THE DAY-TO-DAY INTERBANK MARKET, VOLATILITY, AND CENTRAL BANK INTERVENTION IN A DEVELOPING ECONOMY

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Abstract

This paper investigates banking system instability vis-à-vis the day-to-day interbank market and monetary policy effectiveness in the Dominican Republic. The analysis reveals a negative relationship among excess banking system reserves and the interbank interest rate, and shows that in crisis 'news' affect the interbank rate's volatility asymmetrically and non-linearly. The paper also finds that the 2002-2003 banking crisis and the subsequent central bank intervention as a lender of last resort weakened monetary policy's transmission mechanism. These events undermined the ensuing stabilization effort, stressing the pervasive short-run trade-off between preserving macroeconomic stability and safeguarding financial stability, and the pitfalls of monetary policymaking in a highly volatility setting.

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1. Introduction

Is there a link between banking system instability, the interbank market, and monetary policy in developing countries? In principle, developments in the interbank market are fundamental to monetary policy effectiveness and to financial stability. And many monetary authorities target the short-end of the yield curve as a monetary policy strategy, therefore enhancing the role interbank interest rates play in day-to-day monetary policy implementation (e.g. Prati, Bartolini, and Bertola, 2003; Bindseil, 2004). But that is not generally the case in developing countries where fragile institutions, lack of central bank independence, and a paucity of monetary instruments can render monetary policy design and implementation extremely difficult (e.g. Montiel, 1991).

Even so monetary policy making in developing countries is gradually changing. Particularly, institutions throughout the developing world are moving away from traditional monetary aggregates and exchange rate targeting to an interest rate policy oriented towards achieving an inflation objective, in tandem with similar developments world-wide (e.g. Fry, Goodhart, and Almeida, 1996; Mishkin and Savastano, 2001; Schmidt-Hebbel and Werner, 2002; Bernanke and Woodford, 2004; Carstens and Jácome, 2005). That is why for these economies fostering monetary policy's ability to impinge on aggregate spending decisions via the term structure of interest rates is essential.

Yet there is relatively little knowledge about interbank markets in developing countries; and, importantly, on the linkages connecting banking soundness, the interbank market, and monetary policy effectiveness.[1] This paper aims at contributing to these topics. To this end the Dominican Republic is of interest as a case study. That becomes apparent in the light of the banking crisis that hit the Dominican economy during 2002-2003 and of the ensuing central bank intervention as a lender of last resort. More generally, as Devereux and Mendoza (2006, page 1) note, "The period of turbulence in emerging economies that started in 1994 with the Mexican collapse and continued unabated up to 2004 with the crisis of the Dominican Republic has raised several critical questions for researchers and policymakers…".

Financial crises' adverse impact is often aggravated by the idiosyncrasies, such as the stage of financial development, characterizing small emerging market economies like the Dominican Republic (e.g. Aghion, Bacchetta, and Banerjee, 2004). Notably, in this context engineering related policy responses is also challenging (e.g. Aghion, Bacchetta, and Banerjee, 2000). Further, in this type of economy capital markets are thin, and banks dominate the financial system. And to a great extent that is why in this context managing banking crises tends to be more difficult and costly than in more advanced systems.[2] In this regard the Dominican Republic's central bank bail out package for the troubled banks

[1] However, Martínez Pería (2002) investigates the impact of banking crises on money demand instability and the relation between monetary indicators and prices in a sample of countries. And Demirgüç-Kunt and Detragiache (2005) review a significant literature focusing on the causes and consequences of banking crises.

[2] Interestingly, to the traditional costs generated by banking crises in Latin American countries Halac and Schmukler (2004) add those incurred via the 'financial channel'. They show that the relatively poorer segments of the population not only suffer via the traditional costs of banking crises. On average, they are also net losers in the redistribution arising from the rescue of depositors in troubled financial institutions.

amounted to 20% of GDP in 2003.[3] Furthermore, in the Dominican Republic one commercial bank accounted for approximately 75% of this cost, i.e. 15% of GDP in 2003.

As in similar episodes, the banking system's widespread dollarisation exacerbated the Dominican Republic's banking crisis. The former was an offshoot from the financial liberalisation reforms put in place during the 1990s, which failed to concomitantly strengthen financial supervision. That is one factor explaining why the above developments ultimately led to a twin banking/currency crisis, high inflation, and diminished effectiveness of monetary and fiscal policies (See De Nicoló, Honohan, and Ize, 2005; Levy-Yeyati, 2006).[4]

To better understand and derive lessons from the Dominican Republic's 2002-2003 crisis the paper addresses the following questions. How are day-to-day interbank interest rate and excess aggregate banking system reserves related? What can be learned from the volatility underlying this relationship, particularly in crisis? Does the interbank interest rate contain relevant information on developments in the banking system's interest rates, and hence on monetary policy's likely ability to influence the economy via this channel? If so, is this channel reliable in crisis, which usually ends-up generating volatility and loss of credibility in economic policy?

In tackling these questions the paper proceeds as follows. Section 2 explains monetary policy in the Dominican Republic, and recounts the onset of the 2002-2003 banking and macroeconomic crisis and the ensuing policy response. Section 3 investigates the link between the interbank interest rate and aggregate excess banking system reserves,

[3] As a yardstick, Hoggarth, Reis, and Saporta (2002) find that the average cumulative cost of a banking crisis in emerging market economies is in the range of 15%-20% of annual GDP.
[4] Kaminski and Reinhart (1999) provide stylised facts on twin-crises.

and the volatility underlying this relationship. Section 4 analyses the link between the interbank and market interest rates in the Dominican Republic. Section 5 discusses the paper's findings. Section 6 provides concluding remarks.

2. Monetary policy and the Dominican Republic's 2002-2003 crisis

2.1. Monetary policy

The Central Bank of the Dominican Republic (CBDR) was founded, and the Dominican Peso (DR$) first introduced, in 1947. In terms of governance structure, the country's President appoints the Bank Governor to renewable two-year terms, and the Secretary of Finance and the Superintendent of Banks are members *ex-officio* of the Monetary Board. Six additional members complete the Board, and they are also appointed to renewable two-year terms.[5]

Historically, changes in banks legal reserve requirements, foreign exchange market interventions, and domestic credit to the government have been important in the CBDR's policy making. Policy is gauged via the evolution of net domestic assets – a base money component usually monitored via the IMF's financial programming approach and which serves as an intermediate variable in the monetary policy implementation process. However, from the beginning of the 1990s the CBDR also operates using alternative instruments. Within this approach short-term interest rates are critical to monetary policy implementation. This means that prices rather than quantities are increasingly more

[5] See http://www.bancentral.gov.do/ for further details on the CBDR's structure.

important to policy implementation. And in this setting the interbank interest rate should increasingly serve as the policy operating target and as the anchor to the term structure of interest rates. Table 1 highlights the interbank market's key institutional features.

The Bank intervenes in this market via open market operations (OMOs) in the shape of short-term papers called CBDR's Certificates of Participation. From 1995 the bank's open market committee designs this policy, and implements it through the institution's money desk from 2000. This practice has not, however, ruled-out using the more traditional instruments highlighted above, and particularly changes in reserve requirements. More likely they complement each other. But given the Dominican Republic's financial underdevelopment (reflected in an oligopolistic banking system, and in the thinness of equity, government, and exchange rate markets), and the monetary authorities' still limited credibility with the general public, the effectiveness of these indirect instruments is constrained. So in the end it could be argued that direct interventions still dominate the bank's toolkit in terms of effectiveness.

2.2. The Dominican Republic's 2002-2003 crisis

This section sketches key factors contributory to the Dominican Republic's 2002-2003 banking crisis, and explains the ensuing central bank intervention and macroeconomic instability. Figure 1 exhibits a timeline to elucidate these crucial developments, and Figure 2 shows basic macroeconomic indicators for the period 1990-2003. As has been well documented, the Dominican Republic enjoyed one of the fastest rates of economic growth in Latin America during the 1990s (e.g. Ocampo, 2004). However, the new millennium has brought several adverse shocks, including a major banking crisis costing over 20% of GDP in 2003.[6] Remarkably, the Dominican Republic's banking crisis actually took place shortly after a joint International Monetary Fund-World Bank Financial Sector Assessment Programme (FSAP) exercise was completed.[7]

Arguably, the financial dollarization that started in the 1990s exacerbated these events' ultimate impact on the economy (See De Nicoló, Honohan, and Ize, 2005; Levy-Yeyati, 2006). Some basic figures can help illustrate the financial dollarization process in the Dominican Republic. In 1996 dollar denominated deposits as a share of M2 (measured as currency plus current account and time deposits) amounted to just over 1.1%. In contrast, for 2002 the figure was 25%. Mirroring this development, in 1996 dollar loans as a share of M2 were 1.2%, whereas they stood at 28% at the end of 2002.[8] Unquestionably, financial liberalisation, an appreciated exchange rate, and weak bank supervision were at least partly responsible for the *de facto* banking system dollarization in the Dominican Republic; a further issue was the lower legal reserve requirement for dollar vis-à-vis peso deposits.

As hypothesized by Broda and Levy-Yeyati (2006), a positive correlation between currency risk and default risk, alongside a blind bank liquidation policy (i.e. one that does

[6] See, for instance, Hausmann, Rodrik, and Velasco (2004) on the Dominican Republic's 1990s growth and 2000s collapse.

[7] On that striking fact David Goldsbrough, of the IMF's Independent Evaluation Office (IEO), states that "The FSAP did its job; it identified major weaknesses in the regulation and supervision of the banking system as well as in balance sheets…But there was a failure on the part of the Fund in that the FSAP's message didn't get translated into its article IV surveillance. The staff report commented on different things about the financial system and essentially papered over the cracks. That was a mistake, and that meant there wasn't an effective Board discussion of those issues." *IMF Survey*, February 20, 2006, **vol. 35**, no. 4, page 62, International Monetary Fund, Washington, DC, USA.

[8] It is worth noting that regardless of banks' relative amount of foreign denominated assets and liabilities if borrowing companies are themselves unhedged against currency risk banks are also unhedged.

not discriminate on the basis of currency operations), may be fundamental in determining financial dollarization. Critically, lax financial supervision prevailed even after the wide-spread structural reforms of the 1990s. This was a latent threat to financial stability. And it was in this setting that in 2003 a large commercial bank (BANINTER) failed due to fraud.[9] From September 2002 this was reflected in the activity via the CBDR's usually dormant 'advances and rediscounts window' –exhibited in Figure 3. Parallel to these advances, required reserves were reduced from 20% to 17% between October 2002 and January 2003.

The crisis evolved, and from April 2003 more substantial liquidity assistance started flowing after the formal disclosure of a fully-fledged banking crisis. Figure 3 graphs liquidity assistance (totalling approximately 20% of GDP in 2003) together with the advances and rediscounts. From May 2003 the reserve requirement was actually increased from 20% to 25% for a 90-day period. This was part of the policy tightening cycle to mop-up excess liquidity and restore confidence in the Dominican Peso following the massive rescue effort.

But currency demand by dollar-indebted corporations experiencing swelling foreign exchange losses intensified exchange rate jumps in 2003. And that somehow led to a total of three banks receiving some form of assistance during 2003. [10] Specifically, BANINTER was the subject of intervention by the central bank, while Banco Mercantil and

[9] See *The New York Times* editorial article on the Dominican Republic's crisis (29 December 2003, section A, page 16, column 1).
[10] At the end of 2002 fourteen (14) banks operated in the Dominican Republic's commercial banking system: Banco Popular Dominicano, Banco de Reservas de la República Dominicana, Banco BHD, Banco Intercontinental (BANINTER), Banco Nacional de Crédito (BANCREDITO), Banco del Progreso, Banco Mercantil, Citibank, The Bank of Nova Scotia, Banco BDI, Banco Profesional, Banco Santa Cruz, Banco Comercial Santiago, and Banco VIMENCA.

BANCREDITO received liquidity assistance and were subsequently capitalised by private investors with central bank support.

The issues at hand and the corresponding policy reactions are closely linked to the literature on financial stability, the interbank market, and systemic risk. Research around these topics has many branches. However, those of immediate concern to this paper include the moral hazard implicit in the central bank's supervisory role, and the 'too-big-to-fail' (TBTF) policy-guiding principle. Along these lines Rochet and Tirole (1996) study the relationship between interbank lending and systemic risk. They advance, inter alia, insights on the TBTF policy. Rochet and Tirole argue that by protecting depositors of large insolvent banks the monetary authority could prevent a propagation of this failure through the system. They note that in practice a 'constructive ambiguity' rule underlies the authorities' expected actions.

Freixas, Parigi, and Rochet (2000) model the relationship between the interbank market, the financial system, and the central bank. They derive specific central bank intervention modalities depending on the threats to the banking system. Of particular relevance to this paper is the potential risk from a troubled bank that has an important position in the system –e.g. BANINTER in the Dominican Republic. (This bank was actually the largest in the system after its undisclosed business was made public.) Under certain assumptions, Freixas, Parigi, and Rochet show that this scenario can be typified as 'insolvency leading to contagion'. The corresponding type of central bank intervention is a 'bail out' implying a transfer of taxpayers' money.

Interestingly, Goodhart and Huang (2005) show that central bank interventions as a lender of last resort (LOLR) not only depend on the TBTF argument and contagion risk.

They argue that the decision to act as LOLR also depends on the trade-off between contagion risk and moral hazard. Somehow controversially, the Dominican Republic's central bank reaction to the crisis was to act as LOLR by intervening the main troubled bank (BANINTER). But this decision was taken in the light of somewhat ambiguous liquidity assistance legislation.[11] And this course of action exposed the central bank's judgment on contagion risk vis-à-vis moral hazard.

An IMF-backed programme aiming at restoring macroeconomic and financial stability followed the central bank's intervention.[12] This plan envisioned taking concrete actions in dealing with the more structural problems affecting the banking sector. These steps had the latent threat of contagion in mind, given the size of the main troubled bank. The central bank outlines its crisis managing approach in the memorandum of economic policies submitted to the IMF in August 2003. According to this document the bank's intervention in the crisis was aiming at "1) safeguarding the payments system; 2) protecting all legitimate depositors, 3) preventing payment of ineligible liabilities; and 4) preserving the value of the bank's assets."

Furthermore, the authorities explicitly laid-out the future course of action. This was a signal likely aimed at lessening the adverse impact from the ambiguity implicit in the

[11] The new Monetary and Financial Law no. 183-02, approved on December 3, 2002, dictates stricter criteria for determining the type and amount of central bank liquidity assistance to the banking system. However, this Law was not fully effective at the time of the crisis. The reason was that the new legislation set a time frame of eighteen (18) months, i.e. July 2004 at the latest, for the Law to be fully operational. Still, Goodfriend and Lacker (1999) argue that no institutional mechanism can by itself guarantee a central bank's commitment to limit its lending. They reckon that the only credible signal could come from building a reputation over time for lending restraint.

[12] A 24-month stand-by agreement (SBA) was formally approved by the IMF Board on August 29, 2003. The SBA was for a total of SDR 437.8 million. See http://www.imf.org/external/np/loi/2003/dom/01/index.htm for further details on the agreement.

process described so far. And so the memorandum of economic policies to the IMF stated that "the strategy seeks to enhance transparency and provide a legal framework for bank resolution that effectively protects all deposits in the system. It consists of four pillars: 1) addressing the problems of identified weak banks, 2) ensuring strong governance in the banking system, with safeguards against fraud, 3) implementing an improved bank resolution framework, and 4) strengthening prudential regulations and banking supervision".

3. The interbank interest rate, banking system reserves, and volatility

3.1. Analytical and institutional setting

Central banks attempt to control liquidity in the economy, and ultimately aggregate demand conditions, by sending signals through the interbank market using short-term interest rates. Hence this market is essential to a successful monetary policy implementation. A common framework to analyse the market for bank reserves is one in which the monetary authorities supply a given amount of high powered (base) money. And from this amount banks satisfy their demand for legal and excess reserves and the public its demand for cash. Thus the central bank's total money supply is always claimed.

Figure 4 portrays interest rate determination in the market for bank reserves. This graph shows that the demand for reserves by the private sector is negatively related to the interest rate. The central bank supplies a level of reserves S1 consistent with the private sector's demand D1. And this produces the interest rate R*. The monetary authority will provide additional reserves *RES**S2 at a rate R' to satisfy a higher demand D2 for reserves *RES'*. This will usually be carried out via 'overnight' standing facilities. Hence in this framework monetary policy operates through the central bank's control of the supply of reserves and their influence over short-term interest rates.

In a system like the Dominican Republic's, the legal reserve requirement *LRES* will be a fraction κ of deposits *D* in commercial banks

$$LRES = \kappa D, \tag{1}$$

with $0 < \kappa < 1$.

Changing κ is a direct monetary policy intervention –used in the Dominican Republic and developing countries in general (See Agénor and Montiel, 1999). However, note that changing reserve requirements was a feature of monetary policy making by, for instance, Germany's Bundesbank during the 1960s and 1970s, and by the US's Federal Reserve during the 1950s, 1960s, and 1970s (See Bindseil, Chapter 6). Under such an institutional arrangement banks hold (non-interest bearing) reserves in excess of the minimum requirement depending on market conditions, e.g. the amount of uncertainty regarding future deposits withdrawals. In fact, when reserve requirements are binding (due to their legal nature) only the demand for excess reserves is likely to be affected by market conditions (e.g. Sellon and Weiner, 1996). Accordingly, the analyses that follow model the link between aggregate banking system excess reserves and the interbank interest rate in the

Dominican Republic.[13] That link is expected to be negative as in, for instance, Poole's (1968) model of bank reserves management under uncertainty; see also Clouse and Elmendorf (1997).

In modelling this relationship a crucial factor is the central bank policy instrument, particularly *changes* in reserve requirements, and its link to the interbank interest rate. This focus is sensible given that during most of the sample at hand only limited open market operations (OMOs) took place. Albeit this was not the case from April 2003, after the bank fraud was unveiled, the use of OMOs (in the shape of primary-market central bank paper auctions) from this point aimed at dampening the effect from the liquidity assistance to the banking system. So during this period OMOs are not a good measure of exogenous policy shocks.

In contrast, the sample contains two major, unambiguous, changes in the legal reserve requirement κ. From October 2002 to January 2003 there was a temporary reduction in κ from 20% to 17%. And from May 2003 there was a temporary, 90-day, increase in κ from 20% to 25%. The paper incorporates these changes as exogenous policy shocks. Figure 5 plots the interbank interest rate and κ from 1999 to 2003. During most of this period there was macroeconomic and financial stability, so the graph mostly reflects normal activity in the interbank market. However, κ was reduced from 20% to 17% between October 2002 and January 2003, following the onset of activity via the central

[13] Bernanke and Blinder (1988) study bank reserves' role in a closed economy. These authors consider an IS/LM framework in which both money and credit are important. Within this framework the availability of bank reserves, and hence developments in reserve requirements and excess reserves, impact market interest rates. For instance, a higher reserve requirement κ will decrease banks' lending resources and probably excess reserves as well. And this may ultimately increase the market interest rate. In practice this kind of effect can be expected to propagate to the rest of the economy working its way via the interbank market.

bank's advances and rediscounts window. Questionably, this policy mix aimed at relaxing the monetary policy stance and safeguarding financial stability. But with hindsight it is evident that the banking crisis was deeply rooted and not just a liquidity problem.

Yet Figure 5 shows that this policy shift appears to have been successful in bringing to a halt the increase in the interbank interest rate. However the interbank interest rate shot-up immediately after κ's return to 20%. This reflects the thrust of the lurking banking crisis, not yet evident from the interbank interest rate's normal levels.

Figure 5 shows that the temporary increase in κ to 25% from May 2003 had a significant impact on the interbank interest rate. Actually, the upward trend in the (by then already abnormally high) interbank interest rate following the increase in κ seems to halt only after this ratio's return to 20%. These patterns hint to potential asymmetries and non-linearities amongst these variables: policy contractions appear to be more effective than expansions. The econometrics analyses that follow should further illuminate these developments.

3.2. The interbank interest rate and aggregate excess reserves

The econometric modelling employs daily time series of aggregate excess reserves (millions of Dominican Pesos), that is reserves above/below the legal requirement κ, and of the interbank interest rate (expressed in percentage points). The data set ranges from January 1999 to November 2003 –a total of 1,210 observations on each variable, and the source is the Central Bank of the Dominican Republic. As a preliminary evaluation of the economic time series Figure 6 plots aggregate excess reserves and the interbank interest rate. The graph shows the expected negative relationship between these variables.

In modelling this relationship the investigation follows a two-stage plan. Firstly, it analyses interbank interest rates as a function of aggregate excess reserves, exogenous policy shocks, and institutional and calendar features using a dynamic time series model. Secondly, the inquiry uses the model selected in the first stage as the baseline specification for the mean equation in a generalized autoregressive conditional heteroscedasticy (GARCH) framework (See Bollerslev, 1986; Hentschel, 1995).

The paper models the mean equation using a general-to-specific (GETS) automatic procedure. This technique makes operational the ideas in Hoover and Perez (1999) -which advanced an algorithm to reproduce the GETS methodology- alongside Hendry's approach to empirical econometric modelling (e.g. Hendry, 1995). The automated GETS approach starts the specification search from a general unrestricted model (GUM) assumed to represent the data generating process (DGP). On the approach's reliability, Monte Carlo experiments show that estimates from the computer programme PcGets are close to those recovered from the actual DGP (e.g. Hendry and Krolzig, 2005).

The specification search process starts from the following GUM

$$R_t = \alpha + \sum_{i=1}^{20} \lambda_i R_{t-i} + \sum_{j=0}^{20} \phi_j RES_{t-j} + \beta_1 POLEX_t + \beta_2 POLCON_t + \eta DEC_t + \delta TAX_t + u_t \, . \tag{2}$$

In (2) r is the interbank interest rate and *RES* aggregate banking system excess reserves, while the other variables are as defined above. α is a constant term, while λ, ϕ, $\beta_1, \beta_2,$ η and δ are parameters to be determined empirically. In (2) the key expected coefficients are $\phi < 0$, $\beta_1 < 0$ and $\beta_2 > 0$.

Equation two contains two dummy variables. These capture the reduction and increase in κ and are named *POLEX* and *POLCON*, respectively. Particularly, *POLEX* takes a value of -1 when κ was lower, and 0 otherwise. And *POLCON* takes a value of 1 when κ was higher, and 0 otherwise. A cautioning word is needed on what the paper is expecting from these proxies for exogenous policy changes. Basically, their objective is capturing what could be called monetary policy 'signaling' effects over and above those directly transmitted via changes in aggregate banking system excess reserves following a change in the legally binding reserve requirement κ. This applies in view of the fact that a change in κ is a direct instrument to affect the quantity of liquidity in the system, it also likely impinges on the price of money in the interbank market and the rest of the economy indirectly.

Additionally, in modelling the link between the interbank interest rate and aggregate excess reserves the exercises that follow consider institutional and calendar features. During the Christmas period commercial banks face large withdrawals mainly due to the increased activity in the commercial sector. So the study accounts for this factor by constructing a dummy variable (*DEC*) with a value of 1 during December and 0 otherwise. Also, in March and April commercial banks report and pay taxes. And they make these payments via the government's commercial bank (Banco de Reservas de la República

Dominicana), decreasing the system's reserves during this period. Hence the analysis incorporates a dummy (*TAX*) taking the value of 1 during March and April, and 0 otherwise. The analyses that follow include *DEC* and *TAX* in the mean equation.

Equation (2) is an autoregressive distributed lag (ADL) model of order 20 (See Hendry, Pagan, and Sargan, 1984), thus capturing developments in the previous month's banking activity. Importantly, r and RES are integrated of order zero, and hence the paper models equation (2) as a stationary system.[14]

Computing equation (2) using PcGets and using it as the mean equation in a GARCH model (Bollerslev, 1986) yields the following specification[15]

$$R_t = \alpha + \lambda_1 R_{t-1} + \lambda_2 R_{t-2} + \lambda_3 R_{t-3} + \lambda_5 R_{t-5} + \lambda_9 R_{t-9} + \phi RES_{t-3} + u_t , \tag{3a}$$

$$h_t = \alpha_0 + \alpha_1 (u_{t-1} - \vartheta)^2 + \psi D_{t-1} (u_{t-1} - \vartheta)^2 + \beta_1 h_{t-1} . \tag{3b}$$

The system of equations (3a) and (3b) is quite flexible as it allows for asymmetric (ϑ) and threshold (ψ) in the variance (3b) equation. That is, an ATGARCH (1, 1) specification. In this framework $D_{t-1} = 1$ if $u_{t-1} \prec \vartheta$, and zero otherwise. Importantly, this specification encompasses several members from the GARCH family (See Hentschel, 1995). The

[14] The augmented Dickey-Fuller test statistic for RES is -4.271, and for r is -4.351, both rejecting the unit root null at the 1% level.
[15] See, for instance, Bartolini and Prati's (2003) analysis of overnight rates in the Euro area and the United States.

investigation estimates the model using the maximum likelihood (ML) technique and computes robust standard errors.

Table 2 reports two models and the first column contains the benchmark ATGARCH specification. However, since the threshold effect is not significant, the AGARCH specification in the last column is preferred; the model comparison statistics reported at the bottom of Table 2 endorse reducing the model in this fashion. Most of the coefficients reported in Table 2's column 2 are significant at least at the 5% level. The exceptions are those on aggregate excess reserves in the mean equation, and on the asymmetric component in the variance equation. In this regard it is worth noting that the asymmetry coefficient's t-ratio is only 1.55, significant at the 12% level, but not including it in the specification leads to deterioration in the model's fit according to a battery of information and model comparison statistics (not reported).

The above findings are economically sensible and bear significant implications. The estimated coefficient ϕ implies that, on average, a 1 billion pesos reduction in aggregate excess banking system reserves increases the interbank interest rate by 6 basis points –a 'liquidity effect'. A crucial coefficient reported in Table 2's column 2 is ϑ, capturing asymmetric effects in the variance equation. It shows that shocks affecting the interbank interest rate have asymmetric and non-linear effects on its volatility. For example, a negative shock to aggregate banking system reserves will generate a relatively larger increase in the interbank interest rate and its volatility. This is reflected in the rightward-tilted 'news impact plot' in Figure 7 (See Engle and Ng, 1993) -graphed together with a cubic spline for ease of interpretation. This asymmetric, non-linear, pattern reinforces the less formal evidence portrayed by Figure 5 on the impact from changes in reserve requirements to the interbank interest rate. These results are also in line with the arguments in Clouse and Elmendorf (1997)

Also, the outcomes likely reveal, inter alia, banking failure's impact on market conditions. These events initially generate large uncertainty, which tends to lower the expected net real return on real assets. And this uncertainty, in turn, affects asset and output markets. Additionally, the relative duration of bank assets and liabilities is critical. For instance, suppose that in crisis banks have longer liabilities duration due to a higher number of non-performing loans. In that case a negative shock to the interbank interest rate will have a larger impact -as the above results show. A more direct link between financial crisis and interest rate developments arises from the fact that due to banking failure, and the resulting uncertainty, the total demand for reserves exceeds the existing stock. And that leads to increasing interest rates and to higher volatility.

Figure 8 shows results from recursively analyzing the final AGARCH model, focusing on the critical asymmetric component in the variance equation. The graph reflects the increased significance of the asymmetric volatility indicator's t-ratio roughly from September 2002. And this point marks the beginning of the monetary authorities' liquidity assistance provision to the main troubled bank (BANINTER) through the 'advances and rediscounts window' (See Figure 3). Therefore in times of financial stability positive or negative shocks seem to have similar effects. In contrast, during banking crisis negative impacts generate, on average, larger volatility of interbank interest rates than positive ones.

4. Interest rates modelling

The paper's findings so far have important implications for monetary policy and for financial stability. Essentially, they reveal that adverse developments in the interbank market, such as aggregate banking system reserves deficiencies, can trigger volatility and potentially become a threat to the whole financial system. In fact, in the Dominican Republic the events under analysis contributed to a significant loss of credibility of the monetary authorities with the general public and to a consequential crisis in 2003.

But which are the main implications for monetary policy design and implementation? In principle, the central bank attempts to control liquidity by affecting quantitative monetary indicators like net domestic assets, and ultimately through developments in the interbank market and the term structure of interest rates. Hence by analyzing the latter relationship one could better understand whether or not central bank policy is likely to influence aggregate spending decisions via this channel. The expectations theory of the term structure of interest rates underpins the rationale behind monetary policy's potential to affect economy activity via short-term rates.

In what follows the paper employs this model as a benchmark, bearing in mind the *ex-ante* limitations imposed on this exercise by the Dominican Republic's underdeveloped financial system. Particularly, it is important to remember that in the Dominican Republic no meaningful government securities or equity markets exist. And the banking system, within which there is very limited competition, is the main provider of financial instruments. Yet even in this setting putting to use the basic intuition behind the expectations theory of the term structure of interest rates seems relevant[16].

Under the expectations theory of the term structure the *n*-period interest rate equals an average of the current short-term interest rate and the future short-term rates expected to hold over the *n*-period horizon.[17] To illustrate the link between monetary policy and interest rates consider a simple two-period setup. So if $\Omega_t \equiv i_{2,t}$ is the long interest rate the term structure is

$$\Omega_t = \frac{1}{2}\left(i_t + \mathrm{E}_t i_{t+1}\right). \tag{4}$$

In equation (4) E_t is the expectations operator. This equation implies that the term structure of interest rates depends on short-term rates and market expectations of short-term rates. Importantly, since monetary policy affects short-term rates Ω_t will depend on expectations of future policy actions. This relationship is, however, fairly complex to model in practice.

The literature estimates a positive relationship between the central bank's operating policy interest rate, such as the federal funds rate in the United States, and short-term rates. But the link between policy and market rates is less clear-cut. For instance, Cook and Hahn (1998) find that the relationship between policy and market rates in the United States has

[16] For instance, Sarno and Thornton (2003) model the United States' overnight federal funds rate and the 3-month Treasury bill rate taking an 'agnostic' approach, rather than focusing on testing a particular theory. That is a sensible strategy to follow in modeling interest rates in the context of a small emerging market economy like the Dominican Republic.
[17] Shiller (1990) provides a thorough analysis of the term structure of interest rates. See also Walsh (2003).

broken-down in some periods. Several authors try to explain this problem. Kuttner (2001) argues that this finding arises because previous studies fail to distinguish between anticipated and surprise changes in Federal Reserve policy actions. Rudebusch (1995), for instance, pays particular attention to the role of expectations in this context.

Turning to the relevant data for the Dominican Republic, Figure 9 shows the relationship between the interbank interest rate and the average banking system interest rate from 1999 to 2003. This graph reveals a close association between the two rates. But towards the end of the plot, from April 2003 when the banking system crisis was made public, the interbank interest rate shoots-up. This was a result of two key factors. One was the higher risk in the system -investigated in the previous section. The other was the subsequent move to tighten monetary policy in order to curtail the repercussions from the banking system rescue operations and the ensuing macroeconomic crisis. Yet Figure 9 shows that market rates were not moving proportionally to interbank interest rates. So the central bank's leverage over market rates was somewhat curtailed. And this probably jeopardized achieving crucial monetary targets stipulated in the 24-month stand-by agreement with the IMF approved on August 29, 2003.[18]

4.1. Vector autoregressions (VARs) modeling

As a preliminary, exploratory, step in attempting to achieve a better understanding regarding the interbank interest rate's impact on banking system rates the paper employs

[18] In fact, the first revision of this agreement in October 2003 was not completed, and the programme went off-track. A revised programme was negotiated during the first quarter of 2004.

bivariate vector autoregressions (VARs). Stock and Watson (2001) remark that due to the rich lag dynamics intrinsic to VARs modelling statistics derived from these estimations, such as impulse response functions, tend to be more informative than the usual regression coefficients (See also Christiano et al., 1999).

The analysis proceeds by computing a basic unrestricted VAR specification containing the interbank interest rate and the average banking system interest rate. The model considers a lag length of twenty for each variable.[19] Figure 10 displays the one unit (1%) impulse response functions generated by shocking the interbank rate equation. That is, the impact of surprise, non-systematic, developments in the interbank interest rate on market rates.

The graph exhibits two panels containing the interbank interest rate's own response and the average banking system interest rate. The impulse responses are displayed together with two standard error bands generated by running 1,000 Monte Carlo simulations. Shocks to the interbank interest rate on itself are short-lived, with the major initial impact lasting around two weeks. This corresponds to the series being stationary, as reported above.

In contrast, for each surprise 1 percentage point shock to the interbank interest rate the banking system interest rate increases up to 20 basis points above its baseline trajectory in just under a month. Thus the ratio of changes in the banking system rate $\left(\Delta R^{B}\right)$ to changes in the interbank rate (ΔR) is increasing. Following this duration the central response persists at around 15 basis points above the baseline trajectory. But the two

[19] Note that for the banking system rate an ADF test rejects the unit root null at the 1% level (ADF = -5.004).

standard error bands imply that the trajectory after three months could be in the 10-25 basis points range.

4.2. Interest rate volatility modeling

In further analyzing R and R^B the investigation follows a two-stage strategy as in section 3.3. The specification search process starts from the following GUM

$$R_t^B = \alpha + \sum_{i=1}^{30} \delta_i R_{t-i}^B + \sum_{j=0}^{30} \varphi_j R_{t-j} + \omega_t . \tag{5}$$

In (5) α is a constant term, δ and φ are parameters to be determined empirically, and the key expected coefficient is $\varphi > 0$. This basic specification is akin to, for instance, that employed by Cook and Hahn (1989) in modelling the relationship between the federal funds rate and market interest rates in the United States (but note that Cook and Hahn, 1989, employ an ‘event approach’). The second stage uses the preferred model, resulting from reducing equation (5) using PcGets, as the mean equation in the following two-equation GARCH system

$$R_t^B = \alpha + \delta_1 R_{t-1}^B + \delta_2 R_{t-2}^B + \delta_4 R_{t-4}^B + \delta_5 R_{t-5}^B + \delta_6 R_{t-6}^B + \delta_{13} R_{t-13}^B + \delta_{20} R_{t-20}^B + \delta_{23} R_{t-23}^B$$

$$+ \varphi_4 R_{t-4} + \varphi_{19} R_{t-19} + u_t, \tag{6a}$$

$$h_t = \alpha_0 + \alpha_1 (u_{t-1} - \vartheta)^2 + \psi D_{t-1} (u_{t-1} - \vartheta)^2 + \beta_1 h_{t-1}. \tag{6b}$$

As in the model for the interbank interest rate and banking system reserves, the system of equations 6a and 6b allows for asymmetric (ϑ) and threshold (ψ) effects in the variance equation. The investigation estimates the model using the maximum likelihood (ML) technique and reports robust standard errors.

Table 3 displays the results from the econometric modeling. The first column reports the benchmark ATGARCH model. However, since the threshold effect is not significant, the AGARCH model in the last column is preferred and model comparison statistics reported at the bottom of Table 3 endorse reducing the model in this fashion. Likewise, the final model passes autocorrelation and ARCH tests.

All the coefficients in the mean and variance equations are significant at the 1% level. In the mean equation the lagged dependent variable R^B displays a decaying lag profile. Importantly, the net effect from R to R^B is positive, as expected. Computing the model recursively and calculating $\varphi_4 + \varphi_{19}$ for each period implies that, on average, during the phase spanning 1999-2003 for every 100 basis points increase in the interbank interest rate, R , the banking system rate, R^B , increases by just over 10 basis points. So there is a meaningful statistical link among these two rates. And these results are close to those arising from the preliminary VARs modeling in the previous section.

However, Figure 11 graphs the sum of the key mean-equation recursive coefficients ($\varphi_4 + \varphi_{19}$). Remarkably, the graph shows a collapse in the interbank interest rate's link with the banking system interest rate following May 2003 –i.e. after the monetary authorities' pronouncement with reference to the problems in the banking system. Turning to the variance equation, the asymmetry coefficient (ϑ) shows that, on average, shocks increasing the banking system interest rate ('bad news') have a larger impact on its volatility. However, the asymmetry effect and the associated non-linearity are rather small.

5. Discussion

The VARs and volatility modelling exercises in the previous section reveal the existence of a dynamic link amongst interest rates in the Dominican Republic. However, the investigation also shows that in the Dominican Republic monetary policy's potential to influence the economy via the interest rate channel virtually collapsed after April 2003, following the unveiling of a major banking crisis due to fraud and weak banking supervision.

What led to the breaking-down of the monetary policy transmission mechanism? One key reason behind this development is that in crisis the risk of loan default increases, leading to an erosion of commercial banks' balance sheets. And the Dominican economy actually contracted in 2003. Hence, arguably, a by-product was that the central bank's goal of tightening liquidity conditions partially failed. From the monetary policy implementation point of view this was perhaps the case due to one key factor: the bank was trying to achieve somewhat conflicting goals.

Particularly, one goal was sterilising the excess liquidity in the economy generated by the assistance to the banking system. This goal was parallel to curtailing the capital outflows (resembling developments analysed in the 'sudden stop' literature, e.g., Mendoza, 2006), the related exchange rate depreciation triggered by the banking crisis, and the ensuing inflationary pressures; and, critically, the authorities' loss of credibility with the public. According to the orthodox view on the subject, to ultimately stabilise the economy returns from peso denominated instruments in relation to dollar ones had to increase.

Overall, it seems like these goals, which call for a tighter monetary policy stance, are in conflict with the need to stimulate an economy facing contraction, which demands a looser monetary policy stance. Further, traditional IMF-conditionality focusing on targets for net domestic assets do not help much in this scenario. To the contrary, this element can guide central banks to implementing unwarranted monetary policy actions -like raising interest rates to comply with a net domestic assets ceiling regardless of the expected inflation path.[20]

In a market with bank losses raising the interest rate actually increases the risk profile of the loan portfolio across the whole financial system (e.g. Stiglitz and Weiss, 1981), and accelerates currency depreciation; the absence of widespread hedging strategies complicates this scenario. Hence this situation demands inter-temporally analysing the

[20] See Fraga et al.'s (2004) account of how the IMF's traditional conditionality was adapted for monitoring Brazil's inflation targeting strategy in the context of a Fund-backed stabilisation programme. See also Easterly (2006).

trade-off between achieving price stability and safeguarding the financial system. But even if the monetary authorities understand that the overriding goal of monetary policy is macroeconomic vis-à-vis financial stability the private sector could be reluctant to accommodate a policy stance that might further its demise.

Aghion, Bacchetta, and Banerjee (2000) advance some ideas on this problem. Essentially, they model an economy in which firms are financially constrained and hold debt in domestic and foreign currency -a scenario comparable to the Dominican Republic's depicted in section 2. Aghion, Bacchetta and Banerjee show that, for a certain level of financial development, the optimal interest rate policy in response to a crisis is to decrease the interest rate.

Céspedes, Chang, and Velasco (2003), and Christiano, Gust, and Roldos (2004) advance related models addressing monetary policy's response to crises. The first work highlights financial vulnerability and firms' liability dollarization, whereas the second paper emphasises the role of binding collateral constraints on monetary policy's transmission. The papers show that, under certain conditions, standard interest rate policy usually employed in fighting a crisis is not necessarily the best way forward.

The Dominican Republic followed the orthodox path. Figure 5 clearly shows that increasing the reserve requirement was somewhat initially successful in tightening the monetary policy stance from May 2003 -as reflected by the interbank interest rate. However, as argued above, this contractionary move was not transmitted to the rest of the system. This was probably due to the downturn already faced by the economy, and to the prevailing uncertainty and the increasing adverse selection problems.

In a small open-economy setting an additional pervasive factor can complicate the monetary authorities' liquidity tightening effort and increasing the relative returns from Peso denominated instruments. For instance, Flood and Rose (2002) show that exchange rate depreciation in 23 developed and developing countries generally follow interest rate differentials. And exchange rate depreciation generally fuels inflation and inflationary expectations. This was certainly the case in the Dominican Republic –with inflation escalating to its highest levels since the beginning of the 1990s.[21]

Possibly, the serious problems highlighted above were exacerbated by the fact that the Central Bank of the Dominican Republic still relies on the effectiveness of relatively limited instruments, such as changes in reserve requirements. In addition, and perhaps more importantly, monetary policy making is to-day restricted by the underdeveloped nature of the Dominican Republic's financial system. These major institutional shortcomings were not fully addressed during the 1990s, even though this period saw the implementation of an across-the-board and fairly successful reforms package. And this implied that in the event of a major banking and macroeconomic crisis, as the one faced by the economy in 2002-2003, restoring credibility and stability would prove difficult.[22]

Summarizing, the Dominican Republic's experience highlights the dangers of pursuing an expansionary monetary policy (in the shape of a banking rescue effort) in responding to a financial crisis in a developing economy context. And it also reminds us that traditional IMF-style stabilization policies may not always and everywhere work as

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[21] Frankel (2005), however, shows that the pass-through coefficient from exchange rate to import prices significantly fell in the 1990s for a large sample of developing countries.

[22] Further, it is worth noting that in the fiscal front "Inadequate fiscal-management practices undermined the intended fiscal restraint…" (Finger and Mecagni, 2007, page 4).

expected. So probably the best insurance against a crisis is fostering solid institutions. Alas, that is easier said than done.

6. Concluding remarks

The paper studies the interbank market, volatility, and the central bank intervention as a lender of last resort in the Dominican Republic. The analysis employs daily data comprising a period of declining aggregate banking system reserves, banking collapses, and increasing interbank interest rate volatility. The results highlight the critical asymmetries arising during crisis. The paper also finds that the transmission mechanism of monetary policy weakened during the 2002-2003 banking and macroeconomic crisis, undermining the IMF-supported stabilization effort to restore credibility and macroeconomic stability.

These problems led to a move towards bettering monetary policy institutions. Following the breaking-down of the transmission mechanism of monetary policy in the second half of 2003, largely mirrored in the central bank's inability to comply with a series of monetary targets agreed with the IMF, at the beginning of 2004 the monetary board introduced an 'overnight window'. This standing facility has Lombard and deposit rates, and these rates are expected to serve as reference bands within which the interbank rate floats. That is a 'symmetric corridor system' analogous in principle to, for instance, Canada's and New Zealand's (e.g. Bindseil, 2004; Whitesell, 2006). Once this mechanism is properly operational the interbank market rate should more solidly help in anchoring the term structure of interest rates. And in turn that should allow for a more effective monetary policy implementation.

References

Agénor, Pierre-Richard, and Peter J. Montiel (1999) *Development macroeconomics*, second edition, Princeton University Press.

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee (2000) A simple model of monetary policy and currency crises, *European Economic Review*, **44**, 728-738.

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee (2004) Financial development and the instability of open economies, *Journal of Monetary Economics*, **50**, 1077-1106.

Bartolini, Leonardo, and Alessandro Prati (2003) The execution of monetary policy: A tale of two central banks, *Economic Policy*, 435-467, October.

Bernanke, Ben S., and Alan S. Blinder (1988) Credit, money, and aggregate demand, *American Economic Review Papers and Proceedings*, **78**, 435-439.

Bernanke, Ben S., and Michael Woodford (Eds.) (2004) *The inflation targeting debate*. Chicago, University of Chicago Press.

Bindseil, Ulrich (2004) *Monetary policy implementation: Theory, past, and present*, Oxford University Press.

Bollerslev, Timothy (1986) Generalised autoregressive conditional heterocedasticity, *Journal of Econometrics*, **31**, 307-27.

Broda, Christian, and Eduardo Levy Yeyati (2006) Endogenous deposit dollarization, *Journal of Money, Credit, and Banking*, 38, 963-988.

Carstens, Agustín S., and Luis I. Jácome H. (2005) Latin American central bank reform: Problems and challenges, International Monetary Fund Working Paper 05/114, Washington, D.C., June.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco (2003) IS-LM-BP in the Pampas, *IMF Staff Papers*, **50**, special issue, 143-156.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans (1999) Monetary policy shocks: what have we learned and to what end? Chapter 2 in John B. Taylor and Michael Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1-A, pages 65-148, Elsevier Science Publishers, The Netherlands.

Christiano, Lawrence J., Christopher Gust, and Jorge Roldos (2004) Monetary policy in a financial crisis, *Journal of Economic Theory*, **119**, 64-103.

Clouse, James A., and Douglas W. Elmendorf (1997) Declining required reserves and the volatility of the federal funds rate, Federal Reserve Board Finance and Economics Discussion Series 1997-30, Washington, D.C.

Cook, Timothy, and Thomas Hahn (1989) The effect of changes in the federal funds rate target on market interest rates in the 1970s, *Journal of Monetary Economics*, **24**, 331-351.

Demirgüç-Kunt, Asli, and Enrica Detragiache (2005) Cross-country empirical studies of systemic bank distress: A survey, *National Institute Economic Review*, no. 192, pages 68-93.

De Nicoló, Gianni, Patrick Honohan, and Alain Ize (2005) Dollarization of bank deposits: Causes and consequences, *Journal of Banking and Finance*, **29**, 1697-1727.

Devereux, Michael B., and Enrique G. Mendoza (2006) Emerging markets and macroeconomic volatility: Lessons from a decade of financial debacles, *Journal of International Economics*, **69**, 1-5.

Easterly, William (2006) An identity crisis? Examining IMF financial programming. Forthcoming, *World Development.*

Engle, Robert F., and Victor K. Ng (1993) Measuring and testing the impact of news on volatility, *Journal of Finance,* **48**, 1749-1778.

Flood, Robert P., and Andrew K. Rose (2002) Uncovered interest parity in crisis, *IMF Staff Papers*, **49**, 252-266.

Fraga, Arminio, Ilan Goldfajn, and André Minella (2004) Inflation targeting in emerging market economies, *NBER Macroeconomics Annual 2003*, 365-400, MIT Press, Cambridge, MA.

Frankel, Jeffrey A. (2005) Contractionary currency crashes in developing countries, *IMF Staff Papers*, **52**, 149-192.

Freixas, Xavier, Bruno M. Parigi, and Jean-Charles Rochet (2000) Systemic risk, interbank relations, and liquidity provision by the Central Bank, *Journal of Money, Credit, and Banking*, **32**, 611-638.

Fry, Maxwell J., Charles A.E. Goodhart, and Alvaro Almeida (1996) *Central banking in developing countries: Objectives, activities and independence*, Routledge and Bank of England, London.

Goodhart, Charles A.E., and Haizhou Huang (2005) The lender of last resort, *Journal of*

Banking and Finance, **29**, 1059-1082.

Goodfriend, Marvin, and Jeffrey M. Lacker (1999) Limited commitment and central bank lending, Federal Reserve Bank of Richmond *Economic Quarterly*, **85**, 1-27.

Halac, Marina, and Sergio Schmukler (2004) Distributional effects of crises: The role of financial transfers, *Economía-Journal of the Latin American and Caribbean Economic Association*, **5 (1)**, 1-67.

Hausmann, Ricardo, Dani Rodrik, and Andrés Velasco (2004) Growth diagnostics, mimeo, JFK School of Government, Harvard University, Cambridge, MA.

Hendry, David F. (1995) *Dynamic econometrics*, Oxford University Press, Oxford.

Hendry, David F., Adrian R. Pagan, and J. Denis Sargan (1984) Dynamic specification, Chapter 18 in Zvi Griliches and Michael Intrilligator (eds.), *Handbook of Econometrics*, Volume 2, 1231-1303. Elsevier Science Publishers, The Netherlands.

Hendry, David F., and Hans-Martin Krolzig (2005) The properties of automatic *GETS* modelling, *Economic Journal*, **115**, C32-C61.

Hentschel, L. (1995) All in the family: Nesting symmetric and asymmetric GARCH models, *Journal of Financial Economics*, **39**, 71-104.

Hoggarth, Glen, Ricardo Reis, and Victoria Saporta (2002) Costs of banking system instability: Some empirical evidence, *Journal of Banking and Finance*, **26**, 825-855.

Hoover, Kevin D., and S. J. Perez (1999) Data mining reconsidered: Encompassing and the general-to-specific approach to specification search, *Econometrics Journal*, **2**, 167-191.

Finger, Harald, and Mauro Mecagni (2007) *Sovereign debt restructuring and debt sustainability: An analysis of recent cross-country experience*, Occasional Paper 255, International Monetary Fund, Washington, D.C.

Kaminsky, Graciela L., and Carmen M. Reinhart (1999) The twin crises: The causes of banking and balance-of-payments problems, *American Economic Review*, **89**, 473-500.

Kuttner, Kenneth (2001) Monetary policy surprises and interest rates: Evidence from the Fed funds futures market, *Journal of Monetary Economics*, **47**, 523-544.

Levy-Yeyati, Eduardo (2006) Financial dollarization: evaluating the consequences, *Economic Policy*, 61-118, January.

Martínez Pería, Maria Soledad (2002) The impact of banking crises on money demand and price stability, *IMF Staff Papers*, **49**, 267-312.

Mishkin, Frederic S., and Miguel A. Savastano (2001) Monetary policy strategies for Latin America, *Journal of Development Economics*, **66**, 415-444.

Montiel, Peter J. (1991) The transmission mechanism for monetary policy in developing countries, *IMF Staff Papers*, **38**, 83-108.

Ocampo, José Antonio (2004) Latin America's growth and equity frustrations during structural reforms, *Journal of Economic Perspectives*, **18**, 67-88.

Prati, Alessandro, Leonardo Bartolini, and Giuseppe Bertola (2003) The overnight interbank market: Evidence from the G-7 and the Eurozone, *Journal of Banking and Finance*, **27**, 2045-2083.

Poole, William (1968) Commercial bank reserve management in a stochastic model: Implications for monetary policy, *Journal of Finance*, 23, 769-791.

Rochet, Jean-Charles, and Jean Tirole (1996) Interbank lending and systemic risk, *Journal of Money, Credit, and Banking*, **28**, 733-762.

Rudebusch, Glenn D. (1995) Federal Reserve interest rate targeting, rational expectations, and the term structure, *Journal of Monetary Economics*, **35**, 245-274.

Sarno, Lucio, and Thornton, Daniel L. (2003) The dynamic relationship between the federal funds rate and the Treasury bill rate: An empirical investigation *Journal of Banking and Finance,* **27**, 1079-1110.

Schmidt-Hebbel, Klaus, and Alejandro M. Werner (2002) Inflation targeting in Brazil, Chile, and Mexico: Performance, credibility, and the exchange rate, *Economía-The Journal of the Latin American and Caribbean Economic Association*, **2 (2),** 31-89.

Sellon, Jr., Gordon H., and Stuart E. Weiner (1996) Monetary policy without reserve requirements: Analytical issues, Federal Reserve Bank of Kansas City, *Economic Review,* Fourth Quarter, 5-24.

Shiller, Robert J. (1990) The term structure of interest rates, Chapter 13 in Benjamin H. Friedman and Frank H. Hahn (Eds.), *Handbook of Monetary Economics*, Vol. 1, Elsevier Science Publishers, The Netherlands.

Stiglitz, Joseph, and A. Weiss (1981) Credit rationing in markets with imperfect information, *American Economic Review,* **71**, 393-410.

Stock, James H., and Mark W. Watson (2001) Vector autoregressions, *Journal of Economic Perspectives,* **15**, 101-115.

Walsh, Carl E. (2003) *Monetary theory and policy*, second edition, MIT Press, MA.

Whitesell, William (2006) Interest rate corridors and reserves, *Journal of Monetary Economics*, **53**, 1177-1195.

Table 1
Institutional features of the Dominican Republic's interbank market, 1999-2003

Legal reserve requirements	20% of banks' liabilities. From October 2002 to January 2003 there was a temporary reduction to 17%. From May 2003 5%, 90-day, temporary increase.
Computation period for the reserve requirement	Weekly before, and daily after, April 2003.
Operating target	Net domestic assets with the interbank rate as an implicit operating target. The monetary board introduced an overnight window' (standing facility) at the beginning of 2004, and in this framework the interbank rate becomes an explicit operating target in a 'symmetric corridor system'.
Policy rates	'Advances and rediscounts' window rate. From January 2004 the overnight window's Lombard and deposit rates.
Intervention	Changes in reserve requirements. Discrete open market operations dictated by the central bank's open market committee (OMC), and implemented via the central bank's money desk (MD). The OMC was created in 1995, and the MD established in 2000.

Table 2
GARCH modelling of the day-to-day interbank market interest rate
Maximum likelihood estimation and robust standard errors, 1999-2003

I. Mean equation	**ATGARCH – (1, 1)**	**AGARCH – (1, 1)**
α	0.40* (0.20)	0.40* (0.20)
λ_{t-1}	0.38** (0.06)	0.38** (0.06)
λ_{t-2}	0.25** (0.06)	0.25** (0.06)
λ_{t-3}	0.19** (0.04)	0.19** (0.04)
λ_{t-5}	0.07ψ (0.03)	0.06* (0.03)
λ_{t-9}	0.07** (0.02)	0.07** (0.02)
ϕ_{t-3}	-0.00006ψ (0.00003)	-0.00006ψ (0.00003)
II. Variance equation		
α_{t-1}	0.51	0.51
β_{t-1}	0.48** (0.07)	0.48** (0.07)
ϑ	0.17ψ (0.10)	0.17Ω (0.11)
ψ	-0.01 (0.16)	-
III. Diagnostic and model comparison statistics		
N	1179	1179
No. of parameters	12	11
Log-likelihood	-1375.8004	-1375.8237
HMSE	11.9634	11.8391
AIC.T	2775.6008	2773.6475
AIC	2.3541	2.3525
HQ	2.3737	2.3704
SC	2.4058	2.3999
M. reduction - χ^2	ATGARCH $\Rightarrow$ AGARCH: 0.0467 (0.8288)	
ARCH – F	0.8438	0.8392

Notes on Table 2: Coefficients' robust standard errors are inside parentheses. N denotes the number of observations used in estimating each equation. HMSE is the heteroscedasticity-adjusted mean square error. AIC.T is an information criterion computed as: -2l + 2s, where l is the log-likelihood and s the number of parameters estimated. AIC, HQ and SC are the conventional Akaike, Hannan-Quinn, and Schwarz information criteria. M. reduction tests the validity of the model reduction. ARCH tests the null of conditional heteroscedasticity with a F distribution. For this test the probability value is provided. **, * and ψ denote that a coefficient is significant at the 1%, 5% and 10% levels. Ω denotes significance at the 12% level.

Table 3
GARCH modelling of the day-to-day banking system interest rate
Maximum likelihood estimation and robust standard errors, 1999-2003

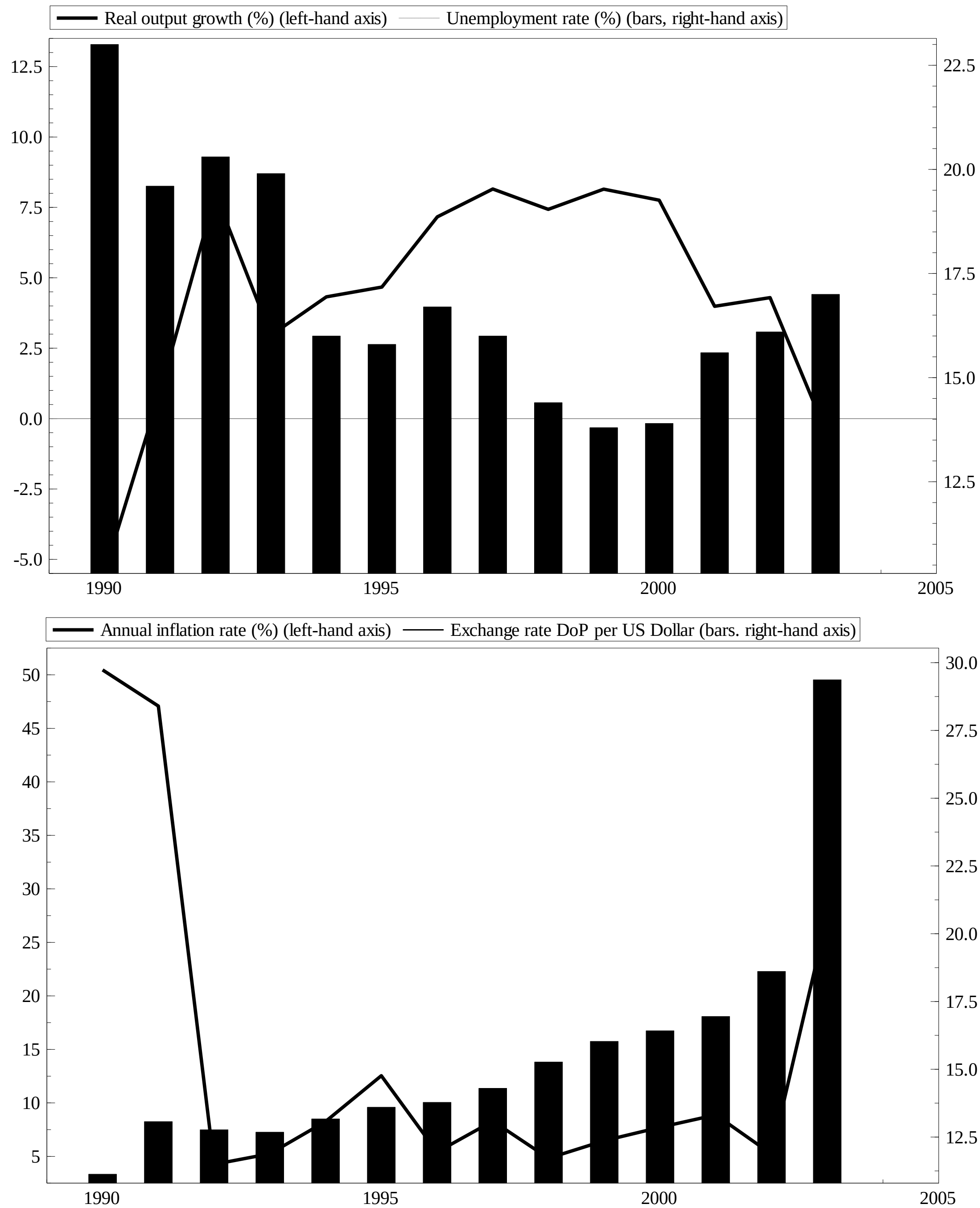
I. Mean equation	**ATGARCH – (1, 1)**	**AGARCH – (1, 1)**
α	0.46** (0.15)	0.48** (0.15)
δ_{t-1}	0.27** (0.03)	0.28** (0.02)
δ_{t-2}	0.17** (0.02)	0.17** (0.02)
δ_{t-4}	0.20** (0.02)	0.20** (0.02)
δ_{t-5}	0.10** (0.03)	0.10** (0.03)
δ_{t-6}	0.09** (0.02)	0.09** (0.02)
δ_{t-13}	0.10** (0.02)	0.10** (0.02)
δ_{t-20}	0.07** (0.02)	0.07** (0.02)
δ_{t-23}	-0.09** (0.02)	-0.09** (0.02)
φ_{t-4}	0.07** (0.01)	0.07** (0.01)
φ_{t-19}	-0.04** (0.01)	-0.04** (0.01)
II. Variance equation		
α_{t-1}	0.03	0.02** (0.01)
β_{t-1}	0.96** (0.01)	0.96** (0.01)
ϑ	-0.34** (0.05)	-0.37** (0.09)
ψ	-0.01 (0.01)	-
III. Diagnostic and model comparison statistics		
N	1166	1166
No. of parameters	17	16
Log-likelihood	-1529.74	-1530.11
HMSE	2.9437	2.9223
AIC.T	3093.48	3092.22
AIC	2.6531	2.6520
HQ	2.6809	2.6782
SC	2.7269	2.7214
M. reduction - χ^2	ATGARCH $\Rightarrow$ AGARCH: 0.7379 (0.39)	
ARCH – F	0.8520	0.8604

Notes on Table 3: Coefficients' robust standard errors are inside parentheses. N denotes the number of observations used in estimating each equation. HMSE is the heteroscedasticity-adjusted mean square error. AIC.T is an information criterion computed as: -2l + 2s, where l is the log-likelihood and s the number of parameters estimated. AIC, HQ and SC are the conventional Akaike, Hannan-Quinn, and Schwarz information criteria. M. reduction tests the validity of the model reduction. ARCH tests the null of conditional heteroscedasticity with a F distribution. For this test the probability value is provided. ** and * denote that a coefficient is significant at the 1% and 5% levels.

Figure 1
Timeline
Dominican Republic's 2002-2003 banking and macroeconomic crisis

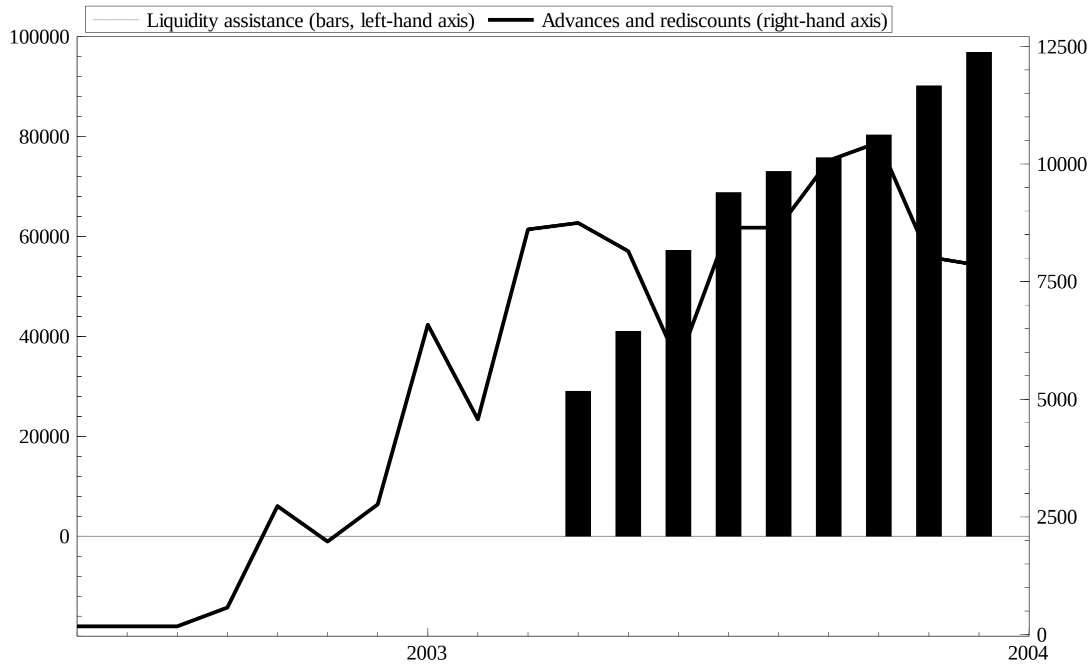
From mid-1990s	2000	September 2002	May 2003	August 2003
Interest rate liberalisation and subsequent dollarisation of the banking system alongside weak bank supervision and an appreciated exchange rate	End of the USA economy's long-boom	Start of central bank liquidity provision to the main troubled bank (BANINTER) via the 'advances and rediscounts window'	Banking crisis formally revealed to the public on 14 May 2003	Stand-by agreement signed with the IMF

Figure 2
Dominican Republic
Basic macroeconomic indicators, 1990-2003



Source: Central Bank of the Dominican Republic.

Figure 3
Advances and rediscounts, and liquidity assistance by the Central Bank of the Dominican Republic, 2002-2003 (millions of DR$)



Source: Central Bank of the Dominican Republic.

Figure 4
Interest rate determination in the market for bank reserves

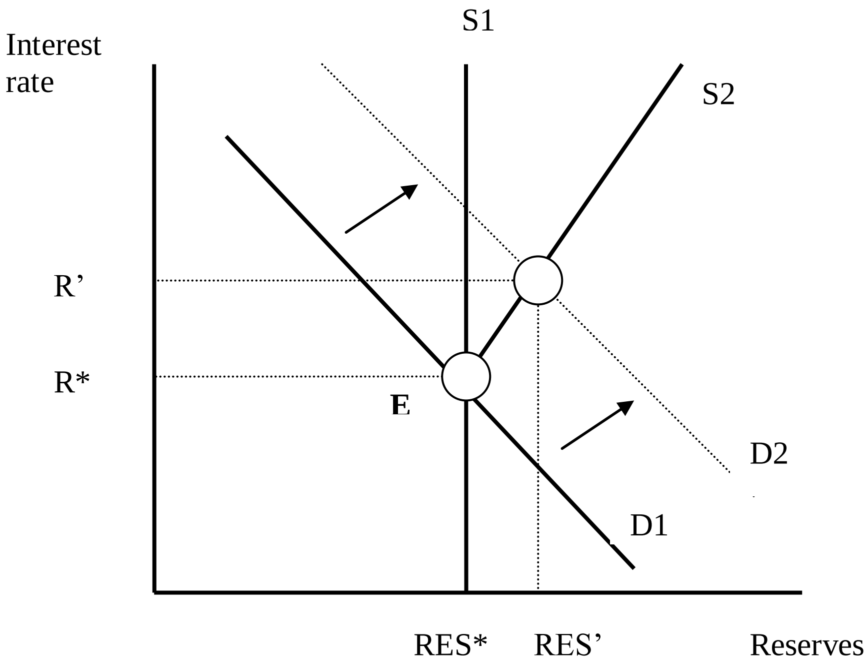
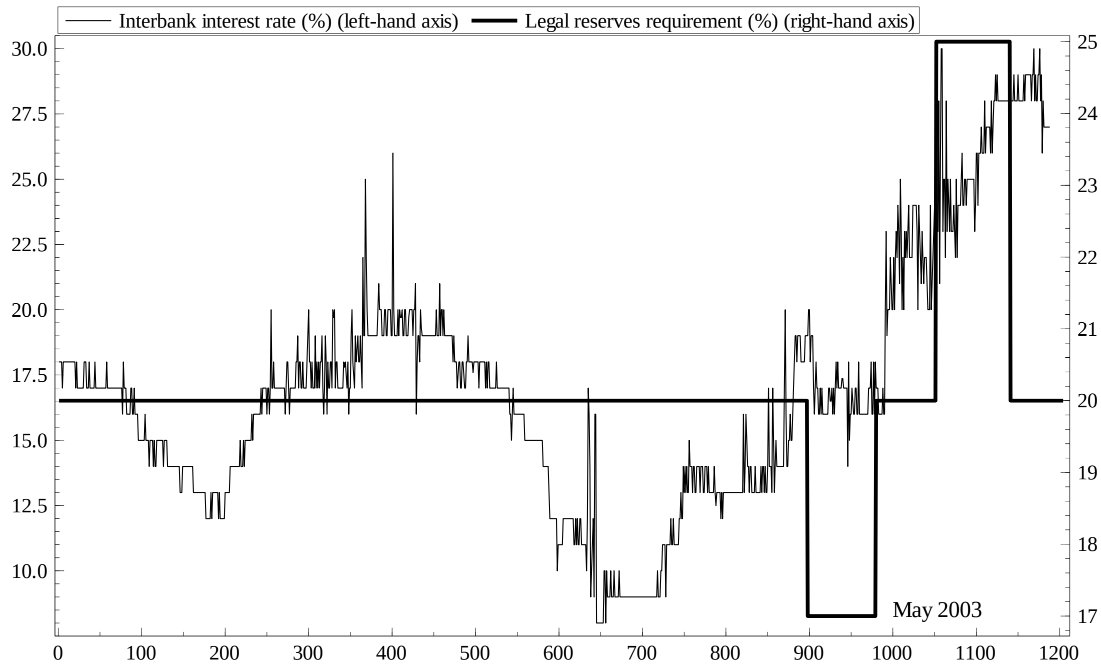
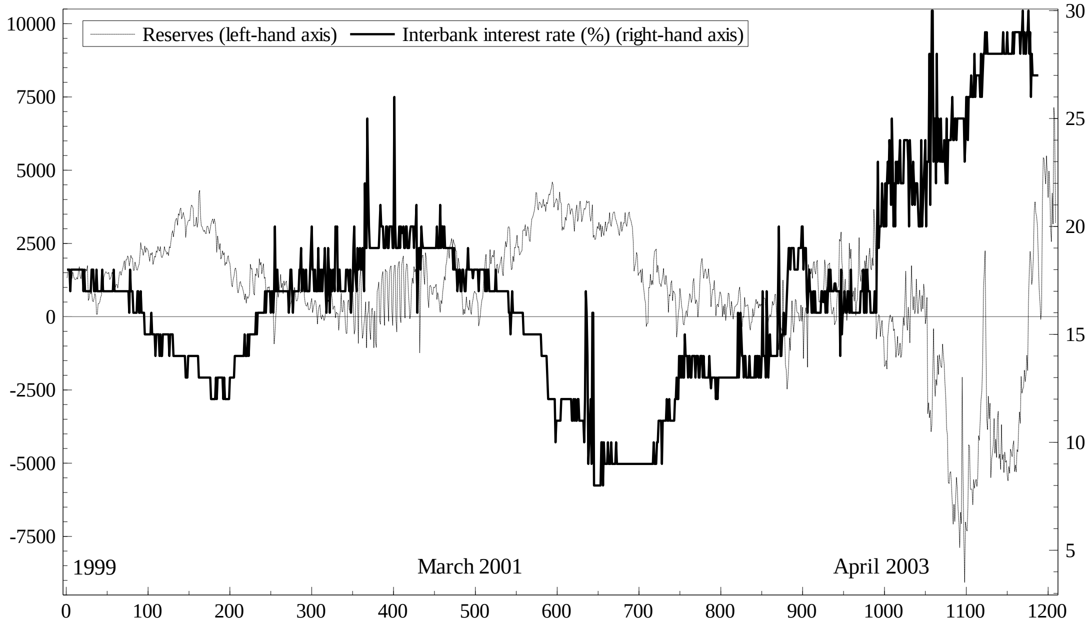


Figure 5
Interbank interest rate and the legal reserve requirement (%)



Source: Central Bank of the Dominican Republic.

Figure 6
Interbank interest rate (%)
and aggregate excess banking system reserves (millions of DR$), 1999-2003



Source: Central Bank of the Dominican Republic.

Figure 7
'News impact plot' (Engle and Ng, 1993)
Interbank interest rate volatility (with cubic spline)
Table 2's AGARCH model

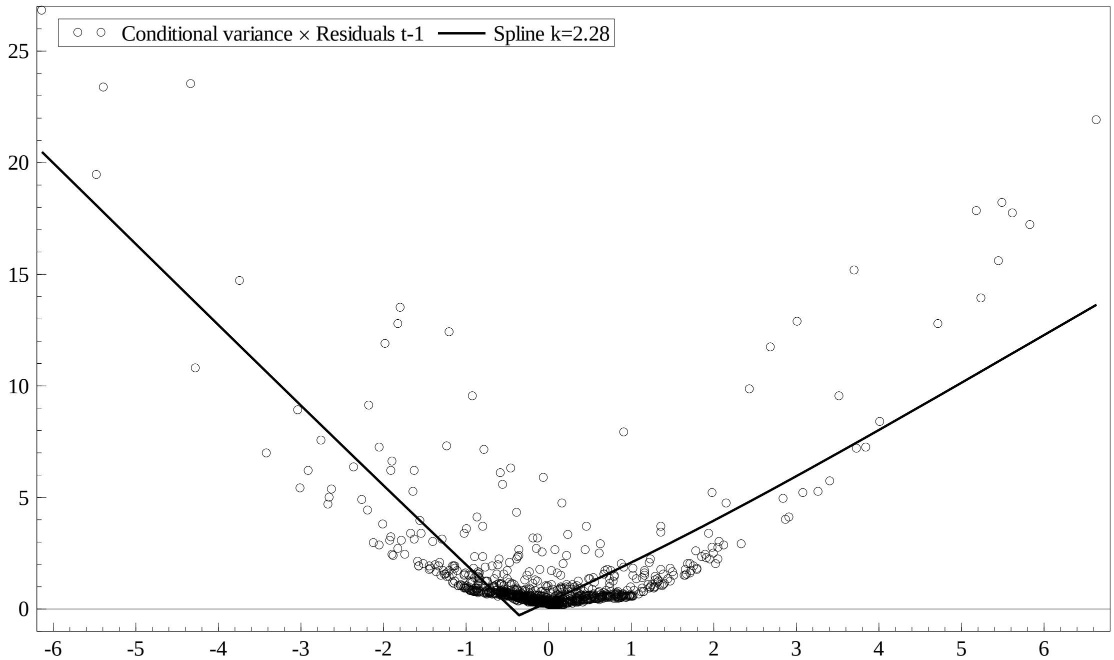


Figure 8
Interbank interest rate volatility
Asymmetry coefficient recursive t-ratio, 2002-2003
Table 2's AGARCH model

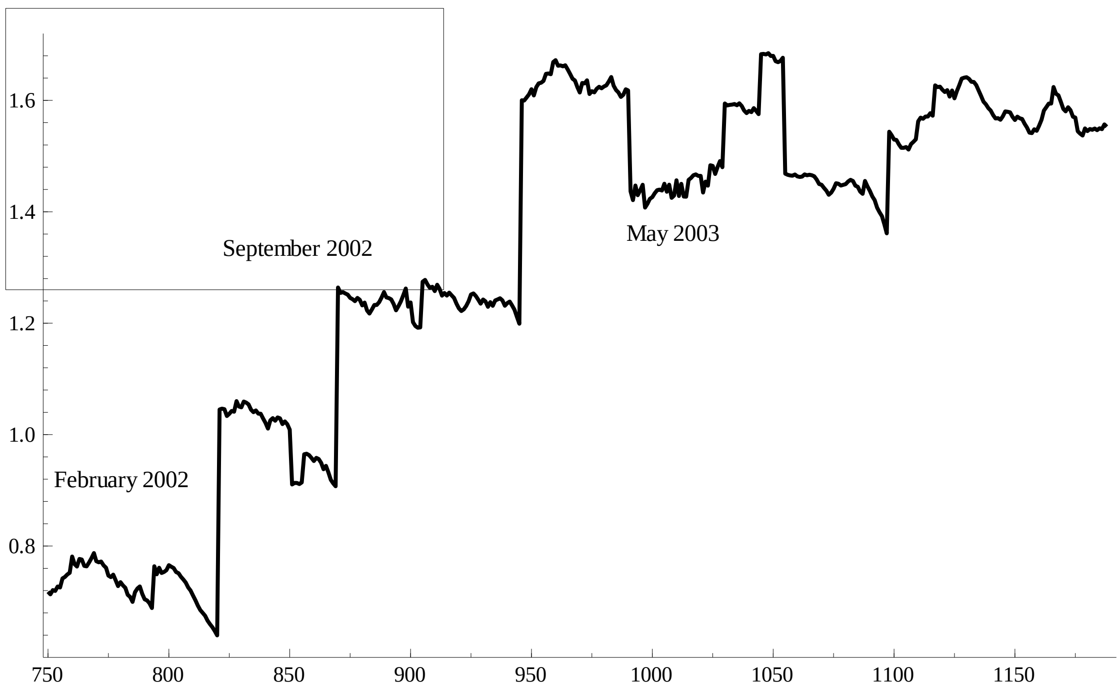
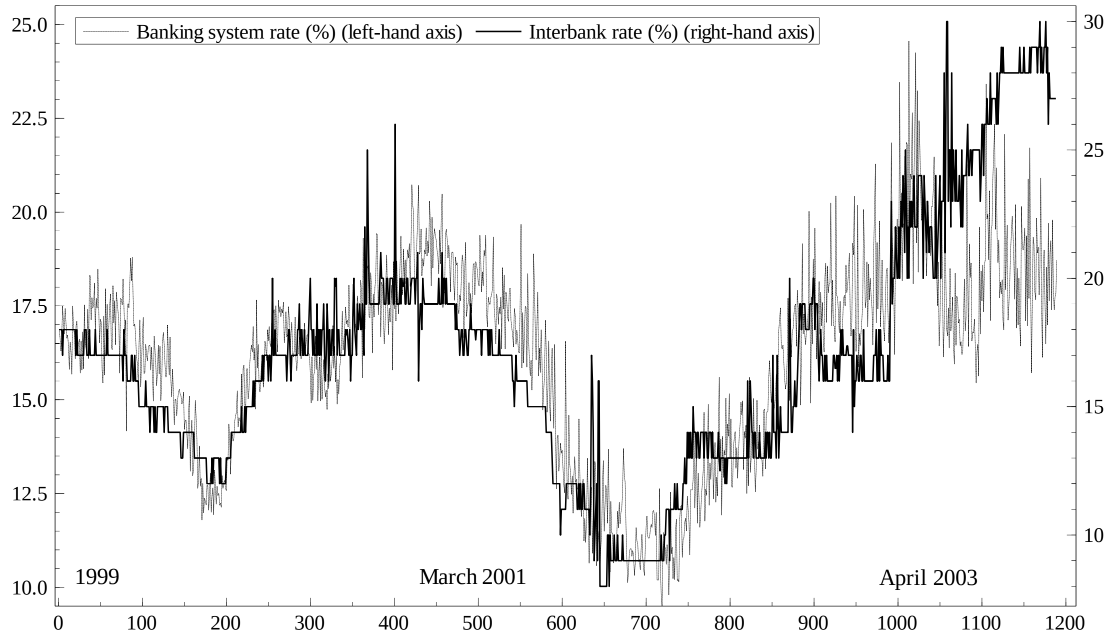
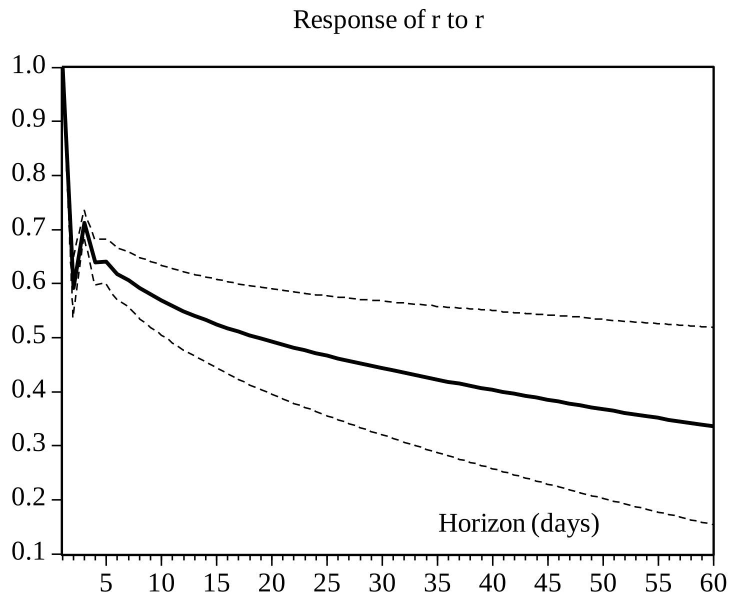


Figure 9
Interbank and banking system interest rates (%), 1999-2003



Source: Central Bank of the Dominican Republic.

Figure 10
VARs impulse response functions
One unit (%) innovations to the interbank interest rate
Monte Carlo simulated 2 s.e. bands



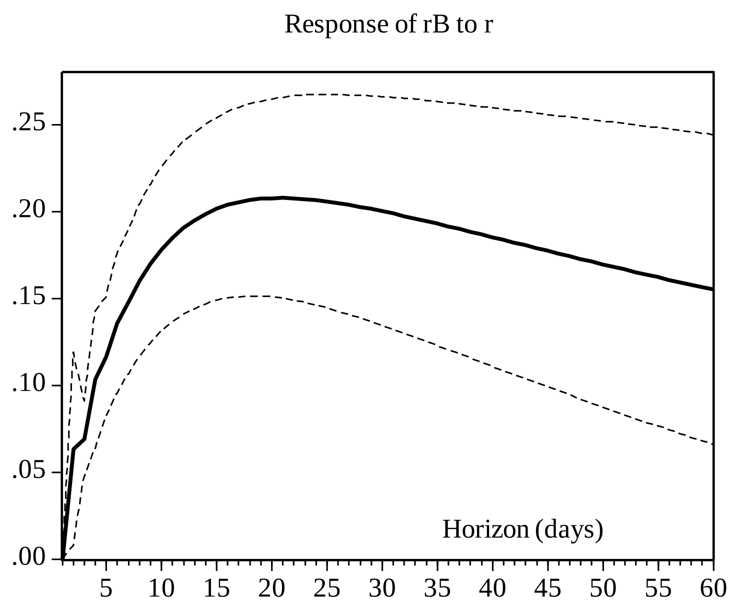


Figure 11
Sum of the recursive coefficients $\varphi_4 + \varphi_{19}$
Interbank rate's impact on the market interest rate
January 2002-December 2003
Table 3's AGARCH model