertain. On the one hand, higher RR make them more expensive for banks and reduce demand. On the other, if deposits have longer maturities than central bank credit, a larger reliance on the latter generates higher interest rate risk, makes deposits more convenient and increases deposit demand by banks[5]. As a result, the effect on deposit interest rates is also ambiguous.

The impact of RR on the volume of loans and deposits follows the effects they have on the respective interest rates. If credit demand is inversely related to the lending rate, higher RR imply higher loan interest rates and a smaller volume of credit. Given a deposit supply schedule, higher RR have an ambiguous effect on the volume of deposits.

(ii) Effects of RR on Interest Rate Pass-Through

RR may not only affect market interest rates directly, but also influence the pass-through from policy rates to market rates. I.e. the transmission of monetary policy is determined to some extent by the RR. A policy interest rate hike makes central bank credit more expensive and induces banks to rely more on deposits, pushing up deposit interest rates. The marginal cost of funds for banks increases, bank loan supply is cut and lending interest rates go up. In this context, higher RR do not affect transmission to loan rates, but they do influence deposit rates. Increased RR imply costlier additional deposits and, therefore, a smaller expansion of deposit demand by banks. Thus, the transmission of the policy interest rate hike to deposit rates decreases with the level of RR.

[5] In a world with several types of deposits, it also leads to more reliance on long term deposits.

The effect of RR on monetary policy transmission is further complicated when RR affect the risks facing banks. For example, in the case studied by Betancourt and Vargas (2009), RR induce demand for central bank credit by banks to fund their assets, exposing them to interest rate risk. In this situation, a policy rate hike amplifies interest rate risk by raising the need for short term central bank credit in the future, as the initial borrowing plus the accrued interest must be rolled over. The rise in interest rate risk is larger when central bank credit is larger too, which is likely when RR are higher.

Moreover, higher RR reduce the amount in which additional deposits alleviate interest rate risk. In this case, one additional dollar in deposits yields less funds to be used to substitute for central bank credit. These effects entail a larger cut in loan supply by banks in the face of a policy interest rate increase. Therefore, RR strengthens the pass-through from policy rates to lending interest rates.

The impact of RR on the pass-through to deposit interest rates is ambiguous in this case. On the one hand, additional deposits are less profitable in the presence of higher RR, so deposit demand by banks expands less after a policy interest rate rise, as mentioned above. On the other hand, higher RR exacerbate the interest rate risk related to central bank credit and induce banks to demand more deposits instead.

Finally, notice that these outcomes depend on the extent to which the central bank is a net creditor of the financial system. When the supply of monetary base is large relative to bank reserves, central bank credit to financial institutions may be low or negative, even if RR are high (in percentage). In the case of Colombia in recent years, for example, international reserve accumulation has provided financial intermediaries with large amounts of new deposits, reducing the net creditor position of the central bank. According to the foregoing hypotheses, this would weaken interest rate pass-through, since the interest rate risk facing banks is lower. Appendix 1 formally shows these results in the context of the model by Betancourt and Vargas (2009).

3. Effects of Reserve Requirements in Colombia

a. Reserve Requirement Measures

To gauge the effects of RR in Colombia, aggregate measures of them must be generated (in addition to the deposit-specific ratios). These measures must be related to the purpose for which RR were set. The same concept of aggregate RR may not necessarily be useful to pin down the effects on both the liquidity of the financial system and the impact on credit expansion or market interest rates. In Colombia this is further complicated because of the many changes in the structure of RR between 2006 and 2009, including the establishment of marginal RR and shifts in RR remuneration (Table 1).

A simple measure of RR is the ratio of Observed Required Reserves to Deposits Subject to RR (*ORR* henceforth). This indicator includes both average and marginal RR (when effective) and is affected by the changes in deposit composition occurred throughout the period. While ORR is useful to capture the liquidity changes introduced by RR policy, it may not be the best measure of the effect of RR changes on the marginal cost of bank funds and market interest rates. It may put too much weight on average rather than marginal RR and it does not consider movements in RR remuneration

The last drawback is especially relevant in 2007 and 2009, when RR remuneration was changed (Table 1). In addition, the existence of RR remuneration affects the actual burden of RR on the marginal cost of bank funds, so the ORR ratio alone may overestimate the impact of RR policy on market interest rates. To correct for this possible bias, two Remuneration-Adjusted RR (*RARR* hereafter) concepts were calculated as explained in Appendix 2. One allows for changes in deposit composition through time, while the other assumes a fixed composition equal to the May 2002-November 2009 average. This distinction may be important, for RR shifts induced important re- compositions of deposits in some periods (Saade and Pérez, 2009).

Graph 12 shows that the dynamics of the three measures are similar up until 2009, when RR remuneration was reduced and ultimately eliminated (Table 1). In this year the RARR gauges increased, indicating that the burden of RR on market financial intermediation rose, despite the fact that RR ratios remained stable. Throughout the period 2002-2008 RR remuneration implied a reduction of roughly 1 percentage point in RR ratios in terms of their effect on the marginal cost of deposits (Graph 12).

b. Reserve Requirements, Interest Rates and Liquidity

Based on simple inspection of the data it is difficult to judge the effectiveness of RR policy in influencing market interest rates. Graph 13 indicates that short term CD interest rates (90-360 days) tracked policy interest rates more closely after 2006. Savings accounts interest rates are in general more sluggish than policy rates. Longer term CD interest rates (greater than 360 days) are more volatile than other deposit interest rates, a feature that may be attributed to the relatively small issuance of this type of deposits.

The spread between short term CD interest rates and the policy rate started to increase around the time marginal RR were adopted and has been growing slowly ever since (Graphs 14-15). The spreads for the other deposit interest rates do not exhibit a clear relationship with RR. In the particular case of savings accounts interest rates, their spread with respect to the policy rate fell after marginal RR were introduced, but rose in 2009 when RARR measures increased (Graph 16).

Regarding loan interest rates, the impact of RR is not apparent either. The spreads between lending and policy interest rates tended to increase or stopped falling by the end of 2006 and the beginning of 2007, before marginal RR were imposed (Graph 17). The consumer loan interest rate spread shifted abruptly in February 2007 due to a redefinition of the usury limits, which seem to be binding for a significant fraction of these loans.

Interestingly, the spreads between commercial bank treasury and prime lending rates with respect to the policy rate started to fall in the beginning of 2009, after RR had been reduced to increase liquidity. The Central Bank was successful in this regard, since the cumulative effect of international reserves purchases and the reduction of RR did expand liquidity in money markets, as reflected by the growing deviation of the interbank overnight interest rate from the policy rate (Graph 18).

In general, capturing the effects of RR on market interest rates and interest rate pass-through requires controlling for other variables affecting deposit and credit markets, like economic growth, expectations of future policy rates, credit and sovereign risk shifts etc. An empirical exercise along these lines is presented in the next section.

c. Econometric Evidence

(i) Market Interest Rate Models and the Effects of Reserve Requirements

To assess the effect of RR on market interest rates and interest rate pass-through, a simple model is posited in the spirit of the expectations theory of interest rates:

$$i_{m_t} = \beta_o \; i_{b_t} + \beta_1 \; s_t + f(X_t) + \varepsilon_t \qquad (1)$$

i_{mt} is a deposit or loan interest rate, i_{bt} is the overnight policy interest rate, s_t is the slope of the zero-coupon curve for Government bonds corresponding to the average maturity of the deposit or loan, and $f(X_t)$ is a function of variables affecting the specific loan or deposit market, like industrial production, credit risk, RR etc. The slope of the zero coupon curve is intended to proxy the expectations on future central bank interest rates and is defined as:

$$s_t \equiv i_{rf_t} - i_{b_t}$$

i_{rft} is the risk-free interest rate for the maturity of the corresponding market interest rate (approximated by the Government zero coupon interest rate).

Equation (1) represents a long run relationship between market interest rates and their determinants. This is complemented with an error-correction equation describing the short run dynamics:

$$\Delta i_{m_t} = \alpha \; \varepsilon_{t-1} + \left(\Phi(L) + \gamma \; e_t\right)\Delta i_{b_{t-1}} + \Gamma(L)\Delta i_{m_{t-1}} + \Lambda(L)\Delta s_{t-1} + \Omega(L)\Delta X_{t-1} + u_t$$

ε_t represents the error correction term. The influence of RR on interest rate pass-through is captured by the term $\gamma \, e_t$, which shows the additional short-run effect of policy interest rates on market rates due to RR.

The estimations were made for different loan and deposit interest rates using Colombian monthly data for the period May 2002 – October 2009. The Johansen VEC Cointegration methodology was utilized. According to the information criteria (Schwarz and Akaike) only one lag turned out to be significant in the VEC models for all cases. After verifying normality[6], the existence of at least one cointegrating vector with the expected signs and weak endogeneity of market interest rates, we found the following results (Tables 2 and 3):

[6] In some cases it was necessary to include dummy variables for particular dates in order to get normality.

Long Run Relationships:

- A positive relationship between the policy interest rate and market rates, except for the mortgage rate. With the exception of the savings accounts and consumer loan rates, in all cases the long run coefficient of the policy rate is close to unity. For savings account rates the coefficient is significantly less than 1 and for consumer loan rates it is greater than 1.
- Mortgage loan rates are positively related to long term government bond rates, with a coefficient close to 1.
- The slope of the zero coupon curve enters positively in the long run relationship for consumer, prime and average lending rates. It also appears in the equations for CD interest rates.
- The RARRh ratio is directly related to commercial, prime and commercial bank treasury interest rates, in line with the hypotheses presented above.
- Marginal CD RARR ratios have a significant positive impact in the longer term and average CD interest rates. Interestingly, longer term CDs, which have a zero RR, are positively affected by *other* CD marginal RR. This is possibly caused by a shift in the composition of deposits induced by changes in the RR structure.
- (Seasonally adjusted) Industrial Production was found to be directly related to commercial, prime and commercial bank treasury interest rates.

Short Run Dynamics:

- The combined effect of the RARRh ratio and the change in the policy rates is significantly positive in the short run dynamics for all market interest rates, except mortgage rates[7]. I.e. the interest rate pass-through appears to be generally strengthened by the RR[8].

The previous result stems from the significance of the coefficient of ($RARRh^{*}\Delta i_b$) in the error correction equations for the market interest rates. This is suggestive, but ignores the overall dynamics of the VEC system involving the joint interaction of the cointegrated variables and their short run responses. This effect is gauged through the examination of the impulse-response functions (Charts 1 and 2). After a policy rate shock, the responses of market interest rates are larger when the RARRh ratio is higher. However, without confidence intervals, the statistical significance of the difference between the responses under distinct RR levels cannot be determined[9].

(ii) Other Features of Interest Rates Dynamics

The long run models posited above may be used to characterize other features of interest rate dynamics. Specifically, it is interesting to verify whether interest rate pass-through is asymmetric and whether the net creditor position of the Central Bank with the financial system affects the short run response of market interest rates to policy rate shocks.

[7] However, mortgage rates are positively affected by changes in policy interest rates in the short run dynamics.
[8] These results did not change when the RARRc measure was used.
[9] A rigorous analysis of the impulse response functions should include confidence intervals. However, this requires further work because the short run dynamics equations include a multiplicative interaction that is not considered in the standard econometric packages.

To check for asymmetric responses of market interest rates to policy rate changes, the short run dynamics model used above was modified as follows:

$$\Delta i_{m_t} = \alpha\ \varepsilon_{t-1} + \left(\Phi(L) + \eta\ dir_t\right)\Delta i_{b_{t-1}} + \Gamma(L)\Delta i_{m_{t-1}} + \Lambda(L)\Delta s_{t-1} + \Omega(L)\Delta X_{t-1} + u_t$$

dir_t is a dummy variable that takes the value of 1 when the lagged change in policy rates is positive and zero otherwise[10]. In general, downward movements in the policy rate appear to generate a stronger response of market rates than upward movements (Tables 4 and 5). In fact, for some market rates (consumer, commercial, average lending rates and long CD rates) the short run response is *negative* after an increase in the central bank rate[11].

Again, these results are derived from the sign and the significance of coefficient of ($dir^*\Delta i_b$), which are suggestive, but ignore the joint interaction of the VEC system. Charts 3 and 4 confirm that the asymmetric response result holds when the complete system dynamics are considered[12].

Turning to the effect of the net creditor position (NCP henceforth) of the central bank on interest rate transmission, the short run dynamics equations were transformed as follows:

$$\Delta i_{m_t} = \alpha\ \varepsilon_{t-1} + \left(\Phi(L) + \vartheta\ ncp_t\right)\Delta i_{b_{t-1}} + \Gamma(L)\Delta i_{m_{t-1}} + \Lambda(L)\Delta s_{t-1} + \Omega(L)\Delta X_{t-1} + u_t$$

or

$$\Delta i_{m_t} = \alpha\ \varepsilon_{t-1} + \left(\Phi(L) + \theta\ dir_t\ ncp_t\right)\Delta i_{b_{t-1}} + \Gamma(L)\Delta i_{m_{t-1}} + \Lambda(L)\Delta s_{t-1} + \Omega(L)\Delta X_{t-1} + u_t$$

ncp_t is a dummy variable, taking the value of 1 when the net creditor position of the Central Bank is lower than Col$ 1 trillion (approx. US$ 500 million) and zero otherwise. Unlike the effect of RARRh on interest rate pass-through and the asymmetric responses to policy rate changes, the influence of the NCP of the central bank is not general. It is restricted to a few lending interest rates (commercial bank treasury and prime lending rates) and most deposit rates (Tables 6 and 7). In these cases, a low or negative NCP weakens the interest rate pass-through in both directions. For an increase in policy rates, the abundant liquidity implied by the low NCP runs counter to the policy tightening. For a decrease in policy rates, it is possible that the market rates are already low in response to the small NCP. Hence, when the policy rate is reduced, a strong concurrent movement in the market rate is not observed. Impulse response function analysis corroborates these results when allowing for complete VEC system dynamics (Charts 5 and 6).

Finally, the interaction of ncp_t and dir_t has negative coefficients for commercial treasury lending rates, savings and short term CD rates (Tables 6 and 7), indicating that the

[10] A general model should include simultaneously the effects of RR, the asymmetry of the interest rate responses and the impact of the net creditor position of the central bank in the short run dynamics equation. However, these variables are all transformations of the lagged change in policy rates. Therefore, severe multicolinearity problems may arise, complicating statistical inference on the significance of the coefficients. That is why the estimation was done for each case separately.

[11] The only exception is that of long term CD rates (greater than 360 days) for which the response to policy rate increase is stronger.

[12] See footnote 9.

transmission of policy interest rate *increases* is diminished when the Central Bank´s net creditor position is low or negative.

4. Conclusions

RR have been used in Colombia under an IT regime with different objectives. In 2007 increases in RR were aimed at speeding up monetary policy transmission and at curbing excessive credit growth. In 2008 RR were again raised to sterilize part of the monetary expansion resulting from international reserve purchases. Later that year, they were reduced to ensure the provision of adequate liquidity in the context of heightened uncertainty brought about by the Lehman crisis.

The effects of RR on interest rate and interest rate pass-through in an IT regime are not as straightforward as those under a monetary targeting regime. Conceptually, those effects depend on the degree of substitution between deposits and central bank credit as sources of funds for banks and on the extent to which RR changes affect the risks facing banks. The empirical results for Colombia suggest that RR are important long run determinants of business loan interest rates and have been effective in strengthening the pass-through from policy to deposit and lending interest rates.

These findings support the use of RR as a policy instrument in an IT regime in terms of their effectiveness in reinforcing monetary policy transmission. These benefits must be contrasted with the fact that RR are costly taxes on financial intermediation and may be too blunt a tool to fine-tune the adjustment of credit markets or aggregate demand. Hence, their use is justified when policymakers perceive that standard, less costly policy instruments are deemed as insufficient to maintain price or financial stability.

The empirical models used to assess the impact of RR on interest rates were also exploited to characterize other features of the dynamics of interest rate pass-through. For Colombia, policy rate transmission seems to be asymmetric, with rate drops generating larger responses of market rates than policy rate increases. Moreover, a low net creditor position of the central bank with the financial system appears to weaken the transmission of policy rates to CD and short term lending interest rates.

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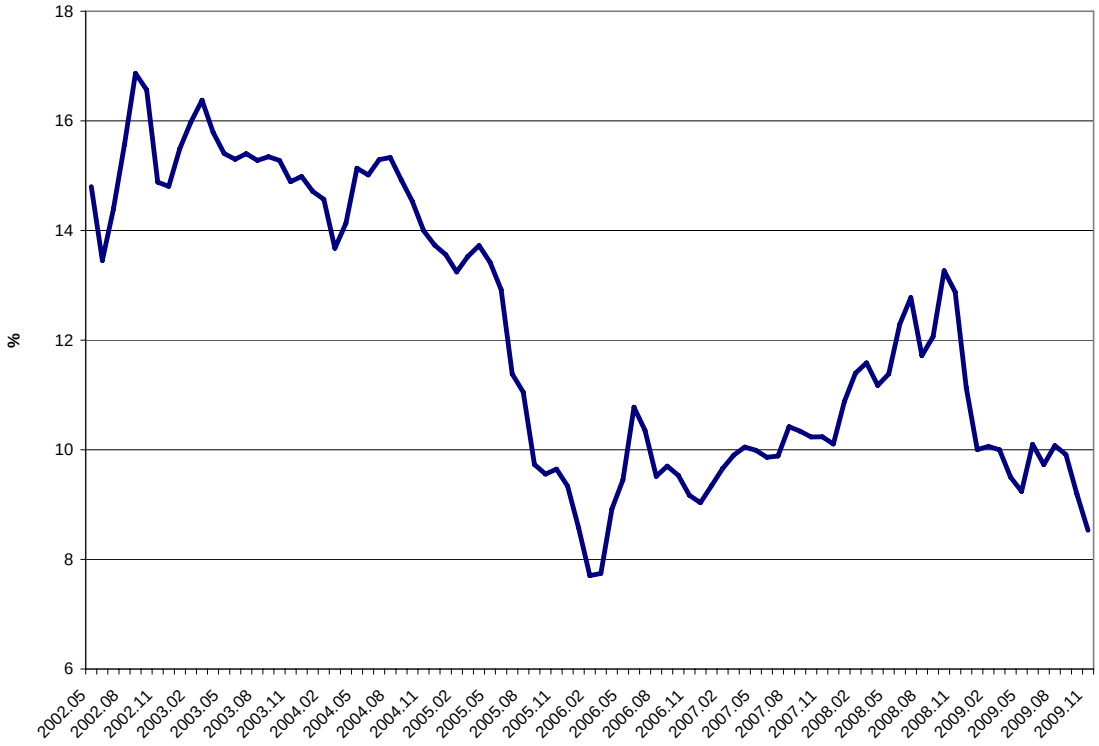
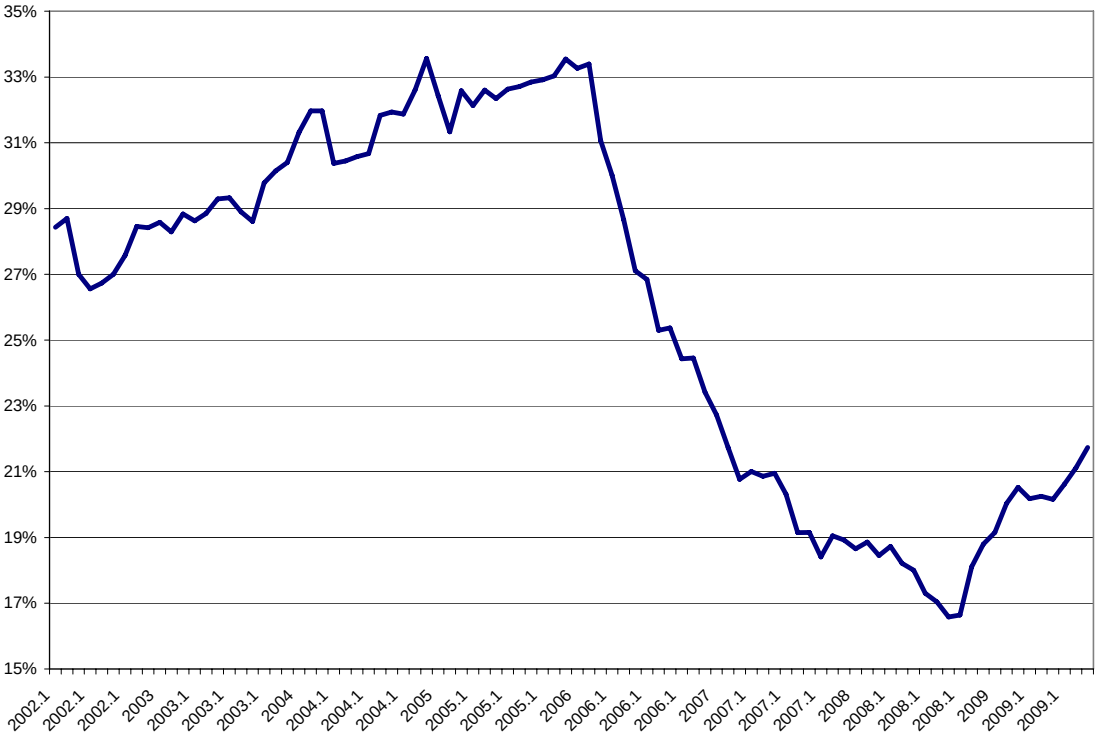
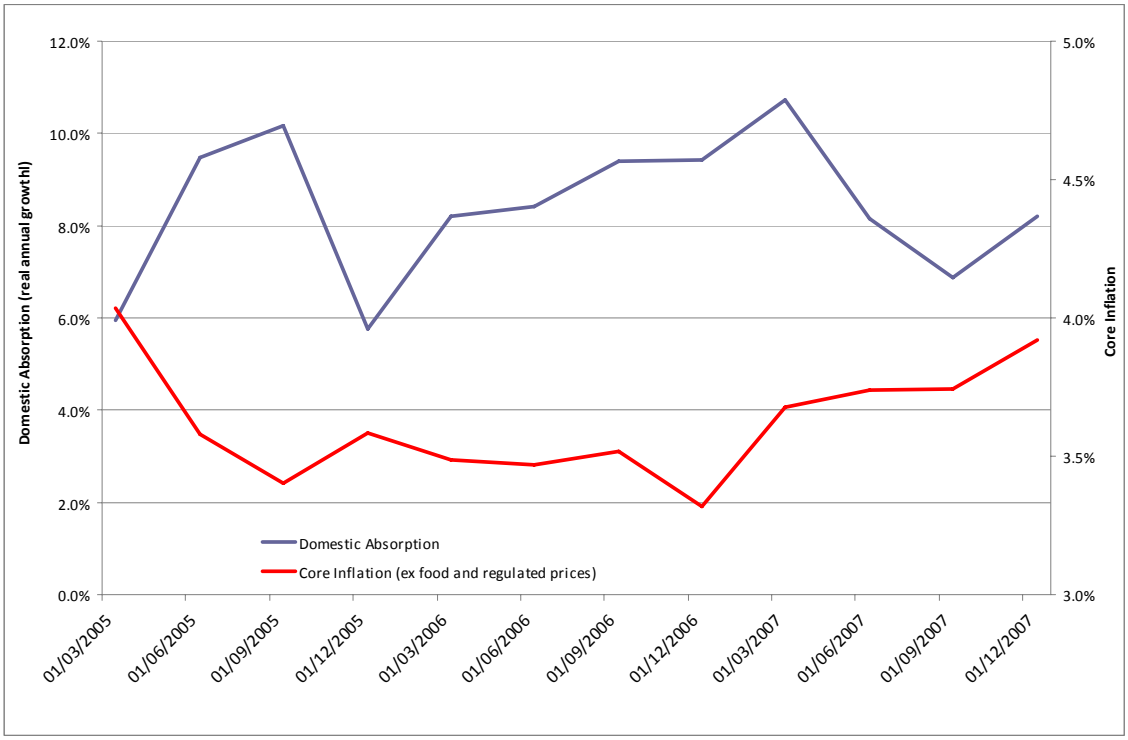
Graph 1
10 Year Interest Rates on Domestic Government Bonds (TES)



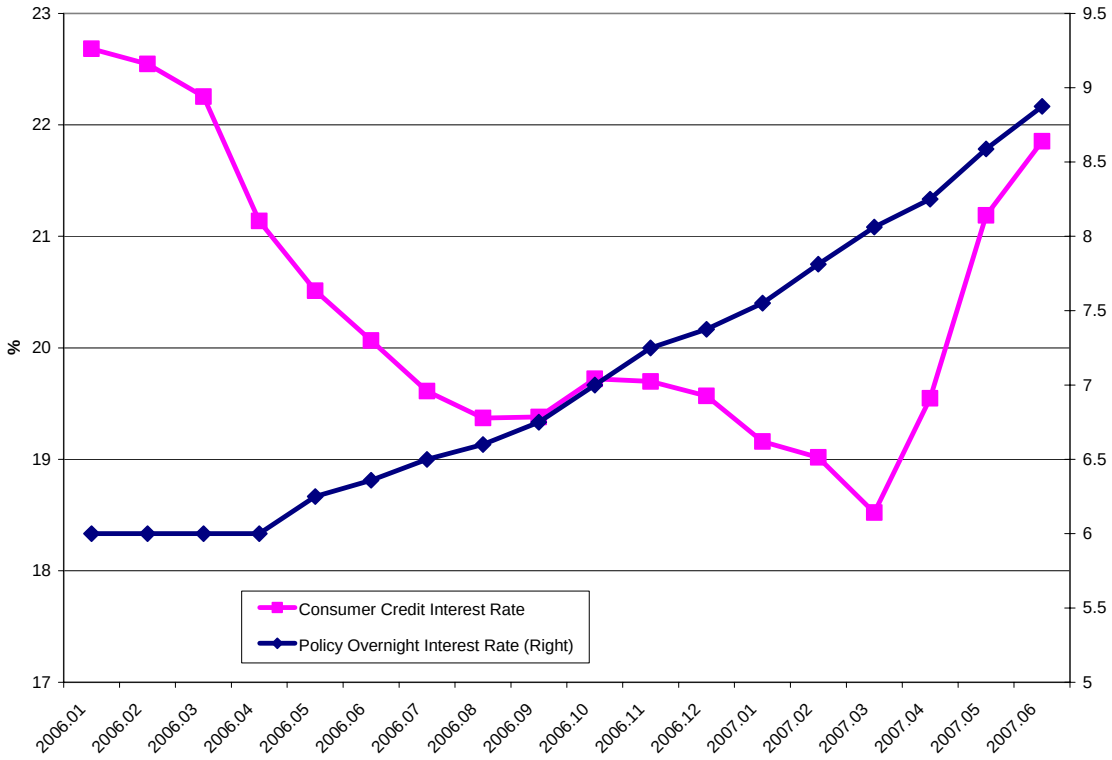
Graph 2
Share of Bond Holdings in Bank Total Assets



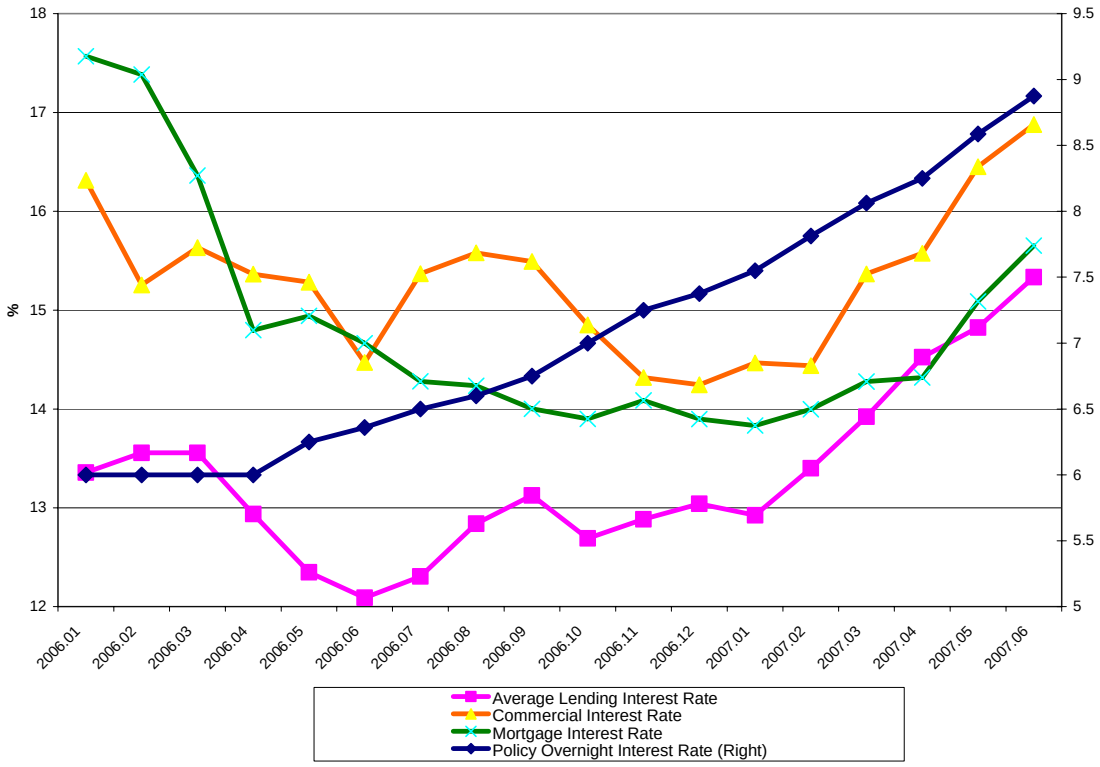
Graph 3
Domestic Absorption Growth and Core Inflation



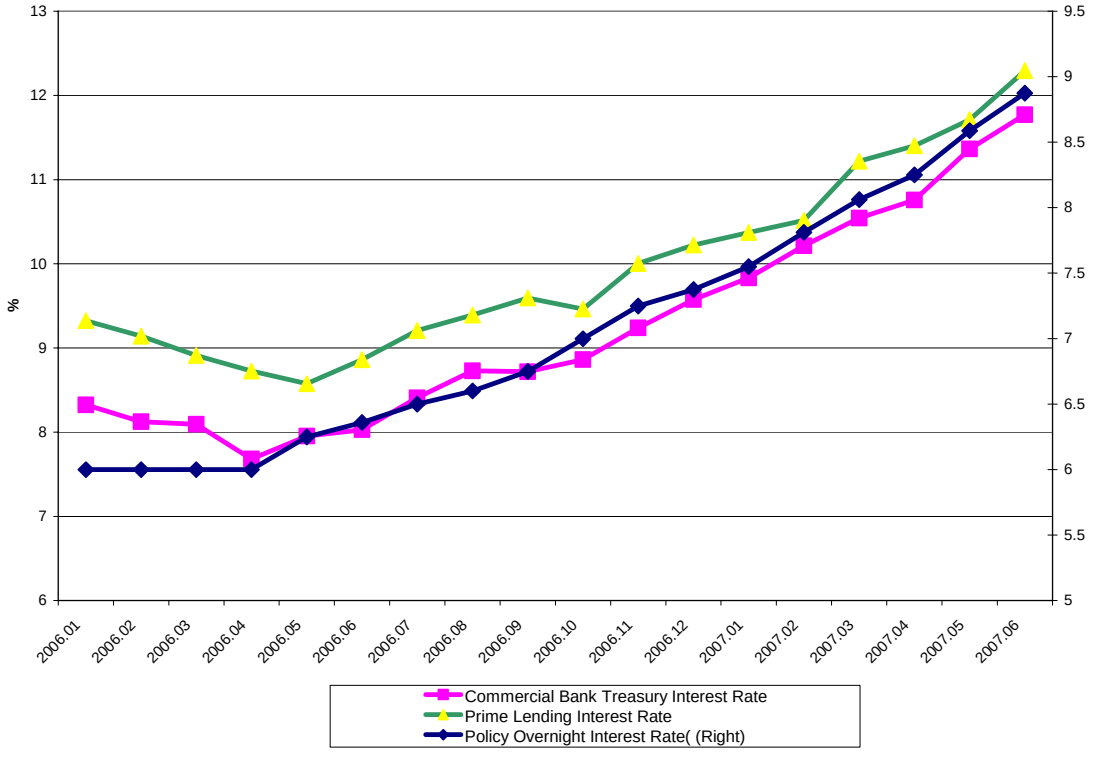
Graph 4
Policy Interest Rate and Consumer Credit Interest Rate



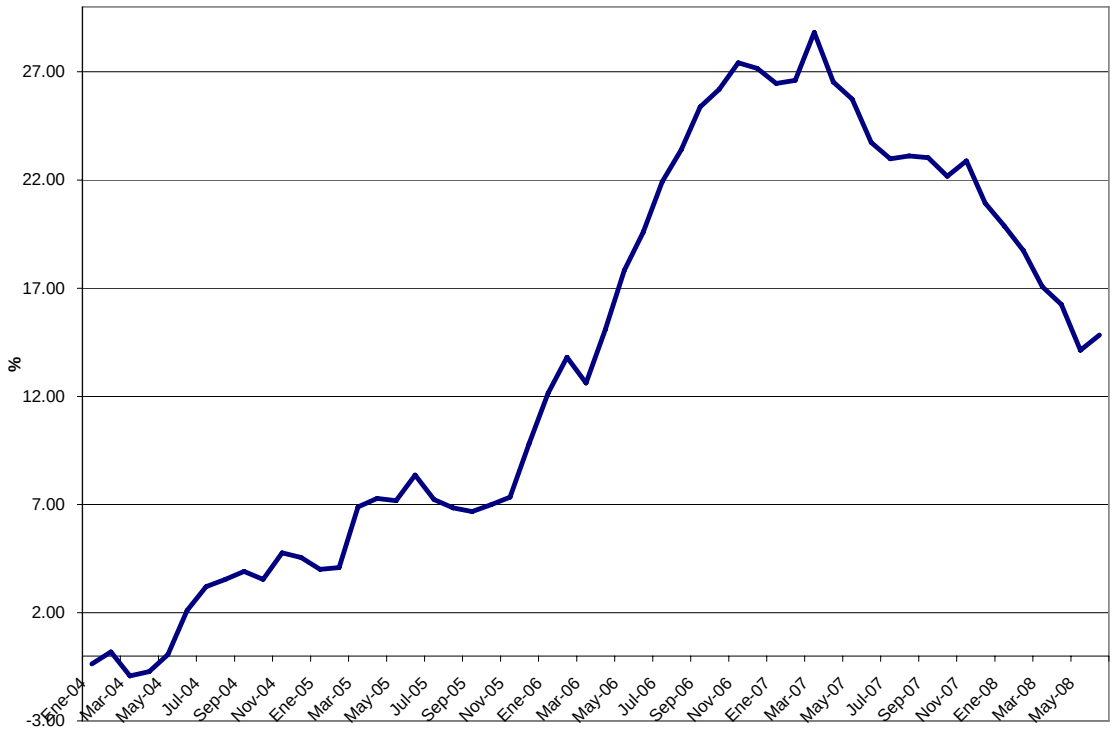
Graph 5
Policy, Average, Commercial and Mortgage Interest Rates



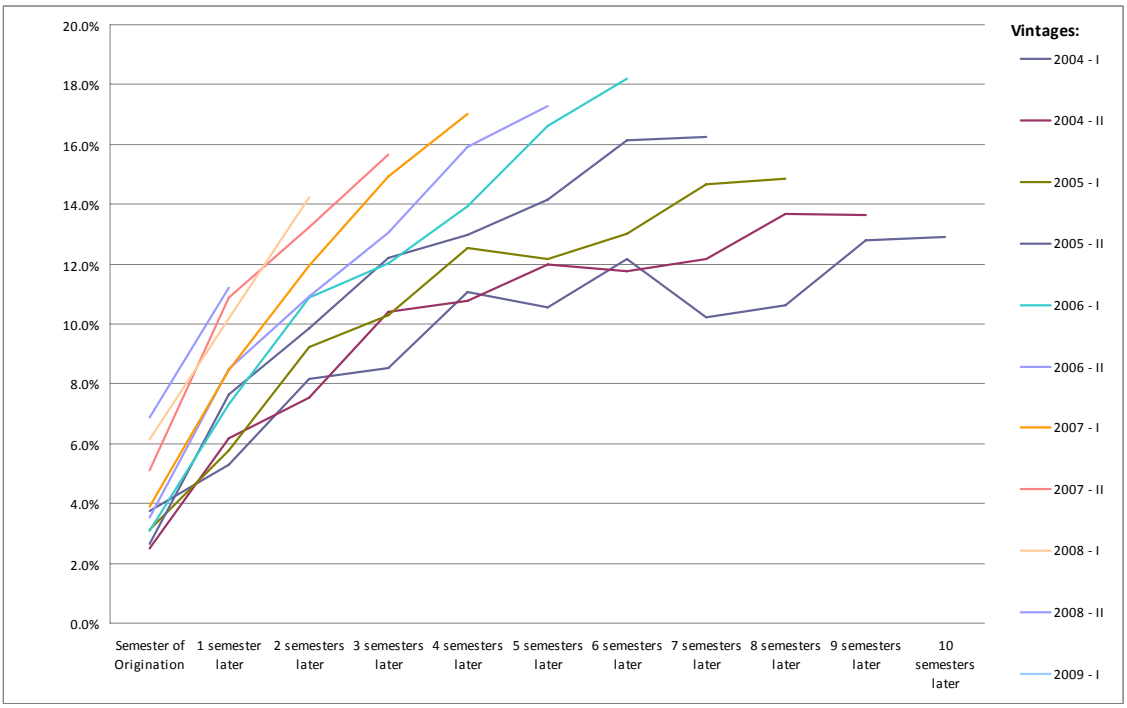
Graph 6
Policy, Prime and Commercial Bank Treasury Interest Rates



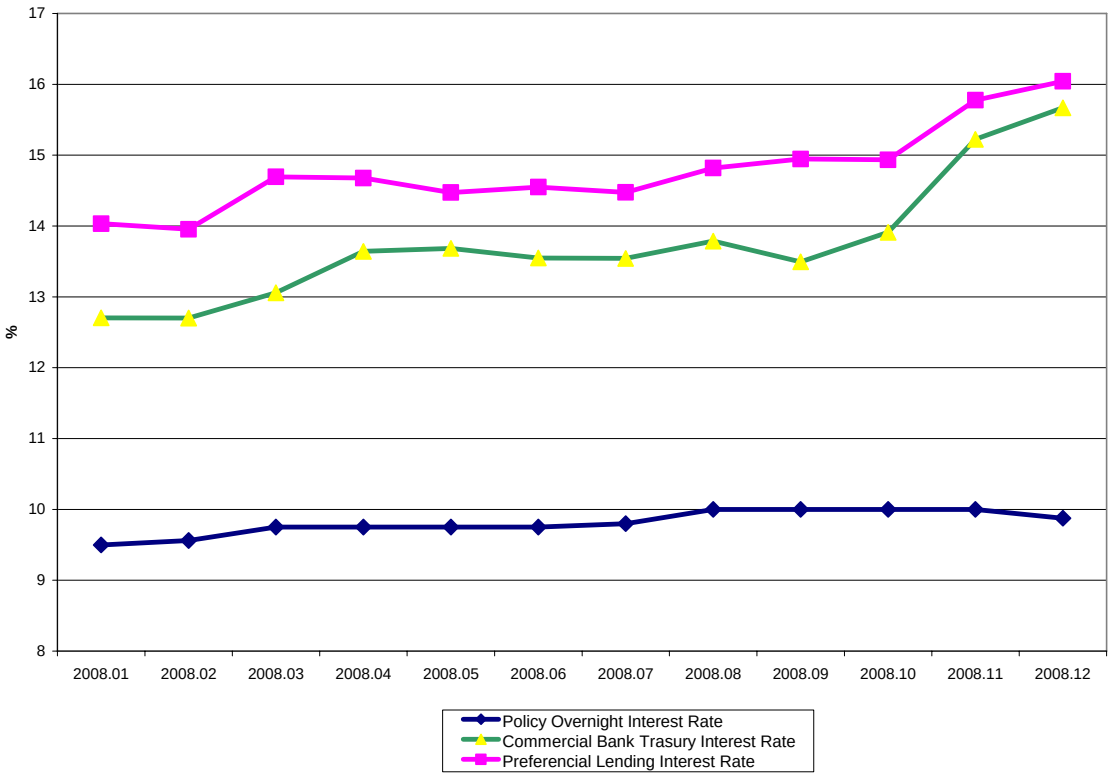
Graph 7
Real Bank Loan Annual Growth (CPI Ex-Food)



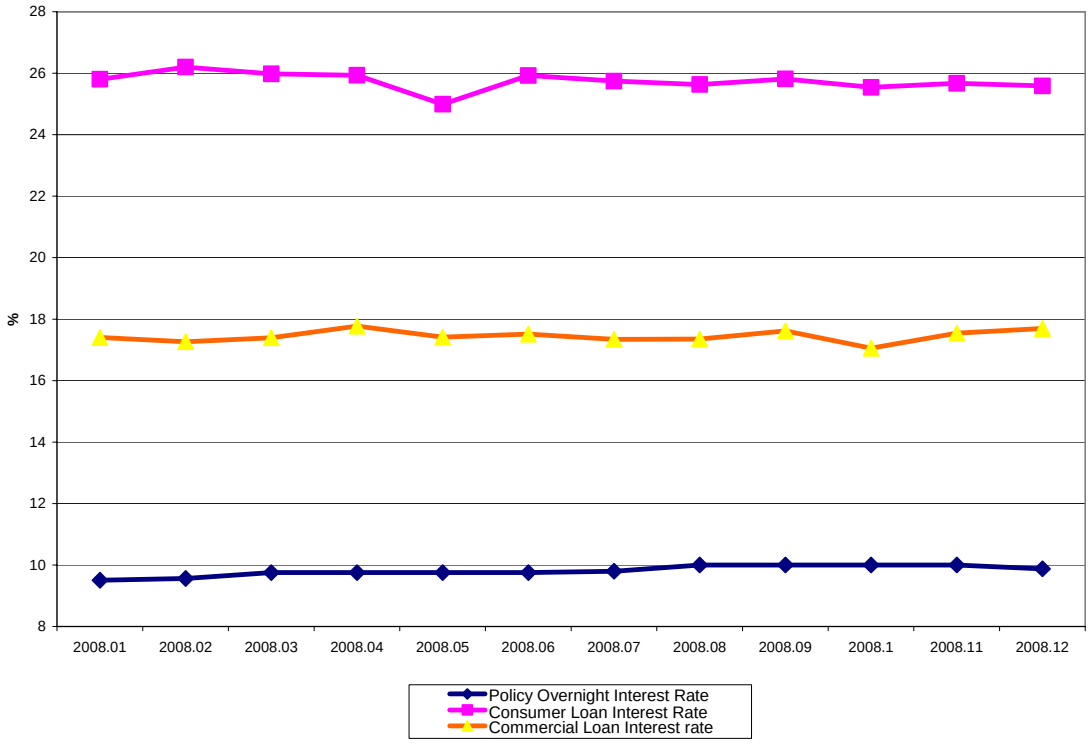
Graph 8
Consumer Credit: Risky Loans/ Total Loans by Vintages



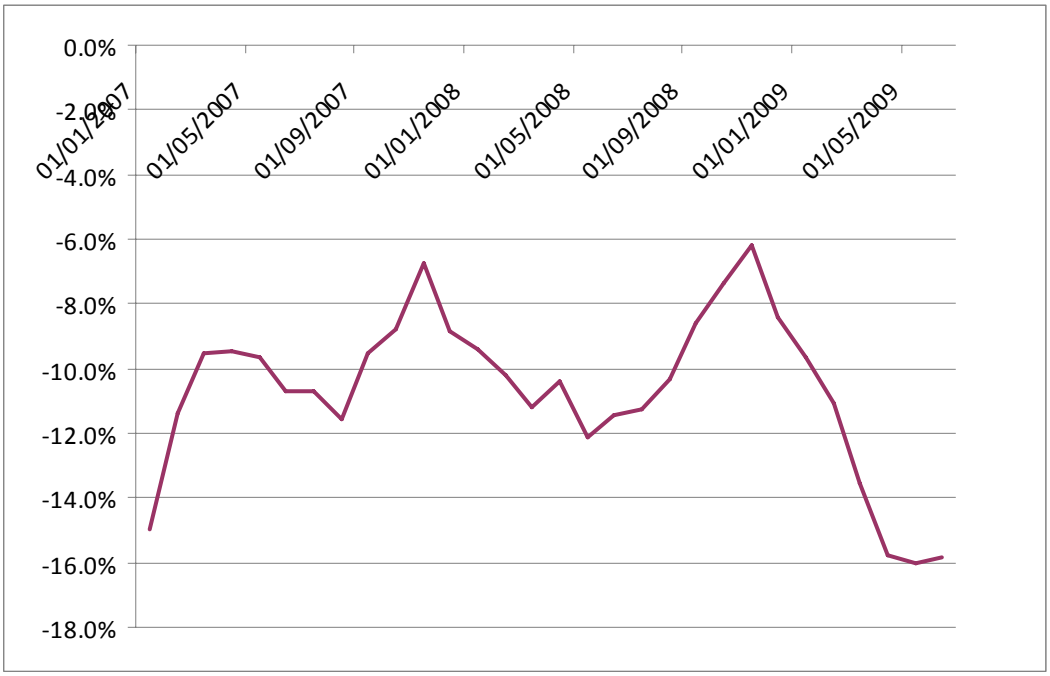
Graph 9
Policy, Prime and Commercial Bank Treasury Interest Rates 2008



Graph 10
Policy, Consumer and Commercial Loan Interest Rates

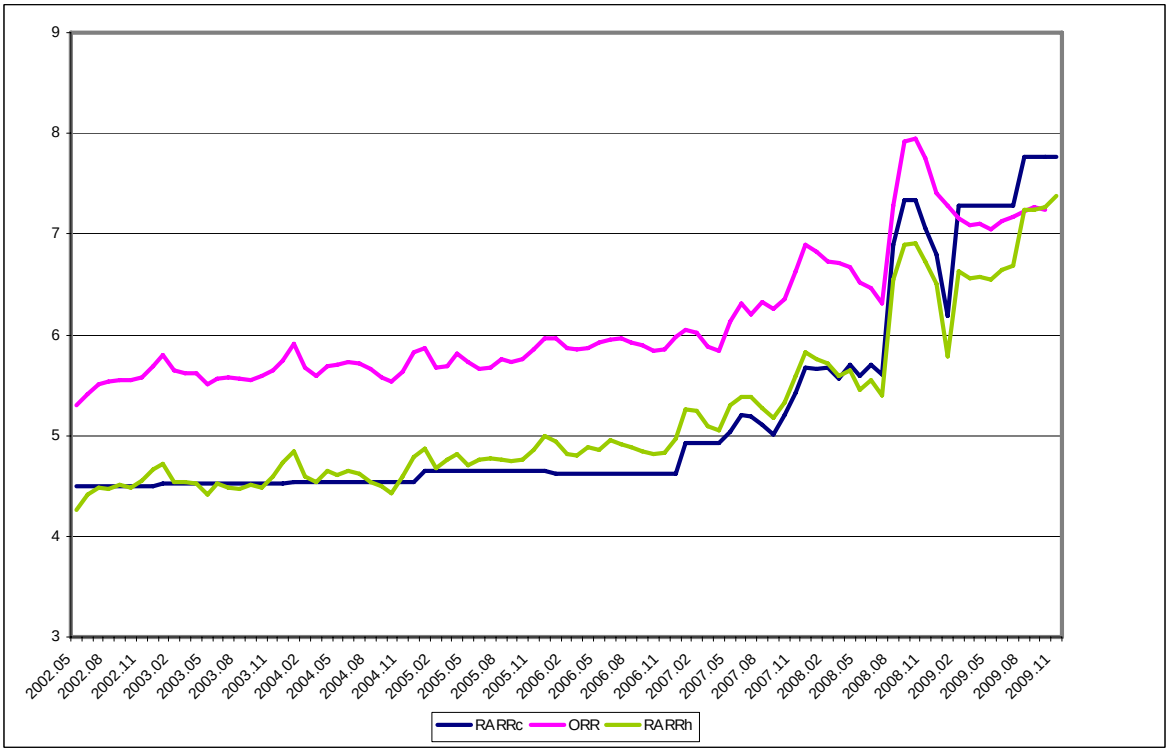


Graph 11
Liquidity GAP Indicator



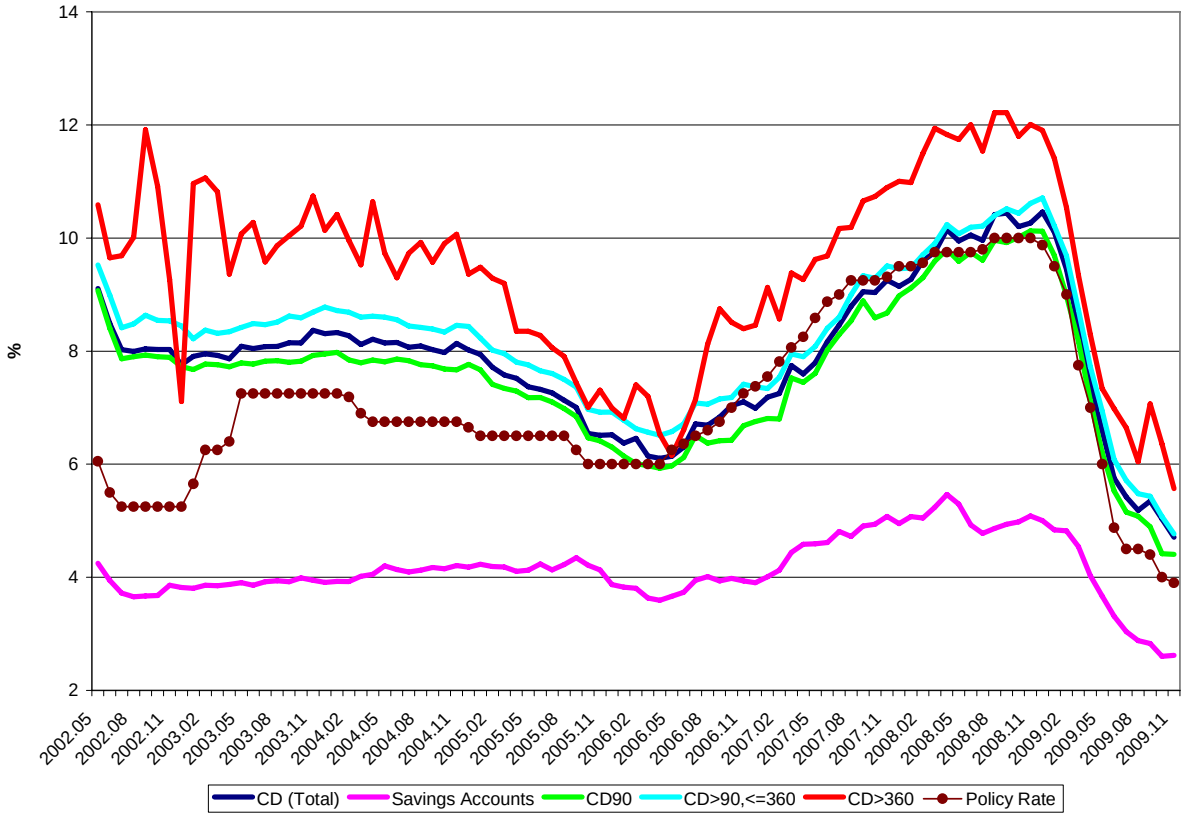
Indicator = (Liquid Liabilities – Liquid Assets) / (Illiquid Assets)

Graph 12
Aggregate Reserve Requirement Ratios

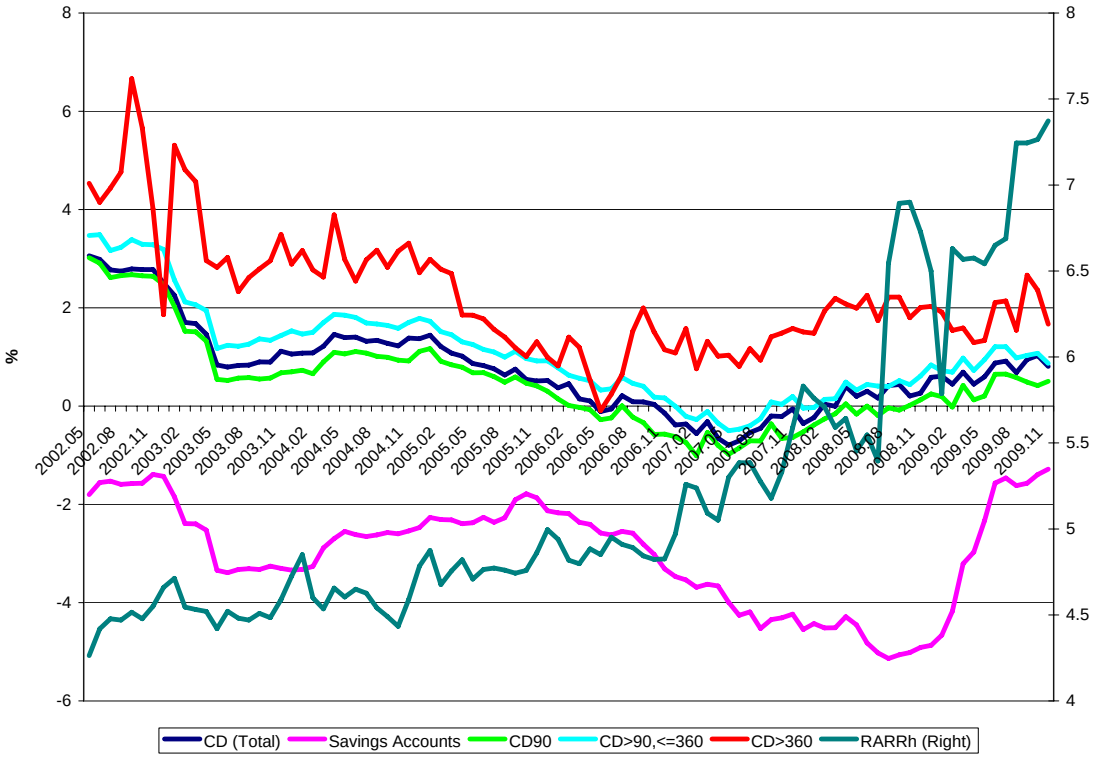


ORR = Observed Requires Reserve / Total Deposits Subject to RR
$RARR_c$ = Remuneration-Adjusted RR Ratio (fixed deposit composition)
$RARR_h$ = Remuneration-Adjusted RR Ratio (variable deposit composition)

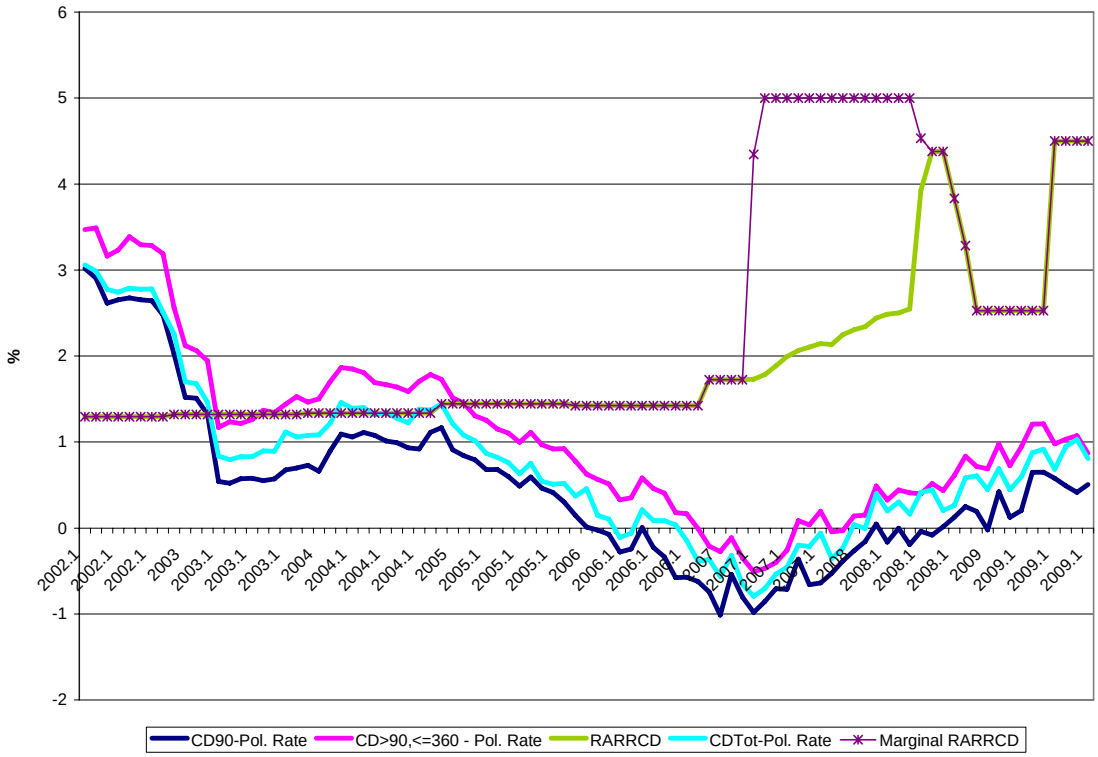
Graph 13
Policy and Deposit Interest Rates



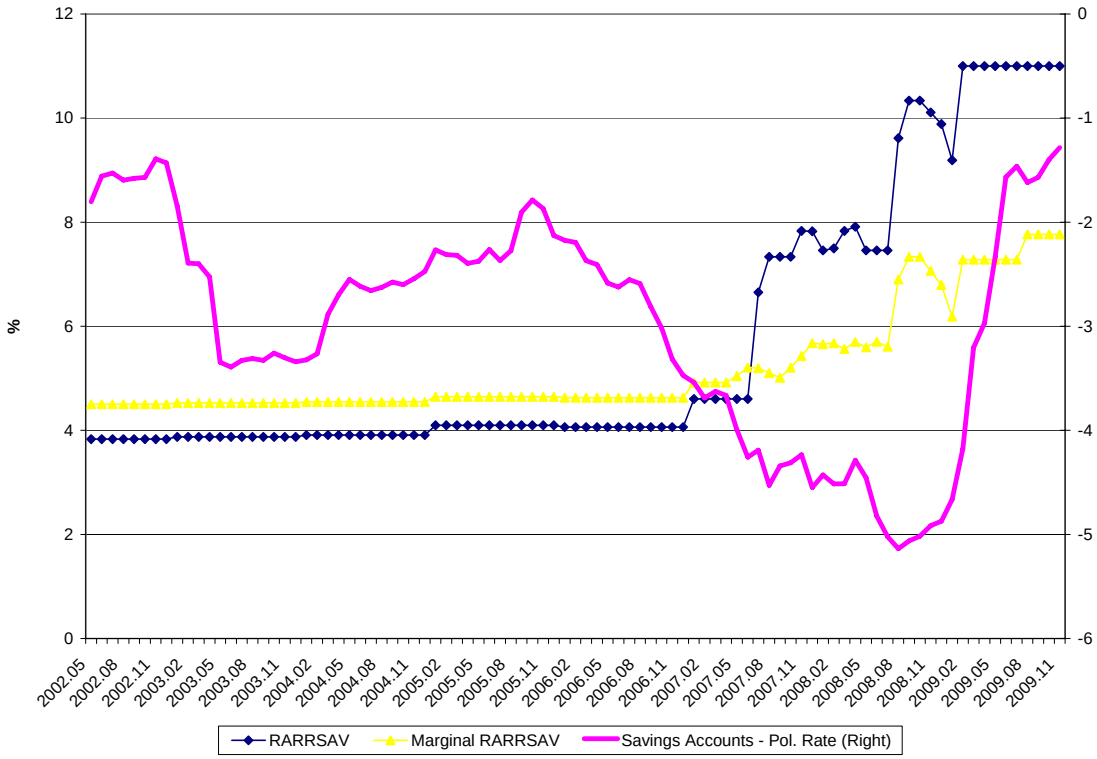
Graph 14
Spread between Deposit Interest Rates and the Overnight Policy Rate



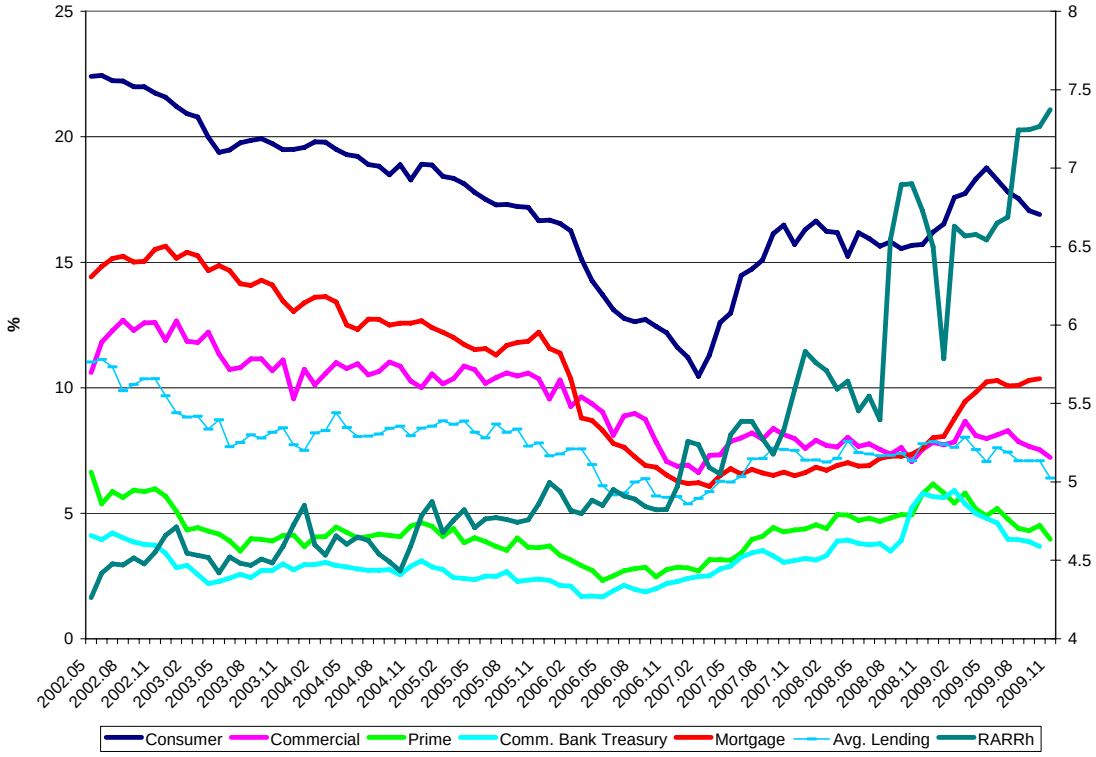
Graph 15
Average and Marginal CD Remuneration-Adjusted Reserve Requirements and Spreads between CD Interest Rates and Policy Interest Rates



Graph 16
Average and Marginal Savings Accounts Remuneration-Adjusted Reserve Requirements and Spreads between Savings Accounts Interest Rates and Policy Interest Rates



Graph 17
Spread between Lending Interest Rates and the Overnight Policy Rate



Graph 18
Overnight Interbank and Policy Interest Rates 2008

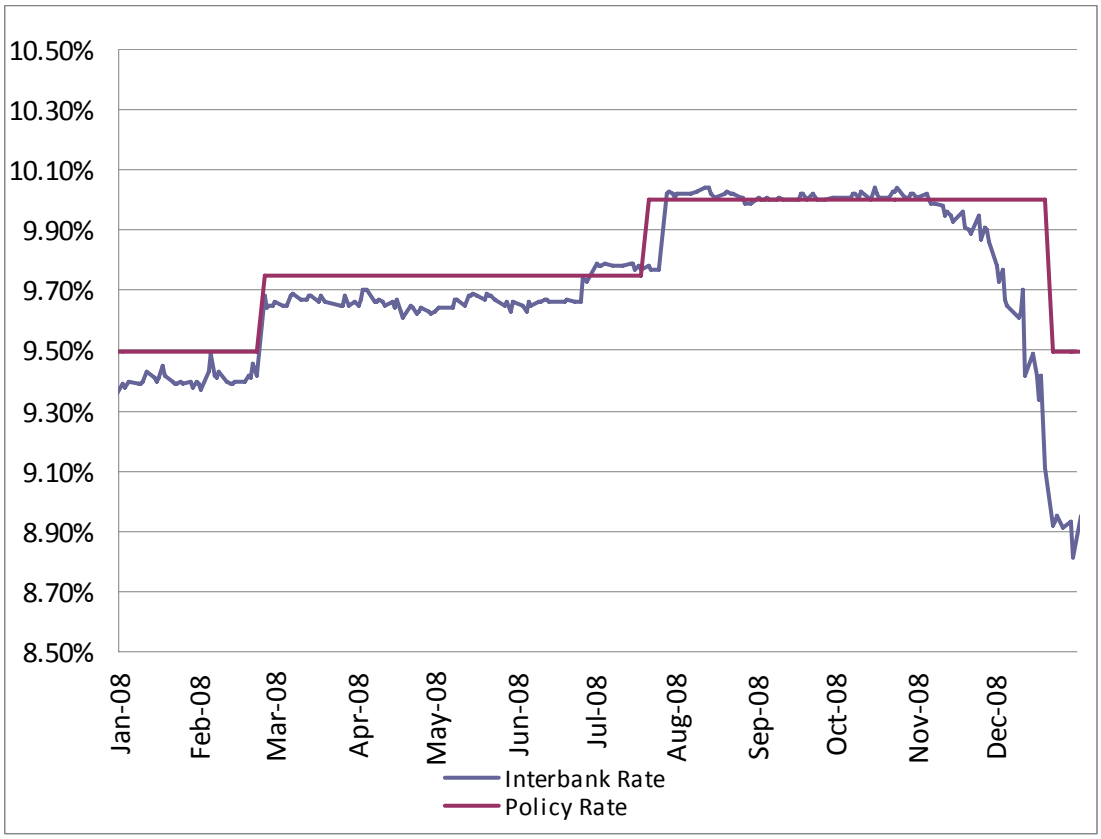


Table 1
Reserve Requirement Regulation

DATE	AVERAGE RESERVE REQUIREMENTS	MARGINAL RESERVE REQUIREMENTS	RESRVE RQUIREMENT REMUNERATION	NOTES
2000-2007	13% Checking Accounts and Sight Deposits 6% Savings Accounts 2.5% CD and bonds with maturity ≤ 18 months 0% CD and bonds with maturity > 18 months	----	75% of the Inflation Target for RR on Savings Accounts 100% of the Inflation Target for RR on CD and bonds ≤ 18 months	----
May 6 2007	Unchanged	27% Checking Accounts and Sight Deposits 12.5% Savings Accounts 5% CD with maturity ≤ 18 months	Marginal RR are NOT remunerated Average RR remuneration is unchanged	Applies since May 7 2007 Marginal RR apply for deposits above the level of May 7 2007
June 15 2007	8.3% Checking Accounts, Sight Deposits and Savings Accounts 2.5% CD and bonds with maturity ≤ 18 months 0% CD and bonds with maturity > 18 months	27% Checking Accounts, Sight Deposits and Savings Accounts 5%. CD and bonds with maturity ≤ 18 months	Marginal RR are NOT remunerated Remuneration of Average RR: • 37.5% of the Inflation Target for RR on Checking Accounts, Sight Deposits and Saving Accounts • 100% of the Inflation Target for RR on CD and bonds ≤ 18 months	RR on Checking Accounts, Sight Deposits and Saving Accounts are leveled.
June 20 2008	11.5% Checking Accounts, Sight Deposits and Savings Accounts 6% CD and bonds with maturity ≤ 18 months 0% CD and bonds with maturity > 18 months	Marginal RR are ELIMINATED	Unchanged	Applies since the last half of August 2008

October 24 2008	11% Checking Accounts, Sight Deposits and Savings Accounts 4.5% CD and bonds with maturity ≤ 18 months 0% CD and bonds with maturity > 18 months	---	Unchanged	Applies since December 2008
January 30 2009	Unchanged	---	Remuneration of Average RR: • 0% for RR on Checking Accounts, Sight Deposits and Saving Accounts • 100% of the Inflation Target for RR on CD and bonds ≤ 18 months	Applies since February 2009
July 24 2009	Unchanged	---	Remuneration of RR is ELIMINATED	---

Table 2
Loan Interest Rates and Reserve Requirements

LONG-RUN RELATIONSHIP						
	***Consumer* Loan Interest Rate**	***Commercial* Loan Interest Rate**	***Prime* Lending Rate**	**Commercial Bank Treasury Interest Rate**	**Mortgage Interest Rate**	**Average Lending Rate**
Market Interest Rate	1.0	1.0	1.0	1.0	1.0	1.0
Constant	-6.690	182.710	0.464	82.036	-4.603 (-3.457)	-5.367 (-5.383)
Trend	0.0135 (0.484)	0.375 (5.721)	n.a.	0.139 (7.124)	n.a	n.a.
Policy Interest Rate	-1.925 (-5.857)	-0.993 (-3.391)	-1.331 (-17.493)	-0.942 (-9.359)	n.a	-1.158 (-9.823)
Slope of the Yield Curve	-1.437 (-4.897)	n.a	-0.463 (-7.370)	n.a	n.a	-0.662 (-5.885)
RARRh	n.a.	-5.143 (-4.265)	-0.723 (-3.921)	-3.203 (-7.921)	n.a	n.a.
Industrial Production Index	n.a	-38.259 (-3.826)	0.461 (0.348)	-15.782 (-5.327)	n.a	n.a.
TES Interest Rate	n.a	n.a	n.a	n.a	-1.060 (-9.956)	n.a
SHORT-RUN DYNAMICS FOR LOAN INTEREST RATES						
	Δ *Consumer* Loan Interest Rate	**Δ *Commercial* Loan Interest Rate**	**Δ *Prime* Lending Rate**	**Δ Commercial Bank Treasury Interest Rate**	**Δ Mortgage Interest Rate**	**Δ Average Lending Rate**
Cointegration Error	-0.072 (-3.339)	-0.092 (-3.817)	-0.314 (-5.369)	-0.155 (-4.395)	-0.102 (-3.792)	-0.253 (-5.015)
Constant	-0.080 (-1.995)	-0.003 (-0.072)	0.024 (0.819)	0.040 (0.926)	n.a	n.a.
Δ Loan Interest Rate (-1)	0.084 (0.955)	-0.336 (-3.718)	-0.108 (-1.287)	0.149 (1.766)	0.253 (2.744)	0.014 (0.130)
Δ Policy Interest Rate (-1)	-2.231 (-2.627)	-2.892 (-2.937)	-2.380 (-3.551)	-0.962 (-1.736)	0.308 (2.646)	-2.670 (-2.878)
Δ Slope Yield Curve (-1)	-0.057 (-0.935)	n.a	0.040 (0.760)	n.a	n.a	0.0006 (0.007)
Δ RARRh(-1)	n.a.	-0.228 (-1.078)	-0.219 (-1.61)	-0.361 (-2.703)	n.a	n.a.
Δ Policy Rate (-1) * RARRh	**0.359 (2.606)**	**0.557 (3.340)**	**0.494 (4.630)**	**0.239 (2.573)**	**n.a**	**0.505 (3.430)**
Δ *SA* Industrial Production Index (-1)	n.a.	-2.202 (-1.940)	0.667 (0.964)	-1.481 (-2.185)	n.a	n.a.
Δ TES Interest Rate	n.a.	n.a	n.a.	n.a	-0.076 (-1.365)	n.a.
Dummy variables	2007_01 2007_04	2003_12	n.a.	2008_11 2009_10	n.a	n.a.

t-statistics in parenthesis.

Table 3
Deposit Interest Rates and Reserve Requirements

LONG-RUN RELATIONSHIP					
	Savings Accounts Interest Rate	**Short-Term CD Interest Rate (90 days)**	**Short-Term CD Interest Rate (91-360days)**	**Long-Term CD Interest Rate (greater than 360 days)**	**Average CD Interest Rate**
Market Interest Rate	1.0	1.0	1.0	1.0	1.0
Trend	n.a.	n.a.	n.a.	n.a.	n.a.
Constant	-1.099 (-2.651)	0.013	-0.842 (-2.12)	0.229 (0.385)	n.a.
Policy Interest Rate	-0.429 (-7.650)	-1.005 (-12.527)	-0.924 (-19.012)	-1.053 (-11.801)	-0.933 (-42.845)
Slope of the Yield Curve	n.a.	-0.638 (-5.352)	-0.550 (-10.88)	-0.565 (-12.786)	-0.491 (-15.569
Marginal RARRh	n.a.	n.a.	n.a.	-0.181 (-2.010)	-0.158 (-3.122)
SHORT-RUN DYNAMICS FOR DEPOSIT INTEREST RATES					
	Δ Savings Accounts Interest Rate	**Δ Short-Term CD Interest Rate (90 days)**	**Δ Short-Term CD Interest Rate (91-360days)**	**Δ Long-Term CD Interest Rate (greater than 360 days)**	**Δ Average CD Interest Rate**
Cointegration Error	-0.091 (-2.214)	-0.153 (-3.631)	-0.248 (-5.549)	-0.546 (-4.979)	-0.276 (-7.01)
Constant	n.a.	-0.018 (-0.945)	n.a.	n.a.	n.a.
Δ Deposit Interest Rate (-1)	0.116 (1.252)	0.017 (0.150)	-0.073 (-0.692)	0.101 (1.113)	-0.241 (-2.76)
Δ Policy Interest Rate (-1)	-0.488 (-2.075)	-0.655 (-1.490)	-1.259 (-3.305)	-2.679 (-2.252)	-1.767 (-5.17)
Δ Slope Yield Curve (-1)	n.a.	0.032 (0.556)	0.030 (0.751)	0.074 (0.739)	0.041 (1.074)
Δ RARRh (-1)	n.a.	n.a.	n.a.	0.044 (0.325)	0.008 (0.222)
Δ Policy Rate (-1) * RARRh	**0.124 (3.158)**	**0.198 (2.66)**	**0.290 (4.553)**	**0.466 (2.489)**	**0.402 (6.878)**
Dummy variables	2008_6	n.a.	n.a.	2002_12 2003_1	2009_03 2009_07

t-statistics in parenthesis.

Table 4
Loan Interest Rates - Asymmetric Response to Policy Rate Changes

LONG-RUN RELATIONSHIP					
	***Consumer* Loan Interest Rate**	***Commercial* Loan Interest Rate**	***Prime* Lending Rate**	**Commercial Bank Treasury Interest Rate**	**Average Lending Rate**
Market Interest Rate	1.0	1.0	1.0	1.0	1.0
Constant	-7.394	103.296	7.503	92.755	-5.056
Trend	0.013 (0.512)	0.243 (6.228)	n.a.	0.152 (7.516)	n.a.
Policy Interest Rate	-1.819 (-5.773)	-0.868 (-4.988)	-1.326 (-14.957)	-0.950 (-9.229)	-1.207 (-9.076)
Slope of the Yield Curve	-1.444 (-5.287)	n.a.	-0.526 (-7.058)	n.a.	-0.763 (-6.014)
RARRh	n.a.	-2.651 (-3.673)	-0.398 (-1.932)	-3.245 (-7.681)	n.a.
Industrial Production Index	n.a.	-23.256 (-3.899)	-1.349 (-0.851)	-18.092 (-5.899)	n.a.
SHORT-RUN DYNAMICS FOR LOAN INTEREST RATES					
	Δ *Consumer* Loan Interest Rate	**Δ *Commercial* Loan Interest Rate**	**Δ *Prime* Lending Rate**	**Δ Commercial Bank Treasury Interest Rate**	**Δ Average Lending Rate**
Cointegration Error	-0.066 (-2.916)	-0.183 (-5.178)	-0.264 (-4.732)	-0.155 (-4.758)	-0.207 (-4.320)
Constant	-0.059 (-1.289)	0.023 (0.463)	0.031 (0.868)	0.041 (1.353)	n.a.
Δ Loan Interest Rate (-1)	0.1024 (1.146)	-0.261 (-2.977)	-0.118 (-1.299)	0.125 (1.457)	0.027 (0.251)
Δ Policy Interest Rate (-1)	0.127 (0.627)	0.481 (2.308)	0.740 (3.878)	0.587 (3.335)	0.668 (3.261)
Δ Slope Yield Curve (-1)	-0.063 (-1.006)	n.a.	0.049 (0.854)	n.a.	0.016 (0.186)
Δ RARRh (-1)	n.a.	-0.139 (-0.674)	-0.049 (-0.350)	-0.325 (-2.472)	n.a.
Δ Policy Rate (-1) * dir (Asymmetric Effect)	**-0.691 (-1.962)**	**-0.944 (-2.467)**	**-0.671 (-2.468)**	**-0.496 (-2.196)**	**-0.993 (-3.121)**
Δ *SA* Industrial Production Index (-1)	n.a.	-3.060 (-2.757)	0.101 (0.135)	-1.821 (-2.673)	n.a.
Dummy variables	2007_01 2007_04	2003_12	n.a.	2008_11 2009_10	n.a.

t-statistics in parenthesis.

Table 5
Deposit Interest Rates - Asymmetric Response to Policy Rate Changes

LONG-RUN RELATIONSHIP						
	Savings Accounts Interest Rate	**Short-Term CD Interest Rate (90 days)**	**Short-Term CD Interest Rate (91-360days)**	**Short-Term CD Interest Rate (91-360days)**	**Long-Term CD Interest Rate (greater than 360 days)**	**Average CD Interest Rate**
Market Interest Rate	1.0	1.0	1.0	1.0	1.0	1.0
Constant	-0.850	0.088	-0.640	-0.802	0.136	n.a
Policy Interest Rate	-0.462 (-6.876)	-1.009 (-13.128)	-0.960 (-19.230)	-0.937 (-20.199)	-1.038 (-11.585)	-0.953 (-38.438)
Slope of the Yield Curve	n.a	-0.711 (-6.362)	-0.591 (-11.534)	-0.566 (-11.873)	-0.550 (-12.433)	-0.506 (-14.359)
Marginal Reserve Requirement	n.a	n.a	n.a	n.a	-0.185 (-2.040)	-0.138 (-2.440)
SHORT-RUN DYNAMICS FOR LOAN INTEREST RATES						
	Δ Savings Accounts Interest Rate	**Δ Short-Term CD Interest Rate (90 days)**	**Δ Short-Term CD Interest Rate (91-360days)**	**Δ Short-Term CD Interest Rate (91-360days)**	**Δ Long-Term CD Interest Rate (greater than 360 days)**	**Δ Average CD Interest Rate**
Cointegration Error	-0.063 (-1.736)	-0.165 (-3.789)	-0.227 (-5.138)	-0.256 (-5.691)	-0.574 (-5.374)	-0.246 (-6.008)
Constant	n.a	-0.001 (-0.063)	n.a	n.a	n.a	n.a
Δ Market Interest Rate (-1)	0.119 (1.256)	0.011 (0.099)	-0.102 (-0.915)	-0.127 (-1.161)	0.109 (1.223)	-0.214 (-2.271)
Δ Policy Interest Rate (-1)	0.304 (5.689)	0.639 (5.186)	0.690 (6.345)	-0.552 (-1.024)	-5.354 (-2.926)	0.840 (7.955)
Δ Slope Yield Curve (-1)	n.a	0.137 (0.232)	0.0345 (0.852)	0.023 (0.567)	0.091 (0.929)	0.044 (1.104)
Δ Marginal RARRh (-1)	n.a	n.a	n.a	n.a	-0.010 (-0.075)	0.049 (1.199)
Δ Policy Rate (-1) * dir	**-0.183 (-2.196)**	**-0.453 (-2.458)**	**-0.656 (-4.512)**	**-0.363 (-2.037)**	**1.161 (1.996)**	**-0.803 (-5.956)**
Δ Policy Rate *RARRh	n.a	n.a	n.a	0.193 (2.323)	0.861 (3.093)	n.a
Dummies variables	2008_06	n.a	n.a	n.a	2002_12 2003_1	2009_3 2009_7

t-statistics in parenthesis.

Table 6
Loan Interest Rates – Central Bank's Net Creditor Position

LONG-RUN RELATIONSHIP			
	Commercial Bank Treasury Interest Rate	**Commercial Bank Treasury Interest Rate**	***Prime* Lending Rate**
Market Interest Rate	1.0	1.0	1.0
Constant	84.667	81.888	2.198
Trend	0.143 (7.201)	0.140 (7.264)	n.a.
Policy Interest Rate	-0.984 (-9.849)	-0.998 (-10.188)	-1.429 (-16.255)
Slope of the Yield Curve	n.a.	n.a.	-0.508 (-7.44)
Average Reserve Requirement	-3.004 (-7.231)	-3.001 (-7.621)	-0.48 (-2.555)
Industrial Production Index	-16.520 (-5.553)	-15.892 (-5.429)	n.a.
SHORT-RUN DYNAMICS FOR LOAN INTEREST RATES			
	Δ Commercial Bank Treasury Interest Rate	**Δ Commercial Bank Treasury Interest Rate**	**Δ *Prime* Lending Rate**
Cointegration Error	-0.163 (-4.778)	-0.166 (-4.761)	-0.264 (-4.682)
Constant	0.013 (0.516)	0.005 (0.210)	-0.01 (-0.344)
Δ Loan Interest Rate (-1)	0.134 (1.522)	0.178 (2.105)	-.077 (-0.864)
Δ Policy Interest Rate (-1)	0.457 (2.730)	0.432 (2.701)	0.607 (3.495)
Δ Slope Yield Curve (-1)	n.a	n.a	0.058 (1.03)
Δ *RARRh* (-1)	-0.301 (-2.304)	-0.303 (-2.316)	-0.034 (-0.241)
Δ Industrial Production Index (-1)	-1.889 (-2.765)	-1.829 (-2.707)	n.a
Δ Policy Rate (-1) * dir * ncp	**-0.518 (-1.648)**	**n.a**	**n.a**
Δ Policy Rate (-1) * ncp	**n.a**	**-0.420 (-1.887)**	**-0.567 (-2.084)**
Δ Industrial Production Index	n.a	n.a	-1.243 (-1.688)
Dummies variables	2008_11 2009_10	2008_11 2009_10	n.a

t-statistics in parenthesis.

Table 7
Deposit Interest Rates - Central Bank's Net Creditor Position Effects

LONG-RUN RELATIONSHIP							
	Savings Accounts Interest Rate	**Short-Term CD Interest Rate (90 days)**	**Short-Term CD Interest Rate (90 days)**	**Short-Term CD Interest Rate (91-360days)**	**Short-Term CD Interest Rate (91-360days)**	**Average CD Interest Rate**	**Average CD Interest Rate**
Market Interest Rate	1	1	1	1	1	1	1
Constant	-0.787	0.528	0.538	-0.003	-0.054	n.a	n.a
Policy Interest Rate	-0.471 (-6.534)	-1.064 (-11.318)	-1.071 (-11.663)	-1.018 (-13.46)	-1.011 (-13.704)	-0.920 (-26.861)	-0.929 (-29.798)
Slope of the Yield Curve	n.a	-0.769 (-5.601)	-0.7101 (-5.323)	-0.631 (-7.961)	-0.591 (-7.765)	-0.497 (-9.868)	-0.479 (-10.617)
Marginal Reserve Requirement	n.a	n.a	n.a	n.a	n.a	-0.179 (-2.242)	-0.153 (-2.106)

SHORT-RUN DYNAMICS FOR LOAN INTEREST RATES							
	Δ Savings Accounts Interest Rate	**Δ Short-Term CD Interest Rate (90 days)**	**Δ Short-Term CD Interest Rate (90 days)**	**Δ Short-Term CD Interest Rate (91-360days)**	**Δ Short-Term CD Interest Rate (91-360days)**	**Δ Average CD Interest Rate**	**Δ Average CD Interest Rate**
Cointegration Error	-0.047 (-1.311)	-0.115 (-2.864)	-0.117 (-3.056)	-0.146 (-3.708)	-0.161 (-4.116)	-0.175 (-3.954)	-0.194 (-4.434)
Constant	n.a	-0.022 (-1.138)	-0.026 (-1.386)	n.a	n.a		
Δ Deposit Interest Rate (-1)	0.156 (1.656)	0.086 (0.773)	0.113 (1.023)	0.043 (0.401)	0.066 (0.63)	-0.070 (-0.694)	-0.038 (-0.394)
Δ Policy Interest Rate (-1)	0.263 (5.448)	0.523 (4.777)	0.539 (5.163)	0.523 (5.021)	0.513 (5.22)	0.612 (5.635)	0.605 (5.850)
Δ Slope Yield Curve (-1)	n.a	0.03 (0.497)	0.048 (0.837)	0.069 (1.68)	0.072 (1.759)	0.023 (0.506)	0.022 (0.504)
ΔMarginal RARRh (-1)	n.a	n.a	n.a	n.a	n.a	0.107 (2.378)	0.110 (2.525)
Δ Policy Rate (-1) * dir * ncp	**-0.185 (-1.425)**	**-0.357 (-1.434)**	**n.a**	**-0.438 (-2.175)**	**n.a**	**-0.474 (-2.337)**	**n.a**
Δ Policy Rate (-1) * ncp	**n.a**	**n.a**	**-.0402 (-2.35)**	**n.a**	**-0.355 (-2.395)**	**n.a**	**-0.430 (-2.876)**
Dummies variables	2008_6	n.a	n.a	n.a	n.a	n.a	n.a

t-statistics in parenthesis.

Chart 1
Impulse Response Functions for Loan Interest Rates
Policy Rate Shock for Different Reserve Requirements Levels

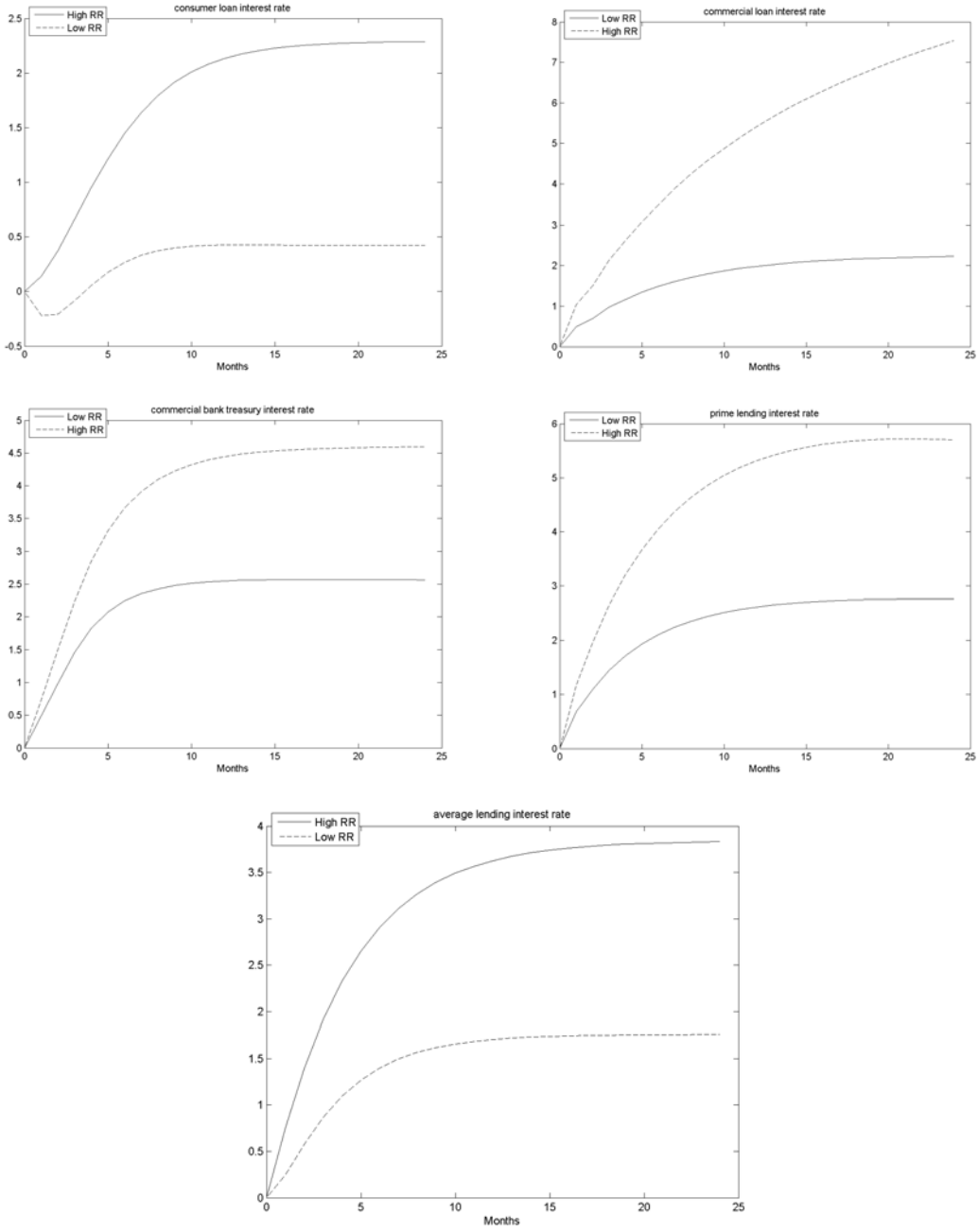
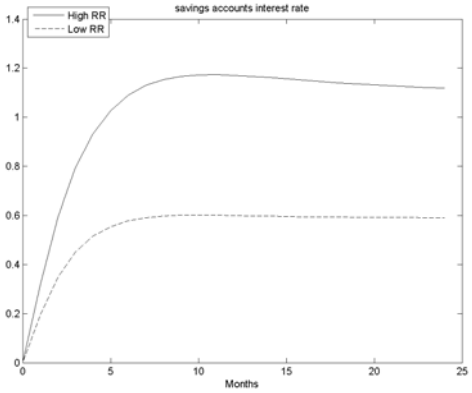
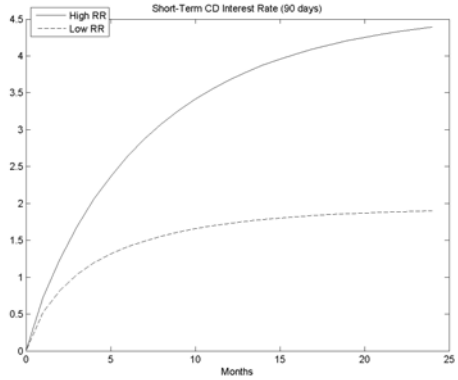
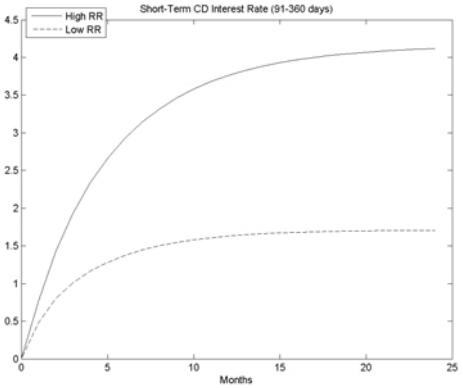
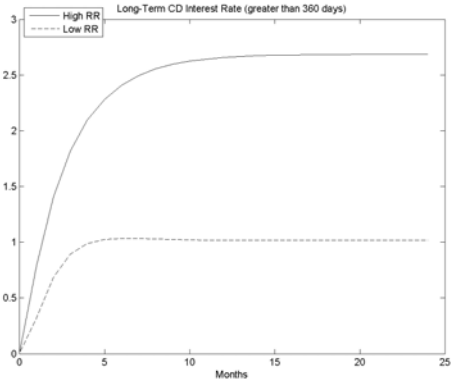


Chart 2
Impulse Response Functions for Deposit Interest Rates
Policy Rate Shock for Different Reserve Requirements Levels









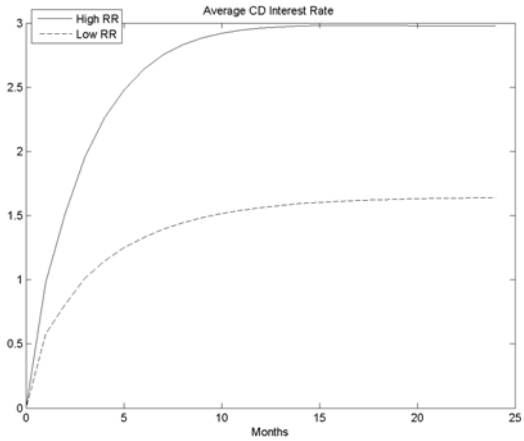
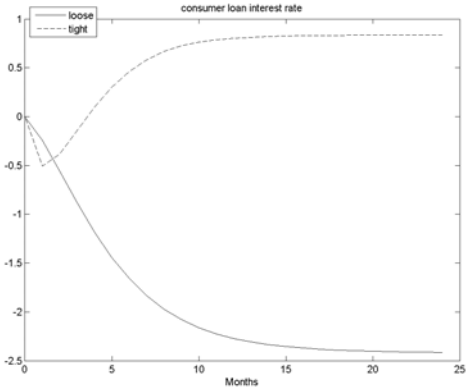
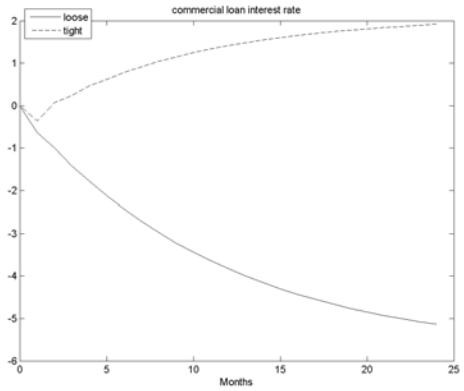
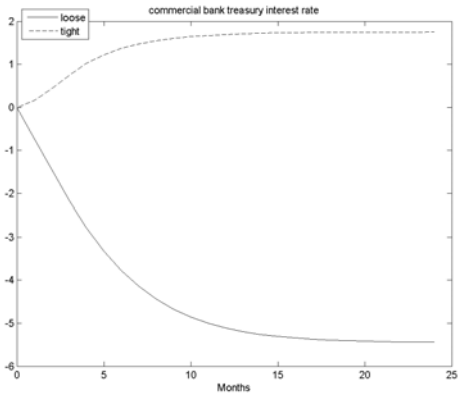
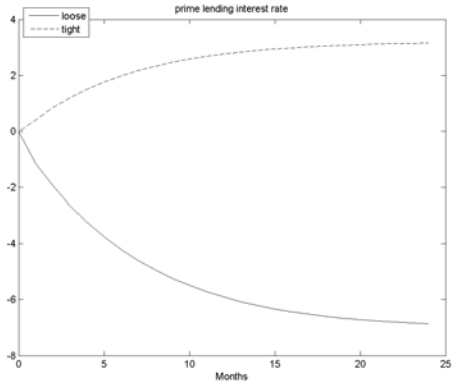


Chart 3
Impulse Response Functions for Loan Interest Rates
Asymmetric Response to Policy Rate Changes









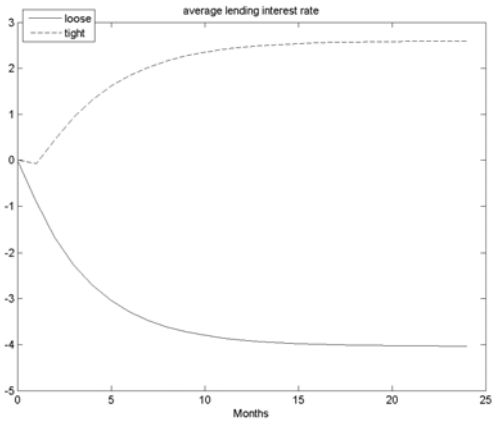
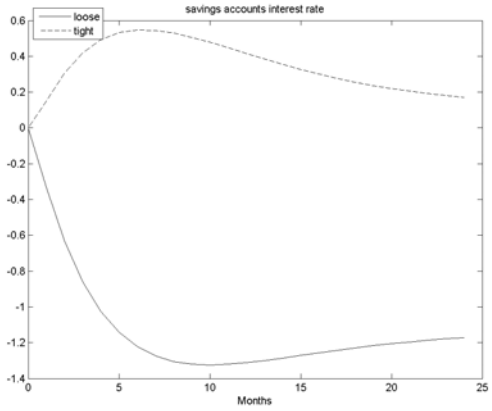
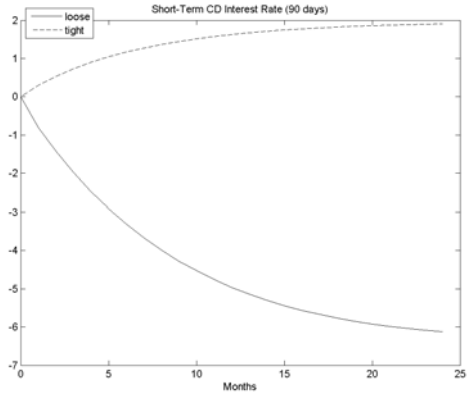
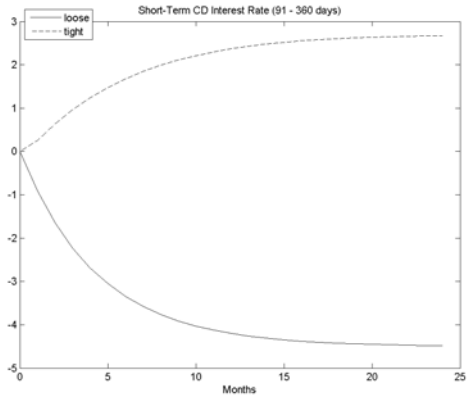


Chart 4
Impulse Response Functions for Deposit Interest Rates
Asymmetric Response to Policy Rate Changes







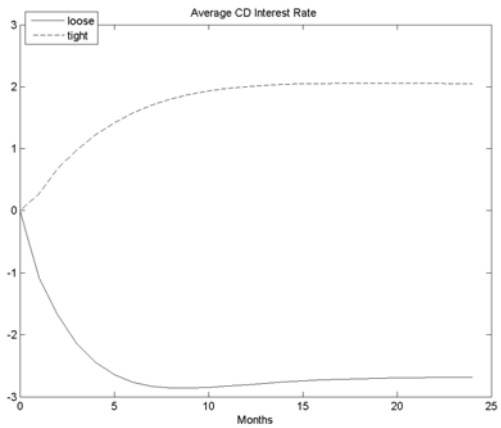
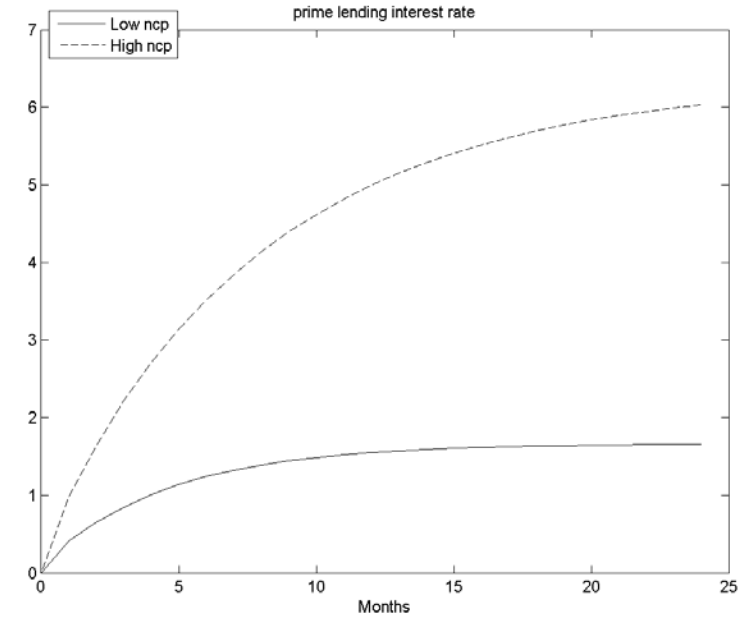


Chart 5
Impulse Response Functions for Loan Interest Rates
Policy Rate Shock – Central Bank's Net Creditor Position Effects



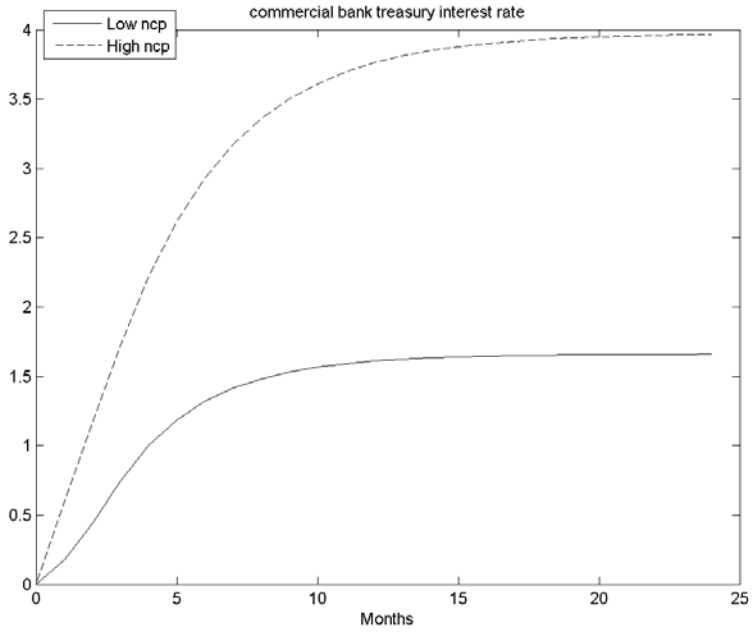
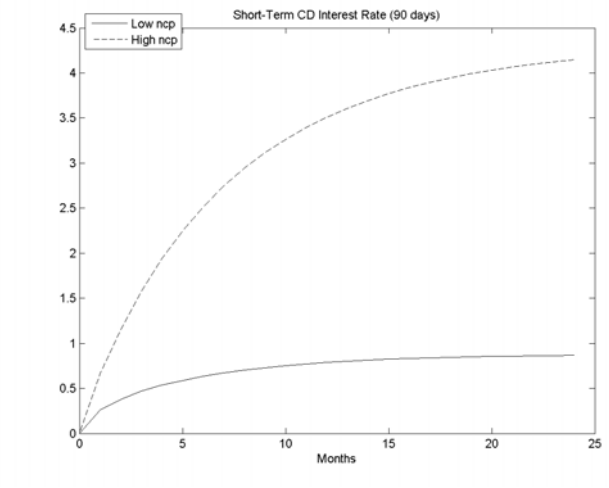
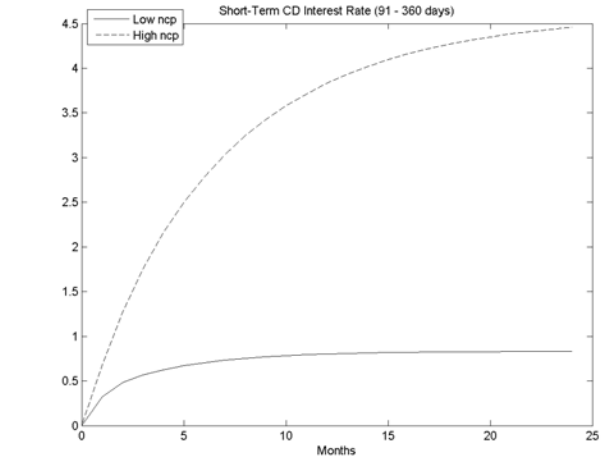
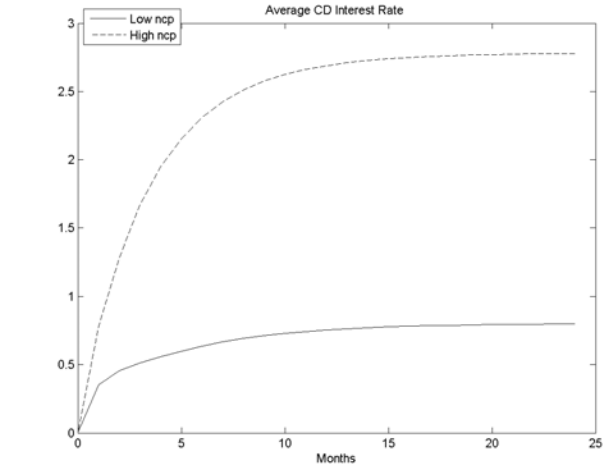


Chart 6
Impulse Response Functions for Deposit Interest Rates
Asymmetric Response to Policy Rate Changes







Appendix 1

Effect of RR on Interest Rate Pass-Through

Betancourt and Vargas (2009) develop a partial equilibrium model of the deposit and credit markets in which risk averse banks use deposits (D) and central bank credit (B) to fund loans (C). A fraction e of deposits must be held as RR. Both credit and deposits have a 2-period maturity, whereas central bank credit has 1-period maturity. This implies that banks face interest rate risk because the cost of part of the funding of credit may change if the central bank moves the policy interest rate (i_b) before loans mature. This risk makes deposit and central bank credit imperfect substitutes. In this setting Betancourt and Vargas find the following results regarding loan interest rates (i_c), deposit rates (i_d) and central bank credit (B), among others[13]:

$$\frac{di_c}{de} > 0, \quad \frac{di_d}{de} \geq or \leq 0, \quad \frac{dB}{de} > 0$$

$$\frac{di_c}{di_{b1}} = \frac{1 + E[i_{b2}] + 2\rho B(1+i_{b1})Var[i_{b2}]}{1 - \rho(1+i_{b1})^2 Var[i_{b2}]\left(C_{ic}^D - (1-e)^2 D_{id}^S\right)} > 0$$

$$\frac{di_d}{di_{b1}} = (1-e)\frac{di_c}{di_{b1}} > 0$$

ρ is the parameter of constant absolute risk aversion of banks. i_{b1} and i_{b2} are the policy interest rates for periods 1 and 2, respectively. Notice that i_{b2} is a random variable in the beginning of period 1. The loan demand function $C^D(i_c)$ depends inversely in lending interest rates: $C^D_{ic} < 0$. The deposit supply function $D^S(i_d)$ depends positively on deposit interest rates: $D^S_{id} > 0$.

Based on these results it is possible to calculate the effect of RR on interest rate pass-through, namely: $\frac{d\left(\frac{di_c}{di_{b1}}\right)}{de}$ and $\frac{d\left(\frac{di_d}{di_{b1}}\right)}{de}$. Assuming that C^D_{ic} and D^S_{id} are constant, these derivates are:

$$\frac{d^2 i_c}{di_{b1}de} = \frac{\left(1 + E[i_{b2}] + 2\rho B(1+i_{b1})Var[i_{b2}]\right)\left(2\rho(1-e)(1+i_{b1})^2 Var[i_{b2}]D_{id}^S\right)}{\left(1 - \rho(1+i_{b1})^2 Var[i_{b2}]\left(C_{ic}^D - (1-e)^2 D_{id}^S\right)\right)^2} + \frac{2\rho\left(\frac{dB}{de}\right)(1+i_{b1})Var[i_{b2}]}{1 - \rho(1+i_{b1})^2 Var[i_{b2}]\left(C_{ic}^D - (1-e)^2 D_{id}^S\right)} > 0$$

$$\frac{d^2 i_d}{di_{b1}de} = (1-e)\frac{d^2 i_c}{di_{b1}de} - \frac{di_c}{di_{b1}} \geq or \leq 0$$

[13] A sufficient condition for these results to hold is $B \geq 0$.

Notice that the magnitude of the derivatives $\frac{di_c}{di_{b1}}, \frac{di_d}{di_{b1}}$, $\frac{d^2 i_c}{di_{b1} de}$ and $\frac{d^2 i_d}{di_{b1} de}$ depends on the value of central bank credit, *B*. The larger it is, the greater the interest rate pass-through and the impact of RR on interest rate pass-through[14]. A larger reliance on central bank credit implies a higher response of interest rate risk to policy rate increases.

[14] Mathematically this can be seen in the expressions for the respective derivatives. In the case of the impact of RR on interest rate pass-through, $\frac{dB}{de}$ depends positively on B, as shown in Betancourt and Vargas (2009).

Appendix 2

Remuneration-Adjusted Reserve Requirements

The remuneration-adjusted reserve requirement for a particular deposit is the RR ratio without remuneration that yields the same equilibrium prices in quantities in the deposit and credit markets as the official RR ratio with remuneration.

To compute it, the marginal net benefit of a deposit under the official RR ratio with remuneration is equated to the marginal net benefit of a deposit under the remuneration-adjusted RR ratio:

Under the official RR ratio, the marginal net benefit of a deposit for a competitive bank is: $i_c(1-r)-i_d+r\ i_r-CMg_d-(1-r)\ CMg_c$. Here i_c is the nominal lending interest rate, i_d is the nominal deposit interest rate, CMg_d is the marginal "operating" cost of deposits, CMg_c is the marginal "operating" cost of loans, r is the required reserve ratio and i_r is the remuneration on the RR. Under the remuneration-adjustment RR ratio, the marginal net benefit of a deposit for a competitive bank is: $i_c(1-e)-i_d-CMg_d-(1-e)\ CMg_c$. Here e is the remuneration-adjusted RR ratio[15].

For the equilibrium that emerges from both RR regimes to be the same, lending and deposit interest rates, as well as deposit and loan volumes (and hence marginal costs) must coincide. Thus, the remuneration-adjusted RR ratio may be found by equating the net marginal benefits in each regime:

$$e = r\left(1-\frac{i_r}{i_c-CMg_c}\right) \qquad \text{(A2-1)}$$

If some market power in the loan market or credit risk were allowed, the above expression should be modified as follows:

$$e = r\left(1-\frac{i_r}{\kappa\, i_c-CMg_c}\right)$$

Here $\kappa \in (0,1)$ represents a "mark-up" term if there is market power or the fraction of interest that is collected if there is credit risk. Notice that the adjustment basically takes into account the fact that the burden of the RR is smaller the larger RR remuneration, i_r, and the smaller the marginal revenue of a dollar lent (i.e. the opportunity cost of the RR).

The expression for the remuneration adjusted RR ratio (e) may be refined to consider all the details that must be included in the net marginal benefit of deposits. In this paper, the basic formula assuming perfect competition (A2-1) is used as a rough approximation. Still, this simple equation has at least two practical problems for empirical purposes. First, "operational" marginal costs of lending are not observed.

[15] Notice that at the bank optimum both net marginal benefits must be zero.

And, second, if this measure is used in lending interest rate regressions, there will be a strong correlation by construction, since the lending rate is used in the definition of *e*.

The second problem was solved by using the *average* overall lending interest rate for each year of the sample, so that monthly variation of *e* does not reflect lending interest rates changes. The first problem was solved by re-expressing equation (A2-1) as:

$$e = r\left(1 - \frac{i_r}{i_c\left(1 - \frac{CMg_c}{i_c}\right)}\right) \qquad \text{(A2-2)}$$

and calculating the term $\frac{CMg_c}{i_c}$ as:

$$\frac{CMg_c}{i_c} \approx \left(\frac{Total\ \ Operating\ \ Cost}{Total\ \ Loan\ \ Interest\ \ \text{Re}venue}\right)\left(\frac{Loans}{Total\ \ Assets}\right)$$

I.e. marginal costs of loans are approximated by average costs. The latter, in turn, are estimated on the basis of an attribution of total operating costs[16] to loans according to the fraction of loans in total assets or in the aggregate Loans + Deposits.

Formula (A2-2) was used to calculate the remuneration-adjusted RR ratio for each type of deposit *j = {Checking Accounts and Sight Deposits, Savings Accounts, CD and Bonds with maturities ≤ 18 months}*. When there were marginal RR (without remuneration), a weighted average of remuneration-adjusted average and marginal RR ratios was computed, using the amounts of deposits subject to average and marginal RR to construct the weights. Hence, for each month, t , and deposit, j , in the sample there are estimates of remuneration-adjusted RR ratios, $e_{j,t}$.

Finally, two measures of aggregate remuneration-adjusted RR ratios were calculated:

$$RARR_{h,t} = \sum_j \phi_{j,t}\ e_{j,t} \qquad (A2-3)$$

$$RARR_{c,t} = \sum_j \bar{\phi}_j\ \ e_{j,t} \qquad (A2-4)$$

(A2-3) allows for changes in deposit composition over time. In contrast (A2-4) uses a fixed deposit composition, corresponding to the sample average (May 2002 – November 2009).

[16] Total operating costs include fees, personnel and depreciation of fixed assets.