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Interest Rate Setting and the Colombian Monetary Transmission Mechanism

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La fijación de tasas de interés y el mecanismo de transmisión de la política monetaria en Colombia

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Resumen

Este trabajo estudia empíricamente la fijación de tasas de interés por parte de los bancos comerciales y cómo la política monetaria se ve reflejada en estas tasas. Para tal fin se estudia la industria bancaria colombiana durante el período 1996-2004. El trabajo usa información microeconómica para el mercado de CDT y de crédito para 21 y 16 bancos, respectivamente; así mismo, intenta superar algunas dificultades econométricas de trabajos previos al realizar pruebas de raíz unitaria en panel y pruebas de cointegración en panel. Los resultados sugieren que la transmisión de la tasa de política a la tasa CDT y la tasa activa es alta y rápida. Adicionalmente, se encuentra que las tasas reaccionan de manera importante a choques inflacionarios, en especial las tasas activas. Finalmente, la evidencia muestra la importancia que las características particulares de los bancos y la inflación tienen como determinantes de largo plazo de las tasas de interés.

Clasificación JEL: C33, E43, E52, E58.

Palabras claves: *bancos, política monetaria, tasas de interés, datos panel.*

Interest Rate Setting and the Colombian Monetary Transmission Mechanism

Carlos Andrés Amaya *

This paper is concerned with interest rate setting by commercial banks and how the transmission of monetary policy is reflected in these rates. For this purpose we study the case of the Colombian banking industry for the period 1996-2004. Using microdata, the Certificate of Deposit (CD) market and the credit market are studied for a balanced panel of 21 and 16 banks, respectively. Overcoming some of the empirical dificulties presented in other studies, this paper performs panel unit root tests and panel cointegration tests. The results suggest that the transmission of the policy rate to the CD rate and the credit rate is on average high and quick. Additionally, rates react strongly to inflation shocks, specially credit rates. Finally, the evidence presented shows the importance of banks' characteristics and inflation as long-run drivers of interest rates.

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JEL Classification: C33, E43, E52, E58.

Keywords: banks, monetary policy, interest rates, panel data.

I. INTRODUCTION

There is a general agreement that, at least in the short-run, the monetary authority may use its instruments to accomplish its objectives. Most central banks conduct their monetary policy by targeting a short-term interest rate.[1] Movements on this rate are then transmitted in the same direction to all the other market rates forcing households and firms to revise their optimal consumption and investment decisions. Then, through several channels, monetary policy may affect the real economy.[2]

The above mechanism hinges on the assumption that indeed, movements on the policy rate are transmitted to other market rates *immediately* and in a *complete* fashion. However, international literature has pointed out that this pass-through is not immediate and is incomplete in the short-run. This implies that the mechanism takes time and is therefore worthwhile to examine. The latter also implies that monetary policy actions transmit with a lag to the financial system and to the real economy. The study of how banks set interest rates and how these are affected by policy rates therefore lies on the heart of the monetary transmission mechanism. This paper deals with this issue studying the Colombian banking industry for the period 1996-2004. The paper therefore examines the first step of the monetary transmission mechanism, *i. e.*, how the monetary authority affects relative prices, but does not study the consequences over consumption and investment of these changes in prices.

Recently, concerns about the effectiveness of the Banco de la República policy instrument have emerged due to the apparent rigidity of the Colombian benchmark rate, the DTF.[3] Graph 1 shows how, in the recent past, the DTF has remained still,

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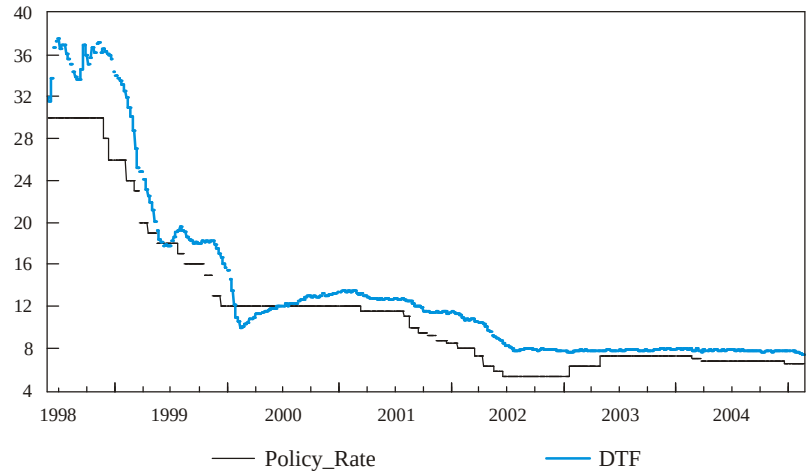
1 Borio (1997) reviews the implementation of monetary policy in industrial countries and shows how these economies have emphasized the role of market oriented policies such as interest rate targets.

2 An excellent survey of these channels can be found on the *Journal of Economic Perspectives* (1995), v. 9, num. 4.

3 The DTF is the weekly average rate for Certificates of Deposits (CDs) maturing on a 90 day horizon.

Graph 1
The DTF and the Policy Rate
(Nov. 1998-Feb. 2005)



Source: Banco de la República.

in spite of changes in the policy rate. Even though this rate is a deposit rate, its stickiness is important since roughly 66% of the credit stock is arranged in a floating scheme tied to the DTF. This paper tries to evaluate the effectiveness of the policy instrument by examining if the stance of policy is transmitted to bank's interest rates.

Although several papers like Clavijo (2004), and Gómez, Vásquez and Zea (2005) have examined different aspects of the monetary transmission mechanism for the Colombian economy, only Julio (2001) has examined the pass-through of the policy rate to market rates using aggregate data. The present paper contributes to the existing literature by taking a microeconomic approach. The use of bank level data is interesting since heterogeneity, a characteristic of Colombian banks, can be examined. Additionally, the use of this type of data is not common in international literature. The paper also has novel features in the econometric methodology such as panel unit root tests and panel cointegration tests. The use of these techniques

allow a much better estimation of time series relations between variables, a desirable characteristic in light of the purpose of this paper.

Overall, the results show that the transmission of interest rates, from the policy rate, proxied by the interbank rate, to the average certificate of deposit (CD) rate and to the average credit rate is high and quick. Rates seem to react vigorously to inflation shocks, specially credit rates. The evidence presented shows the importance of banks' characteristics and inflation as long-run drivers of interest rates.

The paper unfolds as follows. The next section reviews the relevant literature, while section III briefly suggests how the theoretical problem can be addressed. Section IV tackles the problem empirically, while the last section concludes with some policy implications.

II. LITERATURE REVIEW

Arbitrarily, this review classifies relevant literature in three basic groups. The first group discusses interest rate rigidity, the second deals with interest rate setting and the third one reviews the scarce Colombian literature on the subject. Rather than being comprehensive, representative papers are presented.

As mentioned before, international literature has found that interest rates exhibit rigidity. The first paper that examined this issue was Hannan and Berger (1991) in which rigidity was examined for deposit rates in the American banking industry. Rigidity emerges from menu costs in which banks weight the benefits of changing rates against the costs. Their empirical results show that smaller banks operating in more concentrated markets are less likely to change interest rates. Furthermore, they find that rigidity is exacerbated when the stimulus for a change is upward, suggesting asymmetric adjustment.[4]

Cottarelli and Kourelis (1994) were the first to provide a systematic measure of the degree of lending rate stickiness across a set of developed and developing

[4] Evidence about asymmetry is not concluding between countries. While papers like Mojon (2000) find positive evidence for the euro, others as Espinosa-Vega and Rebucci (2003), for Chile, have failed to accept it.

countries. In a first step, they measure the speed of adjustment of bank lending rates to money market rates. In a second step, they regress this speed against several variables related to the structure of the financial system. In such a way, the paper first evaluates the stickiness and then tries to link it to the countries' financial structure. On average, the paper finds that the degree of stickiness is high. While in the long-run full adjustment takes place, in the short-run, adjustment is only one third of the long-run multiplier. The degree of stickiness, particularly in the short-run, is very different across countries, suggesting that short-run differences may be a consequence of adjustment costs, rather than long-run differences in loan demand elasticities. Relating the stickiness to the financial structure, the authors find several conditions that increase lending rate flexibility: i) the existence of a market for negotiable short-term instruments; ii) relative volatility of money market rates; iii) the absence of barriers to entry in the banking industry; iv) absence of constraints on international capital movements and v) private ownership of the banking system. This paper as well as other in a similar spirit such as Mojon (2000) and Espinosa-Vega and Rebucci (2003), lack microeconomic foundations. However, they provide useful insights since they document stickiness and provide clues about why it happens.

The second group of studies builds its empirical estimations on the microeconomic foundations of price setting by banks. Gambacorta (2004) studies the cross-sectional differences in interest rates for a panel of Italian banks. The study is motivated by a model in which a risk neutral bank operates under monopolistic competition. Under the assumption that bank's interest rates and the money market rate are cointegrated, first order conditions are expressed as an error correction model and are estimated using the Arellano and Bond (1991) methodology. Basically, four conclusions emerge from the empirical analysis. In the first place, there is heterogeneity in the pass-through from money market rates to both deposit and loan rates only in the short-run. In the second place, short-term interest rate loans for illiquid and undercapitalized banks react less to shocks from the monetary authority. In the third place, banks with a high proportion of long-term lending change their prices less. Finally, Gambacorta (2004) finds that bank size is unimportant.

In this group, Berstein and Fuentes (2003a) study the lending rate's flexibility to changes in the policy instrument for the Chilean banking industry. Their work is an attempt to identify bank characteristics that can explain differences in average lending rates and the way they react to changes in the policy rate. In a first step,

their work replicates exercises as the ones documented in the first set of papers finding rigidities only in the short-run. The second part of their work is based on micro data. An asymmetric information model in which banks operate under monopolistic competition is derived as a theoretical base for their empirical estimations. Their dynamic panel data model finds evidence of important differences in the response of banks prices to the policy rate. The smaller the banks, the larger the share of household consumers and the lower the portion of past due loans the smaller the rigidity of interest rates to changes in the monetary authority instrument.

Both of these works provide very useful and interesting insights and overcome the atheoretical treatment of previous papers. However, they lack an adequate econometric treatment. The authors do not deal explicitly with the time series properties of the variables. They assume stationarity or non-stationarity of the variables without performing formal tests. In the case of Berstein and Fuentes (2003a), they estimate the model in levels. In the case of Gambacorta (2004), he assumes interest rates are non-stationary and therefore estimates an *error correction model* assuming bank characteristics are I(0). The strategy implies only one cointegration relation neglecting all other possible stationary combinations.

The third group comprises papers by Julio (2001), and Barajas, Steiner and Salazar (1999). Julio (2001) studies the relationship between the central bank policy rate and the interbank rate, the deposit rate and lending rates for ordinary and preferential customers comparing the exchange rate band period and the free floating period. The study covers the period 1988-2001. Using a vector error correction model, he finds evidence of a long-run relation in which none of the variables is excluded and in which interest rate volatility is less after the central bank adopted the free floating scheme. With the exception of the lending rates, during the free floating period, the variance of the rates is explained in greater proportion by changes in the policy rate. The finding by Julio (2001) therefore provides evidence in favor of the effectiveness of the policy instrument. The paper lacks microeconomic foundations as well as a discussion about the policy implications of the findings.

Despite the absence of Colombian literature on interest rate setting, the work by Barajas, Steiner and Salazar (1999) provides a useful insight in the sense that it studies interest rate margins for the banking industry. Using both aggregate and microeconomic data the paper tries to explain the determinants of the interest rate margin for the pre-liberalization (1974-1988) and post-liberalization periods (1991-1996). Prior to the liberalization period, margins were driven to a great extent by

competition while during the post-liberalization period loan quality became the most important determinant. The panel data analysis for the liberalization period suggests that operational costs are relatively more important than loan quality as determinants of the interest rate margin.

Overall, four main conclusions emerge from this review: i) pass-through is incomplete in the short-run and is therefore worthwhile to study; ii) banks' specific characteristics matter and for the Colombian case loan quality and operational costs seem particularly relevant as determinants of interest rates; iii) a long-run relationship between policy rates and market rates has existed in Colombia, at least in the period 1988-2001; iv) works focusing on microeconomic data have failed to deal properly with the econometric traits of the series.

III. SOME THEORETICAL CONSIDERATIONS

The purpose of this section is to briefly suggest some ideas on how the theoretical problem of understanding how banks set interest rates and how are they related to the policy rate can be addressed.

Probably the most tractable way of understanding how banks set their interest rates is building upon the Monti-Klein model for a monopolist. Although assuming this type of market structure is unrealistic, this model can be generalized to the monopolistic competition case by assuming the existence of *N* banks and adding product differentiation. This approach is partially followed by Gambacorta (2004). In such a model, banking activities would consist in the production of loans, deposits and CDs. The loan portfolio and the reserve would constitute the assets while deposits and CDs would constitute the liabilities. Capital can be assumed exogenous.

The influence of the policy rate on banks interest rates can be addressed theoretically by introducing a liquidity risk. The emergence of such a risk is a consequence of banking activities that are characterized by transforming short-term liabilities into long-term assets. After loans are handed, the bank can face withdrawals larger than the reserve.[5] The bank can solve this liquidity problem by borrowing funds in

[5] An excellent discussion about the reserve management literature can be found on Freixas and Rochet (1997).

the interbank market. Whenever withdrawals are smaller than the reserve, excess liquidity can be invested in that market. Since the interbank rate is directly influenced by the policy rate,[6] banks interest rates are going to be affected by the latter. In such a way, banks interest rates will move in the same direction than the policy rate. An increase in the policy rate will increase the liquidity cost for banks which will be reflected in higher loan rates. Deposit rates will also be increased as a way of attracting funding sources in order to cover for the liquidity shortfall.

Finally, bank's behavior depends crucially on the costs it assumes for its activities. Branching as well as costs arising from screening and monitoring activities need to be considered. Higher labor and administrative costs should be translated to consumers as higher loan rates and smaller deposit rates.

Wrapping up, banking activities could be modelled as the the production of loans, deposits and CDs. Correspondingly, banks maximize profits setting the optimal interest rates (i_l, i_d, i_{CD}). Revenues would result from the interest on loans and a positive position in the interbank market, while costs would arise from interest paid on deposits and CDs, as well as from liquidity, branching, screening, and monitoring activities. The effect the policy rate has on banks' interest rates could be addressed by introducing a liquidity risk that can be solved through the interbank market.

IV. EMPIRICAL EVIDENCE

A. THE DATA

The data set is comprised by two subsets: one for the CDs market and another for the credit market. For the CDs market, information about interest rates is available from January 1996 with monthly periodicity for instruments maturing in 30, 45, 60, 90, 120, 180 and 360 days. Weighting by the amount of CDs maturing in each horizon, i_{CD} was constructed. In the case of the credit market, information begins on May 1997 and includes information on consumer credit and commercial ordinary, preferential and treasury credit. Mortgage credit was excluded since by Sentence 955 of 2000, the

[6] Interbank rates should also respond to bank's particular characteristics. For example, it is reasonable to think that a poorly capitalized institution is charged a higher rate than a healthier one in the interbank market.

Colombian Constitutional Court established interest rate ceilings for these operations. i_l was constructed by weighting the amount of loans in each type of credit operation. For both cases, interest rates are marginal, *i. e.*, they are a monthly average of the interest rates charged on operations during that month and are not based on the stock of credit or deposits. Both data sets end on September 2004. The use of these data is rather novel since it has been rarely used. Only Estrada (2005) has used this information for the CDs market.

This information was complemented by balance sheet data supplied by the Superintendencia Bancaria, the capital adequacy ratio (CAR) and the number of employees.[7] The panels were balanced[8] and resulted in 21 financial institutions for the CDs market and 16 institutions for the credit market.[9]

With the balance sheet information, the following indicators were constructed: nonperforming loans to total loans (*j*), average monthly wages (*w*) for the banking industry, the share of bank *i* assets to total assets and the ratio total loans to deposits. Higher default rates should be reflected in higher lending interest rates while higher wages should have an impact in both lending and deposit interest rates. A higher ratio of total loans to deposits could reflect a higher liquidity risk, thus generating higher funding costs. Finally, the share of bank *i* assets to total assets may capture different possible effects. For instance it could affect interbank funding costs (see footnote 6) or could be capturing market structure characteristics which according to the literature review are relevant. Market structure could have changed during the period of study, as a result of the important number of exits, M&As and FDI, and in this way could have affected the transmission of interest rates.

Microeconomic data were complemented with the seasonally adjusted industrial production index and the twelve month variation of the consumer price index. As

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7 The monthly number of employees was estimated with yearly observations as in Estrada and Osorio (2004) regressing the number of employees against fixed assets and a time trend. Specification tests, suggested the following fixed effects model:

$$\ln(\text{employees}) = \underset{(1.086)}{4.893} + \underset{(0.06)}{0.141} * \ln(\text{fixed assets}) - \underset{(0.008)}{0.0525} * t$$

with $R^2 = 0.676$. Standard error in parenthesis.

8 Balancing the panel could result in an bias even though banks selected are representative. What this implies is that results should be interpreted as exclusive for these banks. However, balancing the panel has important benefits in terms of an adequate econometric treatment.

9 Only the sample for the CDs market includes former savings and loans institutions *(CAVs)*.

for the policy rate variable, the interbank rate was chosen. The main reason for not using the policy rate is the step function behavior it exhibits since policy changes are not frequent. This creates econometric problems since little variation is not a desirable characteristic when thinking in econometric parametric approaches. However, as can be seen from Graph 2, the interbank rate follows very closely the central bank policy rate.[10]

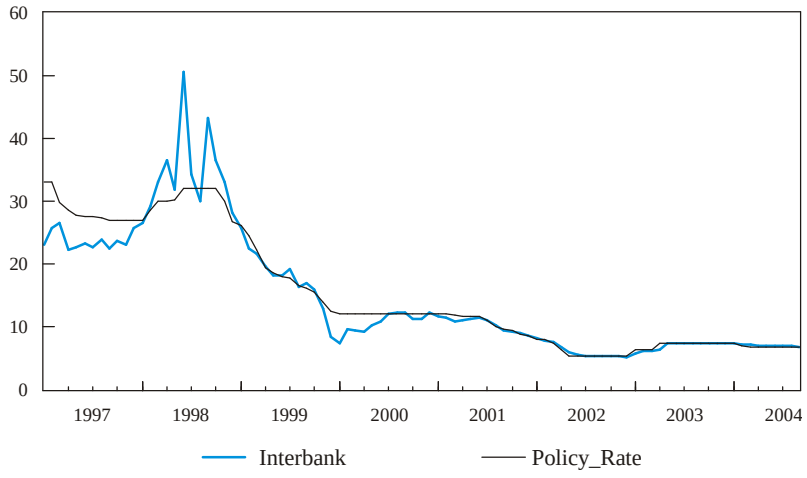
B. EMPIRICAL STRATEGY

The empirical approach followed in this paper assumes that the CDs market and the credit market can be studied separately therefore reduced forms for the two

Graph 2

The Interbank Rate and the Policy Rate

(Jan.1997-Sep. 2004)



Source: Banco de la República.

10 Indeed, this is a common assumption for the Colombian case. See for example Bernal (2002).

different panels are estimated. In first place, this assumption is particularly useful since simultaneity issues can be difficult to address under the presence of persistent series (shown later). In second place, estimating different panels allows the inclusion of mortgage banks in the deposit market which played an important role in this market. The inclusion of additional financial intermediaries could alleviate in some way the selection bias emerging from estimating a balanced panel. Nonetheless, it is worth mentioning that this approach could have important short-comings in terms of endogeneity and omitted variables.

As a first step, unit root tests were conducted to all variables. Traditional augmented Dickey Fuller tests were performed on the industrial production index, the inflation rate and the interbank rate since these series are common for all individuals in the panel.[11] In all cases variables were non-stationary. Unlike previous work by Berstein and Fuentes (2003a) and Gambacorta (2004) in which they assume bank interest rates are either stationary or non-stationary and where they assume bank characteristics are stationary, this paper deals with this issue performing panel unit root test. The Im, Pesaran and Shin (1997) (IPS) test and Maddala and Wu (1999) Fisher test were used. Both tests are discussed in the appendix.[12] The use of panel unit root tests helps us deal with the structure of the data as well as to overcome the low power of traditional tests.[13] As can be seen from Table 1, all variables follow unit root processes.

Given that all variables are $I(1)$, it is natural to think in a cointegration framework. The fact that we have an important number of variables leads us to think of cointegration in the spirit of Johansen (1988) and Johansen and Joselius (1990). Since the dataset has a panel structure, a panel *VEC* estimation seems logical. Following Larsson, Lyhagen and Lothgren (2001), let us consider a panel data set that has N cross-sections (banks) and T time periods. The error correction model for the $VAR(k_i)$ can be written as follows:

$$\Delta Y_{it} = \boldsymbol{P}_i Y_{i,t-1} + \sum_{k=1}^{k_i-1} \Gamma_{ik} \Delta Y_{i,t-k} + \boldsymbol{e}_{it} \qquad (1)$$

11 Results for these tests are not presented but are available upon request.

12 Is worth pointing out two points: i) for both tests the null hypothesis is the existence of a unit root, and ii) the empirical evaluation of these tests by Maddala and Wu(1999) favor the use of the Fisher test.

13 See Chapter 4 of Maddala and Kim (1998) on this issue.

Table 1

Panel Unit Root Tests [a/]

		IPS	Fisher
CD rate	c	0.658	0.99
	c y t	0.472	1.00
Credit rate	c	0.586	0.99
	c y t	0.511	0.99
Size	c	0.3434	0.2896
	c y t	0.8385	0.5015
CAR	c	0.4555	0.2718
	c y t	0.6349	0.6811
Non-performing	c	0.2617	0.2468
Loans	c y t	0.7107	0.4523
Wages	c	0.8260	0.5077
	c y t	0.7964	0.4853
Loans/deposits	c	0.7383	0.4715
	c y t	0.9334	0.5363

a/ p-values reported. Ho = unit root. three lags.
Source: authors' calculations.

Larsson, Lyhagen and Lothgren (2001) propose a likelihood-based cointegration rank test that allows us to test the existence of cointegration which implies a model as (1). If that is the case, then P_i is of reduced rank, and it is possible to let $P_i = a_i \times b_{i.}$ This allows us to estimate the long-run relationship between the variables. The test proposed is similar in spirit to the IPS test and is based on conventional trace tests. The test is discussed in the appendix. The test statistics, Z_t trace, are presented in tables 2a and 2b for the CDs market and the credit market respectively. This test statistic should be compared to a $N(0; 1)$. As can be seen from the tables, a common cointegration rank does exist. For the CDs market, the panel test suggests that there are at least four cointegration relations while for the credit market there are at least eigth cointegration relations.[14]

[14] For the CDs market, the following variables were used: CD rate, industrial production index, inflation rate, interbank rate, *CAR*, wages, loans to deposits and the size proxy. For the credit market the same variables were used with the exception of the CD rate which was replaced by the credit rate and the ratio of non-performing loans to total loans which was included.

Table 2a

Larsson et al. (2001) Cointegration Test: CDs Market

H_0: r	Avg. trace	Z_t trace
0	239.68	27.09 *
1	165.73	16.29 *
2	111.87	8.73 *
3	71.42	2.91 *
4	42.03	-1.28
5	21.07	-4.54
6	7.89	-6.51
7	1.13	-7.00

* H_0 rejected.
Source: authors' calculations.

Table 2b

Larsson et al. (2001) Panel Cointegration Test: Credit Market

H_0: r	Avg. trace	Z_t trace
0	358.99	54.90 *
1	263.23	42.96 *
2	186.59	32.90 *
3	128.27	24.90 *
4	82.74	18.17 *
5	50.15	13.33 *
6	26.47	9.26 *
7	10.64	5.62 *
8	1.30	0.45

* H_0 rejected.
Source: authors' calculations.

Having established the existence of cointegration relationships between the variables, estimation issues have to be addressed. The panel VEC estimation was done estimating equation (1) for each of the banks for each market using the Johansen (1988) procedure. The major limitation of this strategy is that inference is limited because a covariance matrix between individuals cannot be estimated.[15] This limits the analysis since interesting hypothesis, such as $b_i = b$, cannot be tested. However, the strategy followed allows for the estimation of each P_i,[16] which is a much better assumption than $P_i = P$ as in the Engle and Granger panel VEC literature.

Although results varied bank by bank, weak exogeneity tests and exclusion tests suggested the variables used were appropriate. It is interesting to note that variables such as loan risk, *CAR* and size were also important in the work by Berstein and Fuentes (2003b). The signs, given by the theoretical model, and sizes of the coefficients associated with the long-run vector determined which cointegration vector was used. For one bank in the credit market no plausible vectors were found. This bank was excluded from the analysis.

C. RESULTS

As a result of our estimation, we obtained the long-run coeffcients (b) for the interbank rate, the policy rate proxy, for both markets. A coefficient near one means that interest rates set by banks move in line with the policy rate, *i.e.*, the instrument works in the long-run. Arbitrarily, Table 3 classifies banks according to the degree of transmission. A bank was classiffied as a low transmission bank if the coefficient was below 0.5, a medium transmission bank if the coefficient was somewhere between 0.5 and 0.75 and was classified as a high transmission bank if the coefficient was above that range. For the CDs market, eleven out of twentyone banks were classified as high transmission banks, eigth were classified

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15 The only available joint likelihood estimator for equation (1) is proposed by Groen and Kleibergen (2002). Unfortunately, this estimation procedure could not be implemented since computationally it is very demanding.

16 Since what we estimate is the following:

$$\begin{pmatrix} a_1 b_1' & \cdots & 0 \\ 0 & \ddots & 0 \\ 0 & & 0 \\ 0 & \cdots & 0 \quad a_N b_N' \end{pmatrix}$$

as medium and only 2 as low. The average coefficient for all the sample was 0.75. For the credit market, the average coefficient was 0.76 (Table 3). Seven banks classified as high transmission, seven as medium and one as low. The difference between this *b*s widens when we consider only the banks that appear in both data sets. For these *common* banks, the average coefficient is 0.73 for the CDs market and 0.79 for the credit market.

Lutkepohl (1993) emphasizes the fact that properly speaking, long-run coefficients cannot be interpreted as elasticities since this would imply ignoring the endogenous nature of the variables. However, they do show us the long-run relationship between the variables. This endogeneity issue was tackled using impulse response functions that are presented in graphs A.1 to A.6. Impulse response functions are plotted for the corresponding interest rate, CD rate or credit rate, the inflation rate and the industrial production index. For the policy rate shock and the inflation rate the shock amounted to 100 basis points increase. In the case of the industrial production Index, a one standard deviation positive shock was applied.

For the CDs market, it is possible to see that all banks react to the policy shock by increasing interest rates although the intensity is different among banks. It is worth noticing that only one of the banks seems to overreact to the policy rate shock, defining overreaction as a response in a much higher proportion than the shock. It is possible to measure, approximately, how many months a bank takes to respond

Table 3

Distribution of Banks According to their Degree of Transmission

	CDs market	Credit market
Low	2	1
Medium	8	7
High	11	7
Total banks	21	15
Average *b*	0.75	0.76

Source: authors' calculations.

with the maximum interest rate. On average, after 6.1 months the maximum response is observed. As for the credit market, all banks react to the shock and in a different way. However, it is possible to classify five out of fifteen banks as *over-shooters*. These banks increase their credit rate in much more than the 100 basis point shock in the policy rate. On average, after 4.4 months the maximum response is observed suggesting that credit rates react faster than deposit rates to interbank movements. Additionally, one can compare the maximum response of banks that are in both data sets. For the majority of the banks, the maximum response is higher in the credit market than in the CDs market. Big banks react strongly in the CDs market when compared to the rest, while in the credit market, reaction of these seems to be milder.

As expected both rates react to inflation shocks. What is very interesting is that interest rates overreact to unexpected inflation shocks. Rates are increased in a much higher proportion than changes in the inflation rate. While for the CDs market, fourteen out of twentyone banks turned out to be *over-shooters* with respect to the inflation rate, in the credit market all of the banks but one can be classified as *over-shooters* in this sense. Comparing the maximum response of common banks, the reaction is stronger in the credit market.

As for the income shock, the response of the CDs rate and the credit rate is different. On the CDs market, for the majority of the banks, interest rates take some time to react but they do so in a positive humped shaped fashion. For the credit market, the most common reaction is a quick and positive one followed by a downward response.

These facts suggest that deposit rates are stickier than credit rates. This behavior lacks a straight forward explanation if we keep in mind that the period of study is characterized by interest rates going down[17] and that impulse response analysis is symmetrical. The last implies that an explanation to this finding has to work adequately to upward and downward stimuli. For example, explaining this result as the consequence of an oligopolic behavior could fail to work since if this was the case, it would be strange for banks to lower their lending rate faster and stronger than its deposit rate when faced with a downward stimulus.[18]

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17 Out of the 104 monthly observation, 67 periods presented a downward move in the interbank rate.

18 One can think of other reasons as for example the balance sheet structure of Colombian banks, where one third of the assets are denominated in fixed rates while on the liability side most

Variance decomposition exercises, presented on tables A.1 and A.2, turned out to be extremely suggestive. In a 24 month horizon it was possible to observe the following behavior for eleven out of fifteen banks included in the credit market. In the first periods, an important part of the credit rate variance was explained by the rate itself and by the interbank rate. Inflation and variables reflecting the cost of financial intermediation, such as loan quality or wages, explained a minor share of the interest rate variance. On the last periods, the percentage explained by the same rate and the interbank rate dropped importantly. However, the fraction explained by the inflation rate and the proxies for financial intermediation costs increased dramatically. What the latter suggests is that in the short-run credit rates are driven by the interbank rate and the rate itself. In the long-run, the credit rate depends upon financial intermediation costs and inflation. For the remaining 4 banks what could be observed was that the importance of the interbank rate increased as well as financial intermediation costs and inflation. For these banks, the same rate explained a very important percentage of the variance of the rate. For the CDs market, 12 out of 21 banks followed the behavior described above. In the short-run, variance of the CD rate was driven by the same rate and by the interbank rate, while inflation and financial intermediation costs are the main determinants in the long-run. For six banks, the importance of intermediation costs increased with time but inflation did not play an important role. For the remaining three banks, the percentage explained by intermediation costs increased with time but the importance of inflation decreased, which is strange when thinking of nominal interest rates.

Rounding up, the exercises presented highlighted the following facts: i) transmission seems to be high and quick; ii) all banks react in the same direction than the change in stance of policy but some react more than others; iii) the maximum interest rate response is faster in the credit market than in the deposit market when faced with a policy stimulus; iv) interest rates overreact to inflation shocks specially in the credit market; v) variance of interest rates is determined in the short-run mainly by the same rate and the interbank rate while in the long run, inflation and financial intermediation costs seem to be the driving factors.

instruments are on a variable basis. Taking this into account, it would be reasonable to think that when faced with a positive inflation shock, banks have to increase more than proportionally the rates charged in order to compensate for the stock of loans that is set at a fixed rate. However, when thinking of negative inflation shocks this might not make sense because it would not be reasonable to say that banks would forgo the profits already made by lowering interest rates down.

V. CONCLUSIONS AND POLICY IMPLICATIONS

The present paper studied the Colombian monetary transmission mechanism, for the period 1996 to 2004, trying to examine how banks' interest rates are affected by the monetary authority. This is a relevant issue since central banks conduct their monetary policy by targeting a short-term interest rate that affects all other market rates. In addition, the rigidity exhibited lately by the Colombian benchmark interest rate, the DTF, has raised questions about the effectiveness of the policy instrument. The paper tackled the pass-through issue empirically by using microeconomic data for the credit market and the CDs market. Overall the results show that pass-through to both credit rates and CDs rates is high and quick, that rates react strongly to inflation shocks and that the policy rate seems to drive interest rates in the short-run, while in the long-run inflation and financial intermediation costs are the main drivers. The response of credit rates to a policy shock is quicker than for the CDs rate and is stronger when faced by an inflation shock.

These results have at least three important policy implications. In first place, the policy instrument is effective in a first step, since it moves both the CDs rate and credit rates. However, these results do not provide evidence of the effectiveness of the monetary transmission mechanism as a whole, since the paper does not evaluates the effect of monetary actions on consumption and investment decisions. In second place, the empirical results suggest that interest rates react more to inflation shocks than to policy shocks. This result could be interpreted as an argument in favor of monetary intervention. If high interest rates are seen as pervasive, society is better off with central bank intervention (assuming the intervention is indeed effective in taming inflation) than without it, in the face of inflationary risks. As shown, an increase in the policy rate would result in lower interest rates than in a scenario where inflation affects directly interest rates. Finally, as shown empirically, in the long-run, interest rates reflect inflation and intermediation costs. Politicians worried with the inconvenience of high interest rates should pursue real policies to reduce financial intermediation costs such as eliminating the financial transaction tax and *mandatory low yield government investments* as well as improving the legal framework for reducing the time and costs of recuperating delinquent loans.

In spite of the positive evidence presented here, further research should asses the effectiveness of the monetary mechanism as a whole and should study the

consequences of interest rate rigidity in terms of optimal monetary policy. A novel paper in this last area is Kobayashi (2005). Finally, as the results suggest, banks' asymmetric response could be an issue worthwhile to study as well.

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ECONOMETRIC APPENDIX

PANEL UNIT ROOT TESTS

In this paper, two different panel unit root test are performed, namely, Im, Pesaran and Shin (1997) (IPS) test and Maddala and Wu (1999) Fisher test. In what follows, both tests are briefly discussed following quite closely Maddala and Wu (1999).

The basic idea of the parametric IPS test is to test the following model:

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \alpha_i + \varepsilon_{i,t}$$

where under the null, $\rho_i = 0$ and α_i for all *i*. In this way, IPS overcome the major limitation of earlier work by Levin and Lin (1992) in which $\rho_i = \rho$. IPS perform individual unit root test for the *N* cross-section units instead of pooling the data. Letting $t_{i,T}(i = 1, 2, \ldots, N)$ denote the *t*-statistics for testing unit roots, $E(t_{i,T}) = \mu$ and $V(t_{i,T}) = \sigma^2$, then:

$$\sqrt{N}((\bar{t}_{N,T} - \mu) / \sigma) \Rightarrow N(0, 1)$$

where $\bar{t}_{N,T} = 1/N\sum_{i=1}^{N} t_{i,T}$. μ and σ are computed using Monte Carlo methods. In essence, IPS tests the joint significance of *N* independent unit root tests.

The non-parametric Fisher test, proposed by Maddala and Wu (1999), is based on the sum of log-*p*-values derived from individual unit root test. If test statistics are continuous, the significance levels $p_i(i = 1, 2, \ldots, N)$ are independent uniform (0,1) variables, and $-2log_e p_i$ has χ^2 distribution with two degrees of freedom. Using the additive property of χ^2 variables, $\lambda = -2\sum_{i=1}^{N} log_e p_i$ has a χ^2 distribution with $2N$ degrees of freedom. With this statistic, the null of a unit root can be tested.

Based on Monte Carlo experiments Maddala and Wu (1999) favor the use of the Fisher test. Smaller size distortion and higher power, even in the presence of stationary and non-stationary series, support this test.

PANEL COINTEGRATION TEST

Larsson, Lyhagen and Lothgren (2001) propose a panel test for the existence of a common cointegration rank based on likelihood inference for vector autoregressive models as in the spirit of Johansen. They propose an LR-bar test statistic similar to the test statistics proposed by Im, Pesaran and Shin (1997).

Formally, the following rank hypothesis is tested for all $i = 1, \ldots, N$:

H_0: $rank(P_i) = r_i \leq r$

H_1: $rank(P_i) = p$

That is, were are testing the hypothesis that all of the N banks in the panel have at most r cointegrating relationships among p variables.

Denoting the trace statistic for group i as $LR_{iT}\{H(r) \mid H(p)\}$, the LB-bar statistic is defined as the average of the N individual trace statistics:

$$\overline{LR}_{NT}\{H(r) \mid H(p)\} = 1/N \sum_{i=1}^{N} LR_{iT}\{H(r) \mid H(p)\}$$

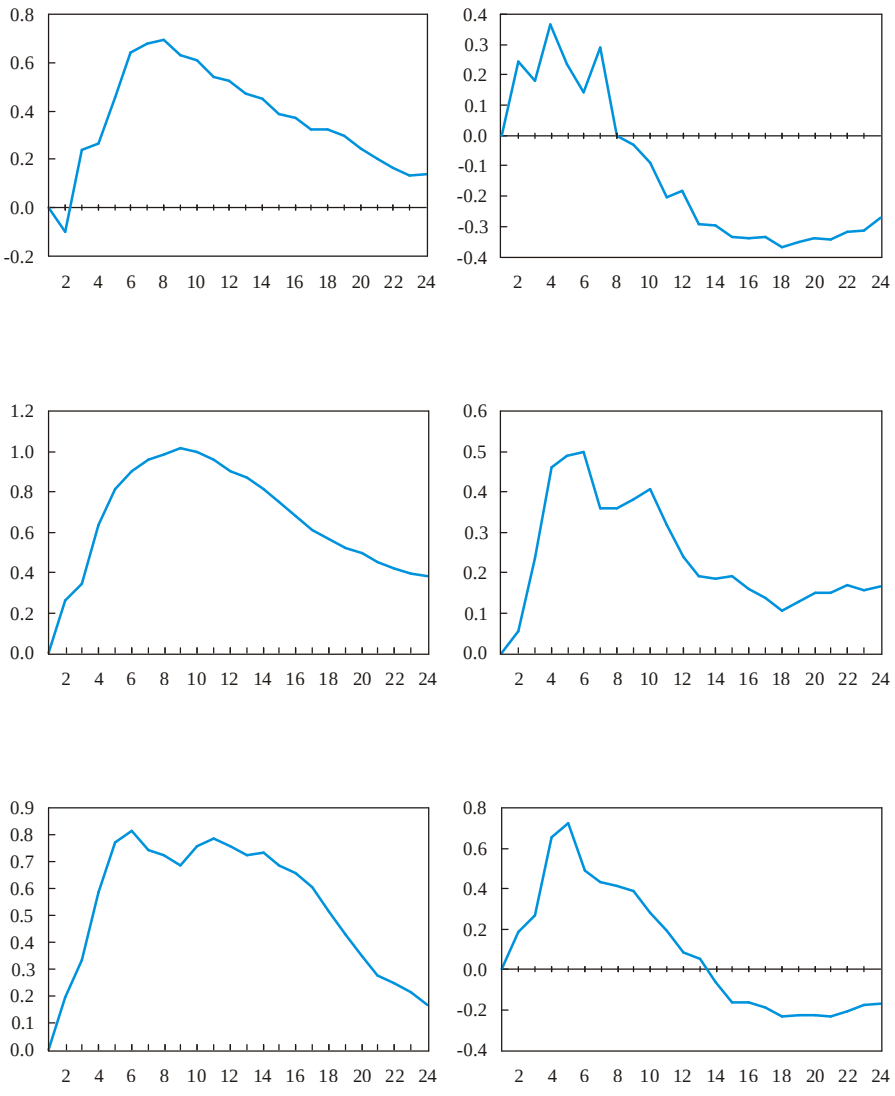
The standarized LB-bar statistic for a common panel cointegration test they propose takes the following form:

$$\Upsilon_{\overline{LR}} = \left[\sqrt{\overline{NLR}_{NT}}\{H(r) \mid H(p)\} - E(Z_k)\right] / \sqrt{Var(Z_k)}$$

The moments of Z_k can be obtained from Table 1 of the Larsson, Lyhagen and Lothgren (2001) paper. The authors also prove that, under certain assumptions, $\Upsilon_{\overline{LR}} \Rightarrow N(0, 1)$ as N and $T \rightarrow$ ¥.

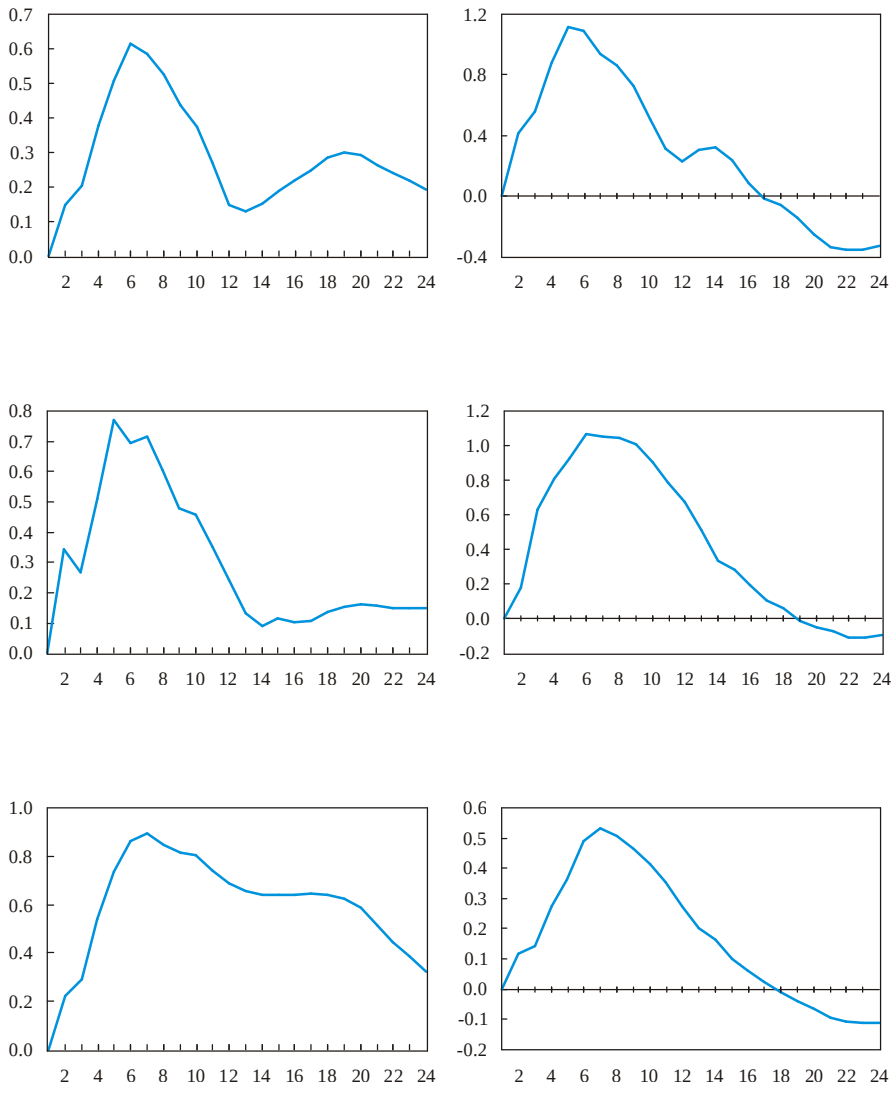
Graph A.1

Banks' CD Rate Response to 100 Basis Points Increase
in the Interbank Rate (21 banks)



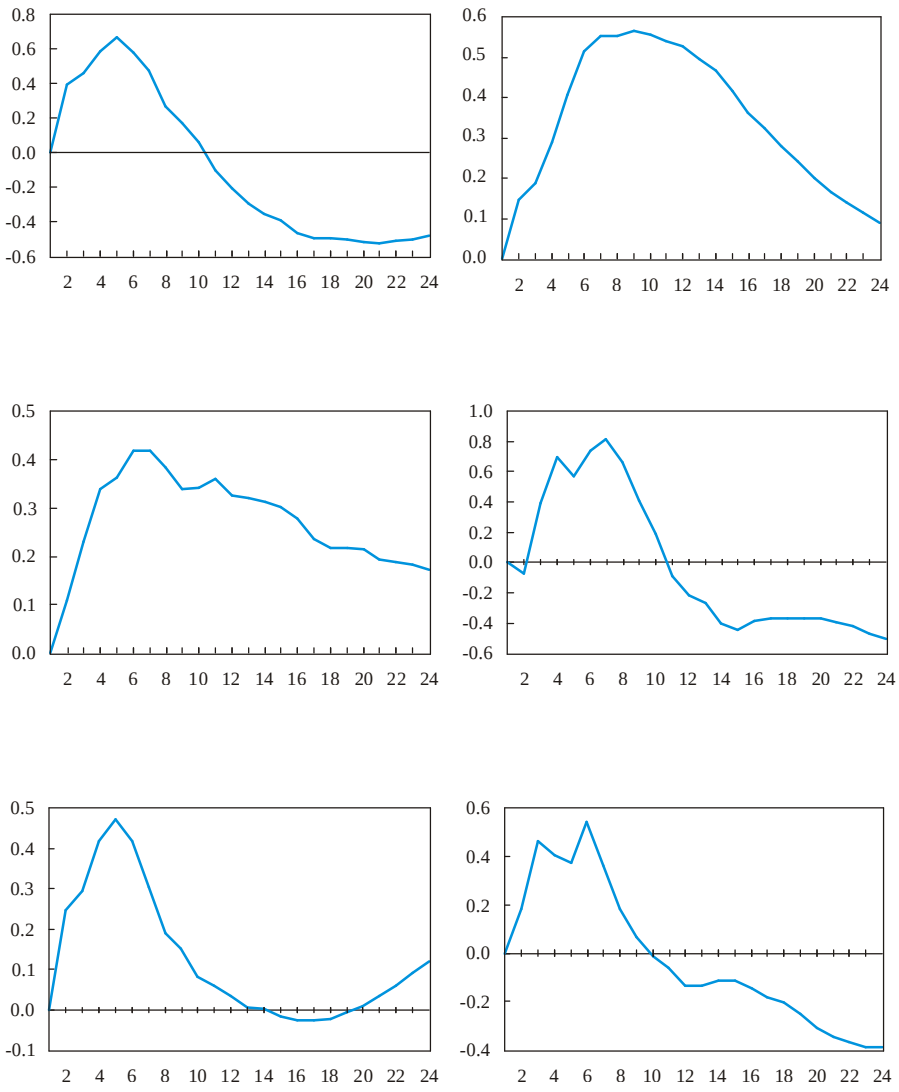
Graph A.1 (continued)

Banks' CD Rate Response to 100 Basis Points Increase
in the Interbank Rate (21 banks)



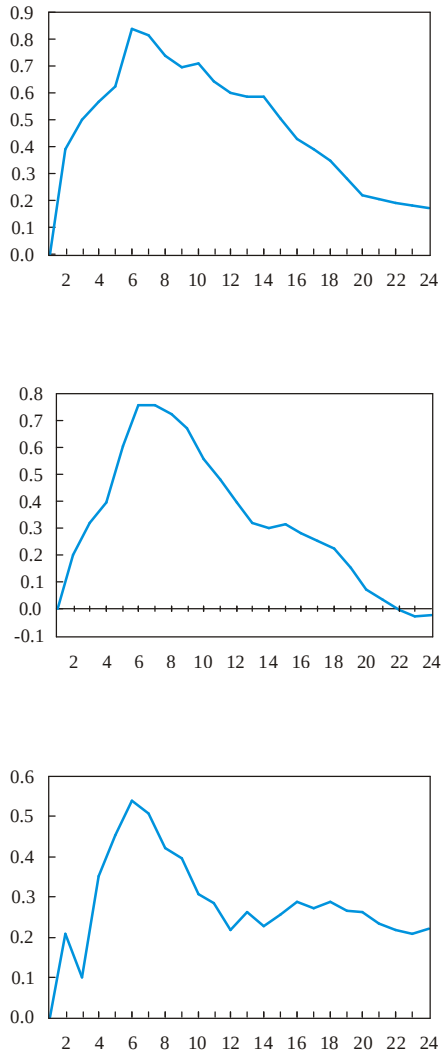
Graph A.1 (continued)

Banks' CD Rate Response to 100 Basis Points Increase
in the Interbank Rate (21 banks)



Graph A.1 (continued)

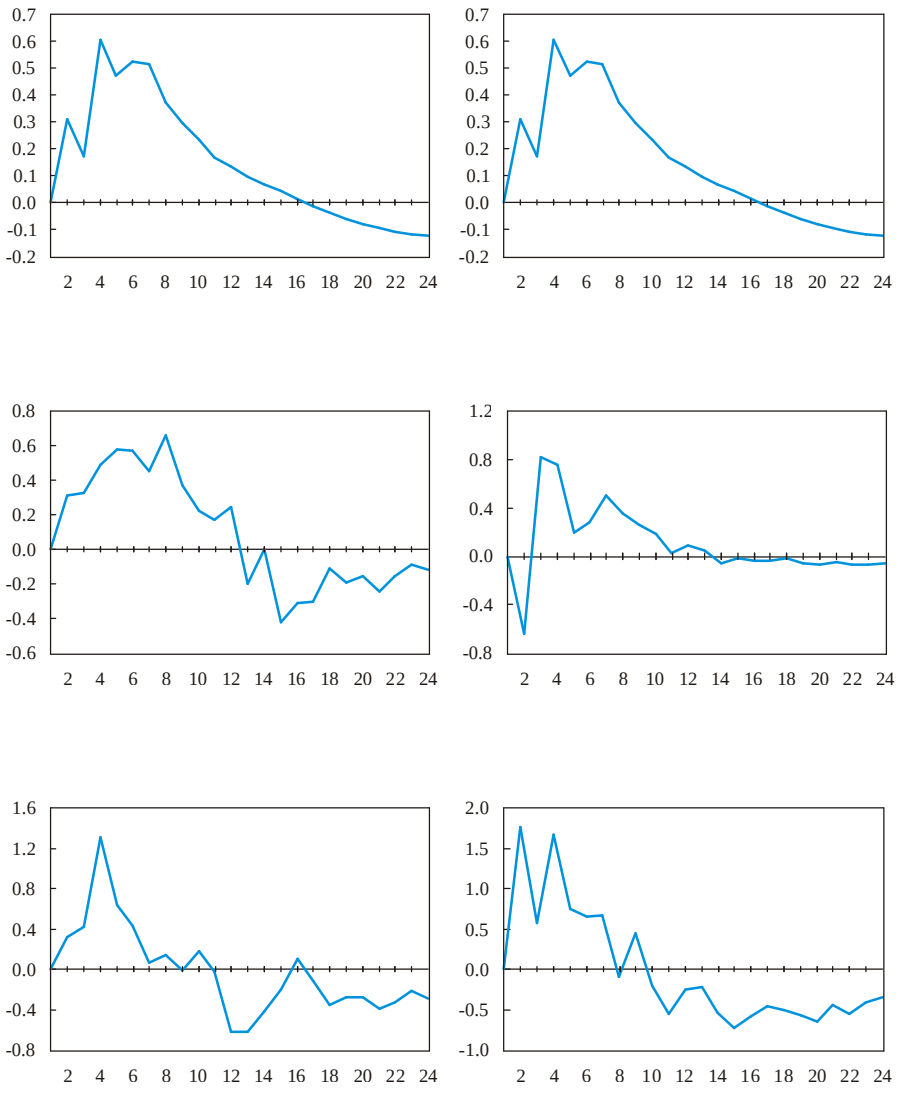
Banks' CD Rate Response to 100 Basis Points Increase in the Interbank Rate (21 banks)



Source: authors' calculations.

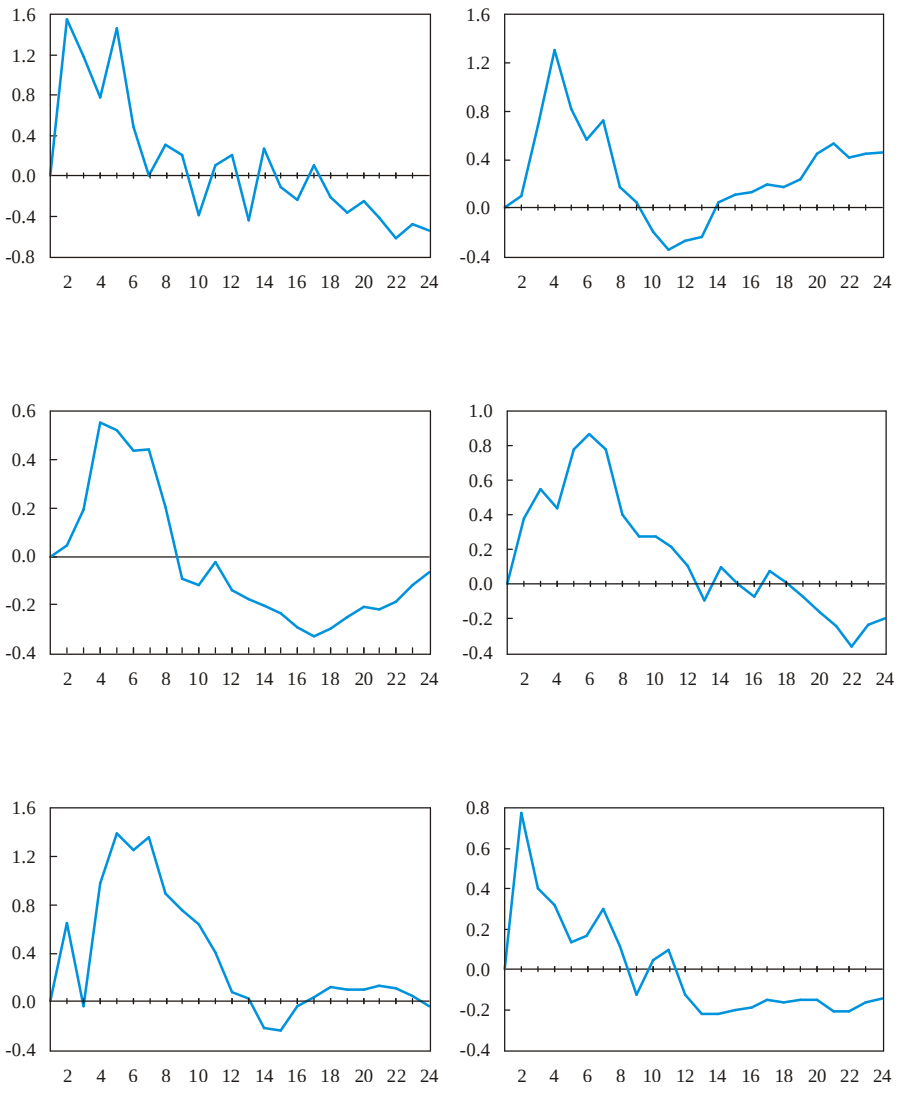
Graph A.2

Banks' Credit Rate Response to 100 Basis Points Increase
in the Interbank Rate (15 banks)



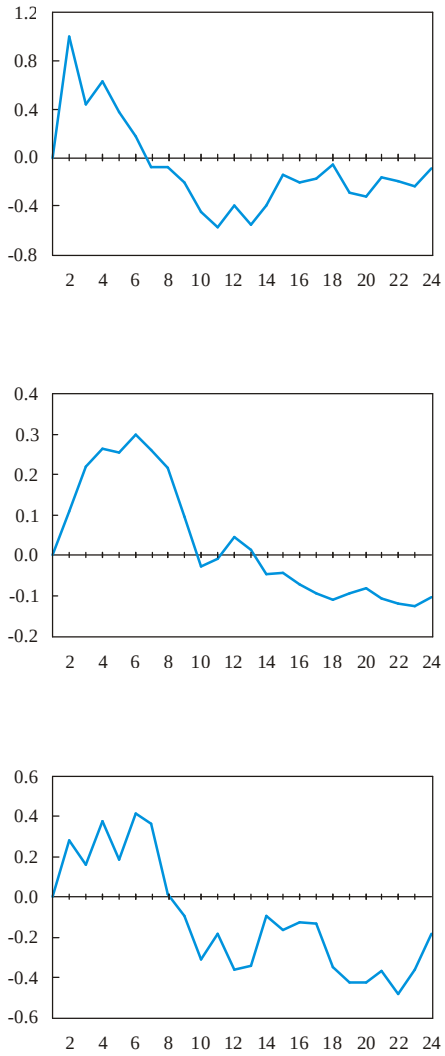
Graph A.2 (continued)

Banks' Credit Rate Response to 100 Basis Points Increase
in the Interbank Rate (15 banks)



Graph A.2 (continued)

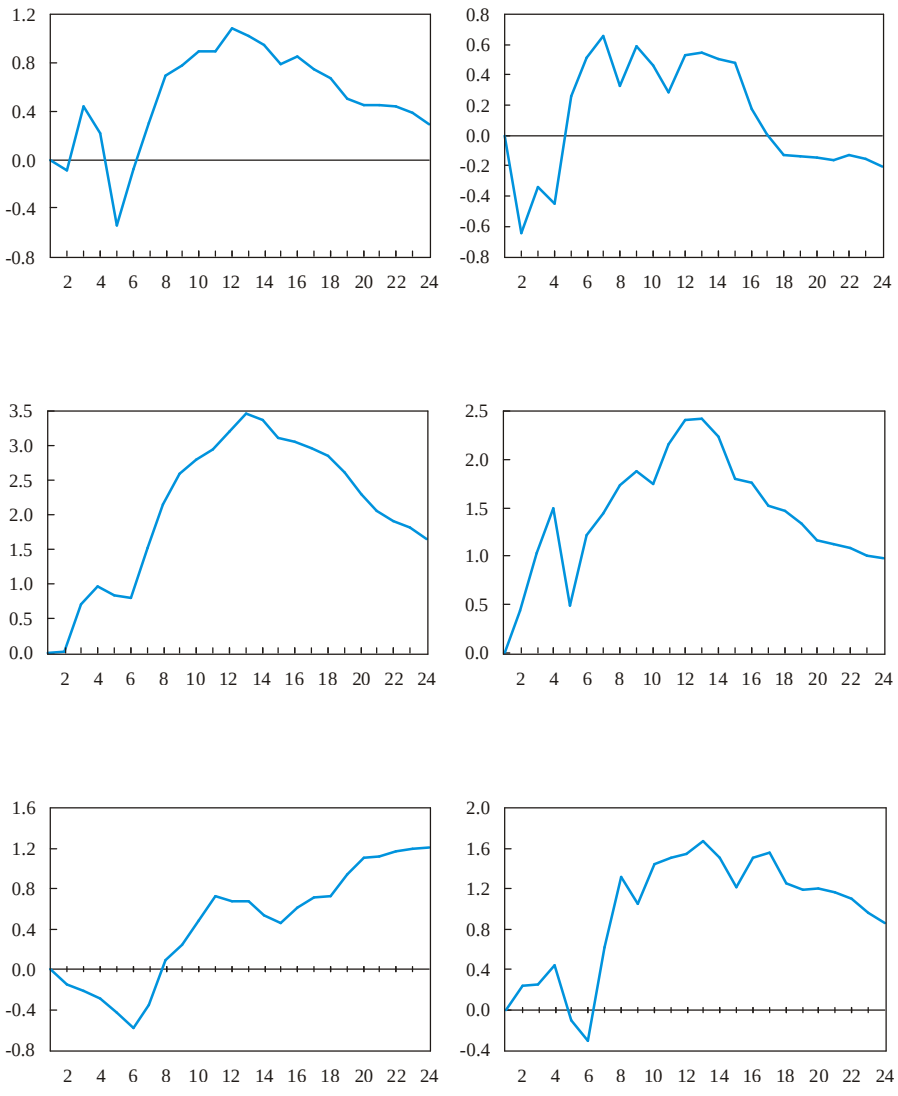
Banks' Credit Rate Response to 100 Basis Points Increase in the Interbank Rate (15 banks)



Source: authors' calculations.

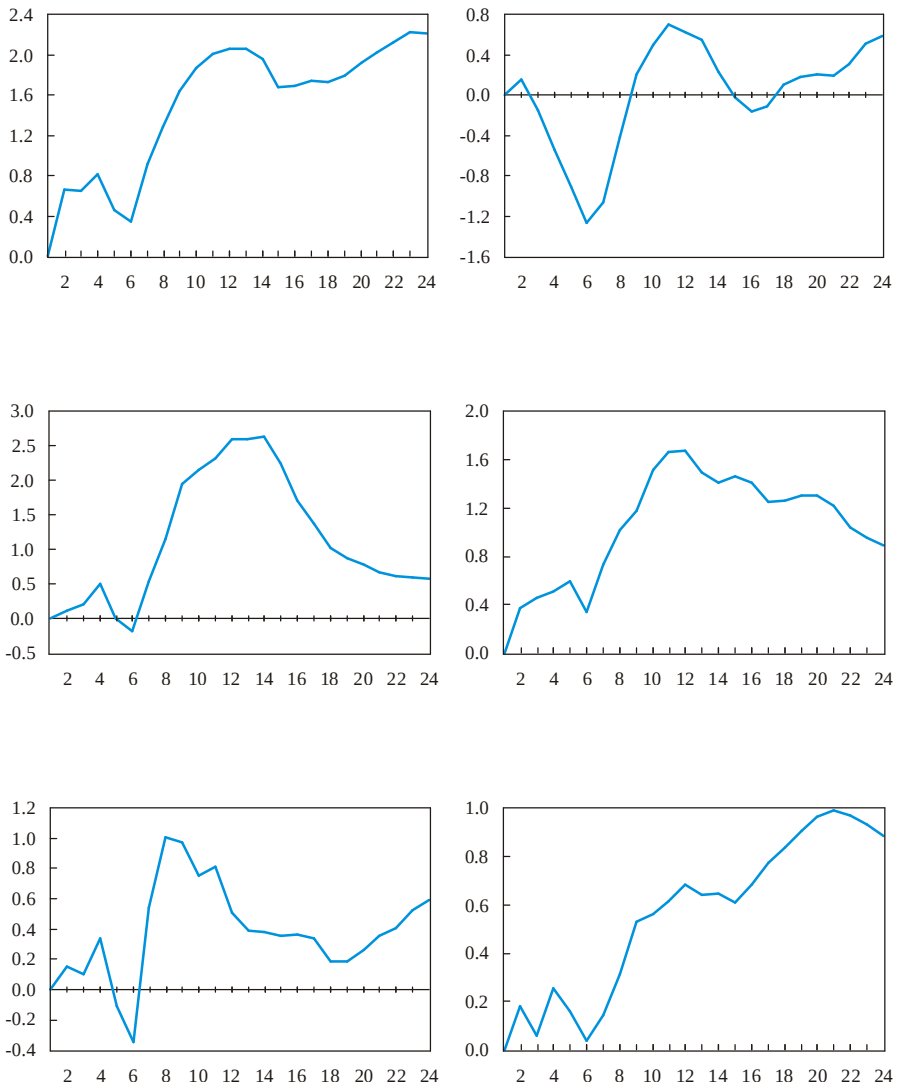
Graph A.3

Banks' CD Rate Response to 100 Basis Points Increase
in the Inflation Rate (21 banks)



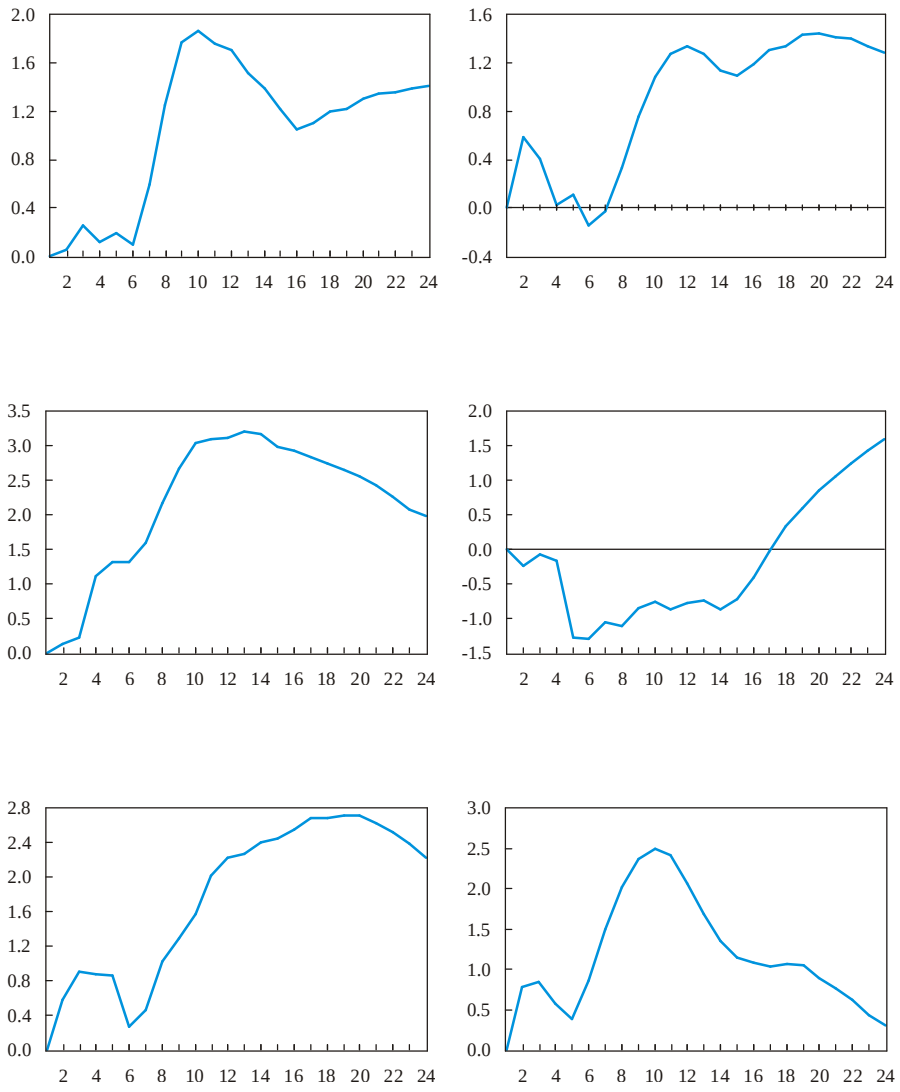
Graph A.3 (continued)

Banks' CD Rate Response to 100 Basis Points Increase in the Inflation Rate (21 banks)



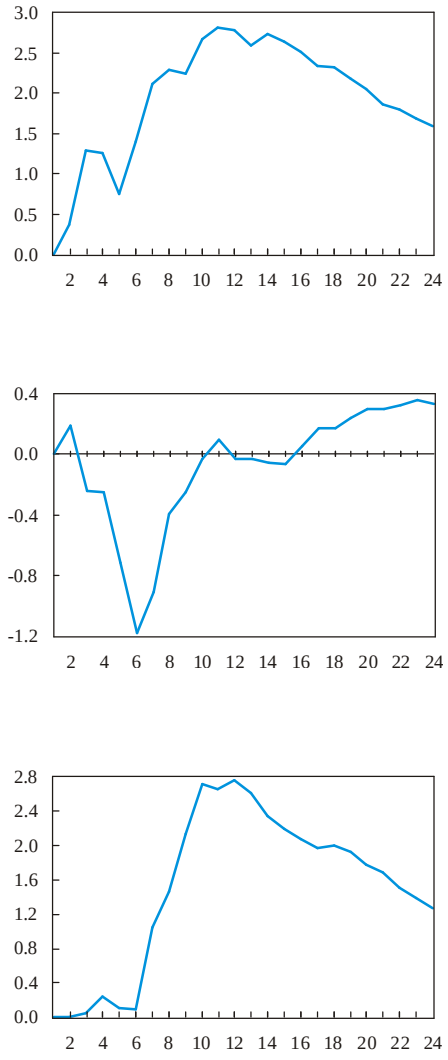
Graph A.3 (continued)

Banks' CD Rate Response to 100 Basis Points Increase in the Inflation Rate (21 banks)



Graph A.3 (continued)

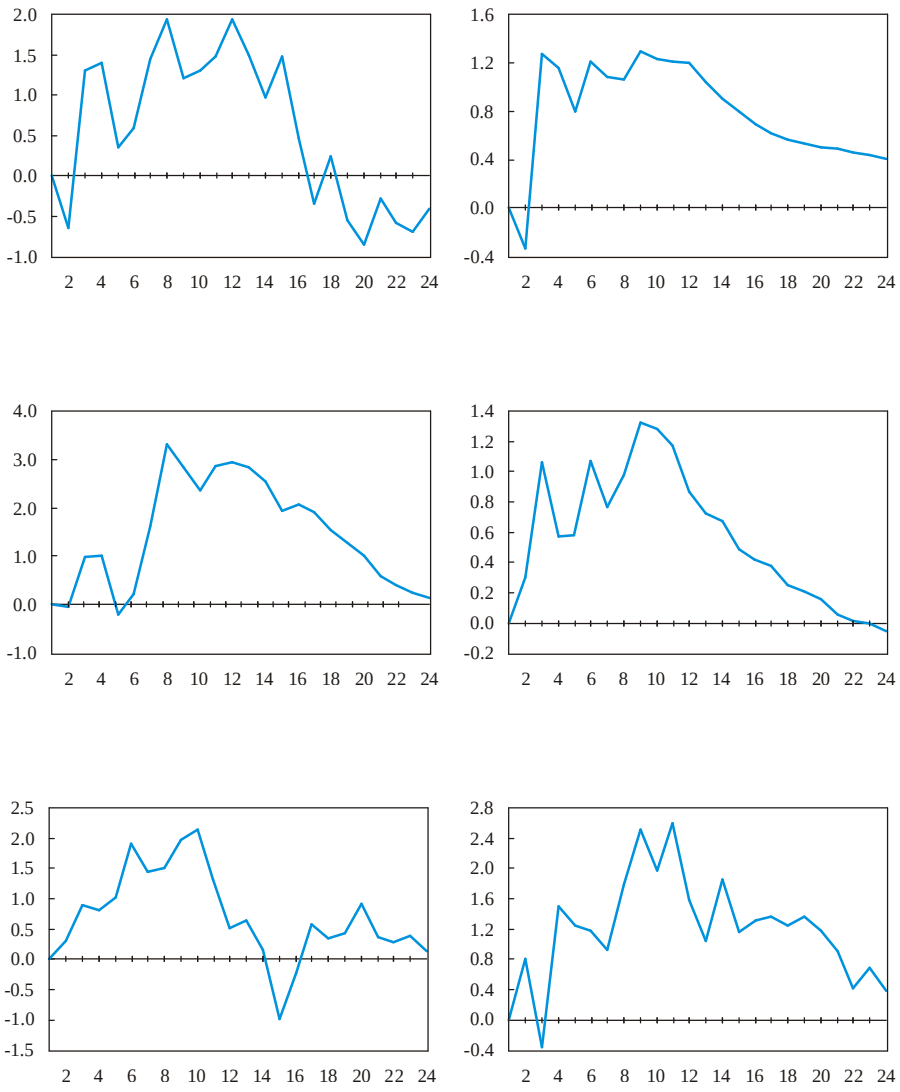
Banks' CD Rate Response to 100 Basis Points Increase in the Inflation Rate (21 banks)



Source: authors' calculations.

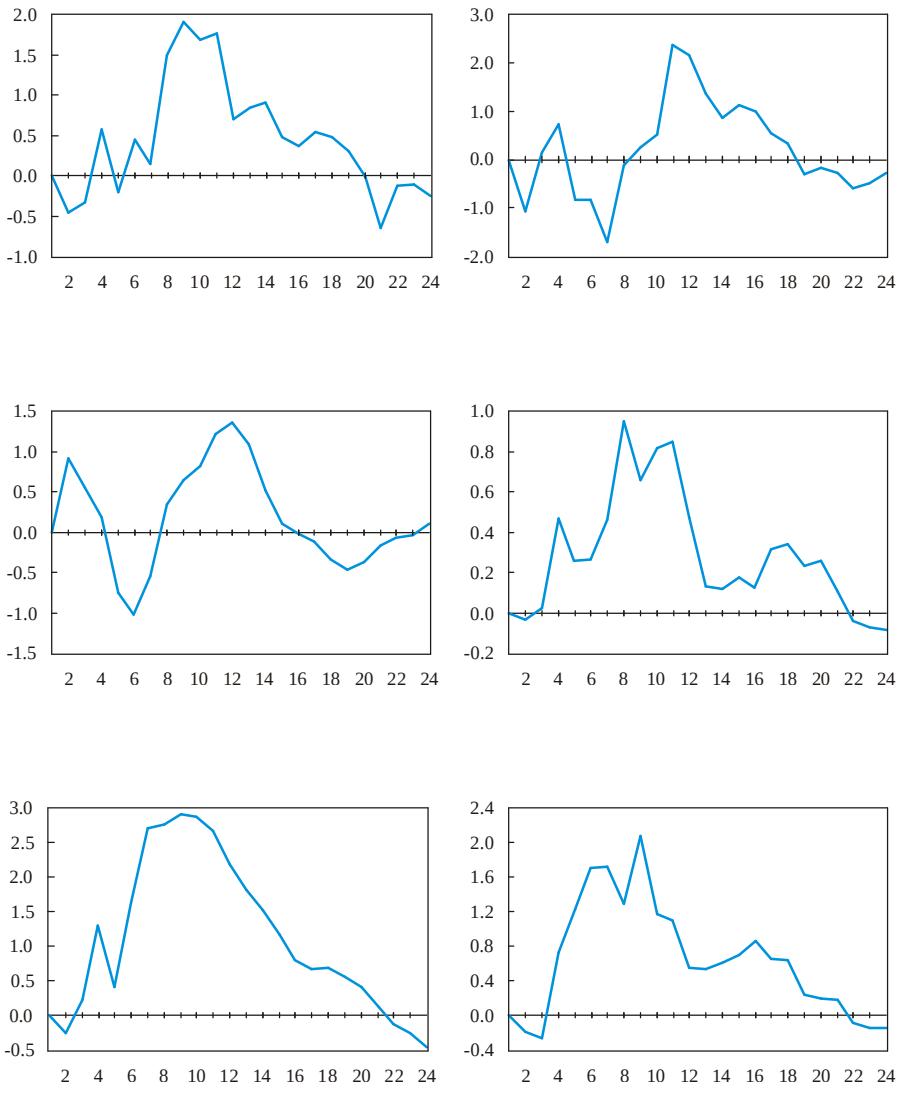
Graph A.4

Banks' Credit Rate Response to 100 Basis Points Increase in the Inflation Rate (15 banks)



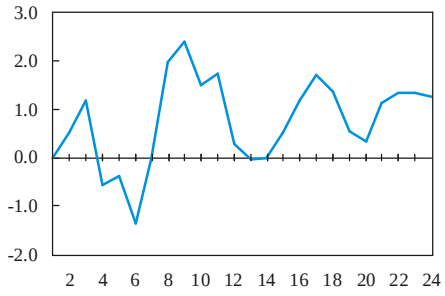
Graph A.4 (continued)

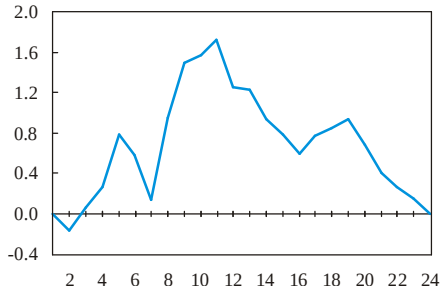
Banks' Credit Rate Response to 100 Basis Points Increase in the Inflation Rate (15 banks)

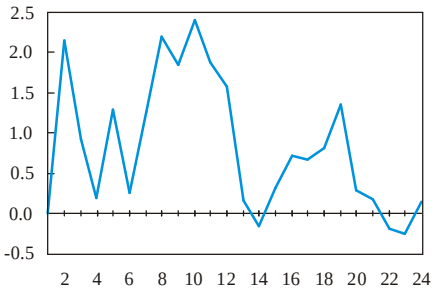


Graph A.4 (continued)

Banks' Credit Rate Response to 100 Basis Points Increase in the Inflation Rate (15 banks)



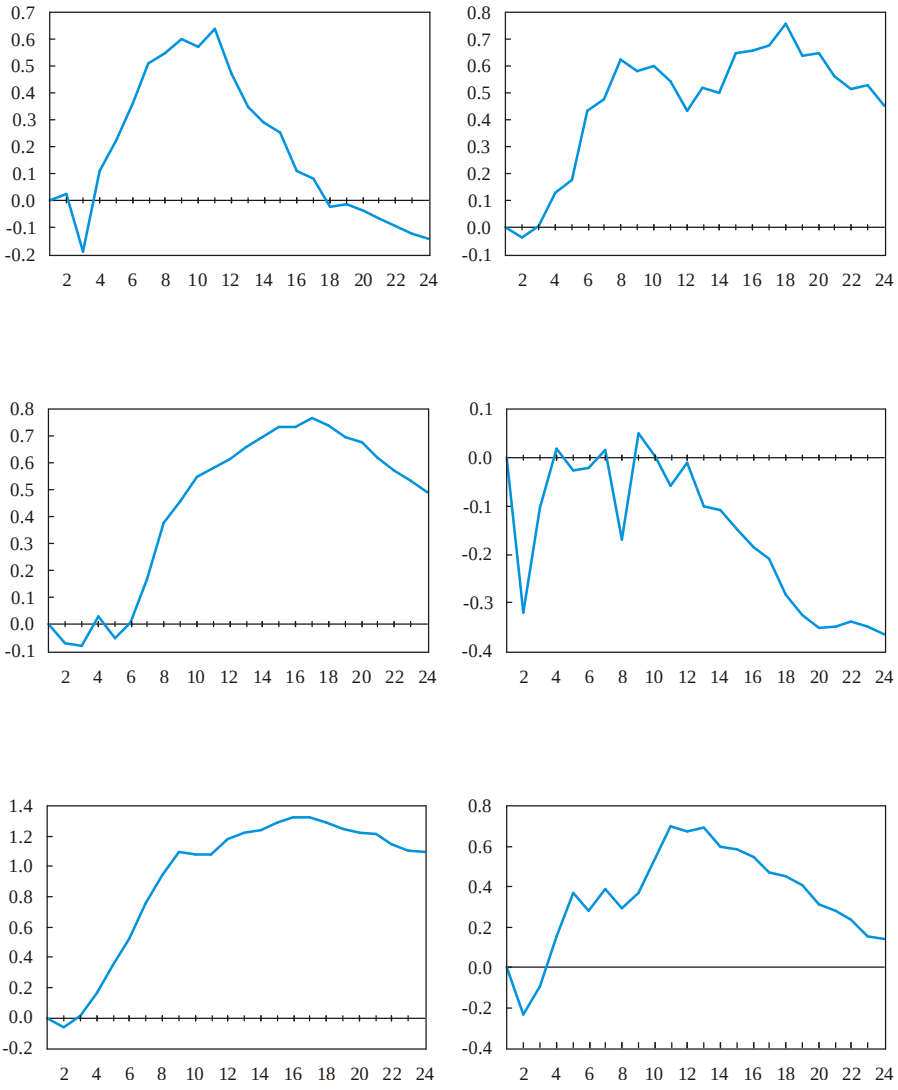




Source: authors' calculations.

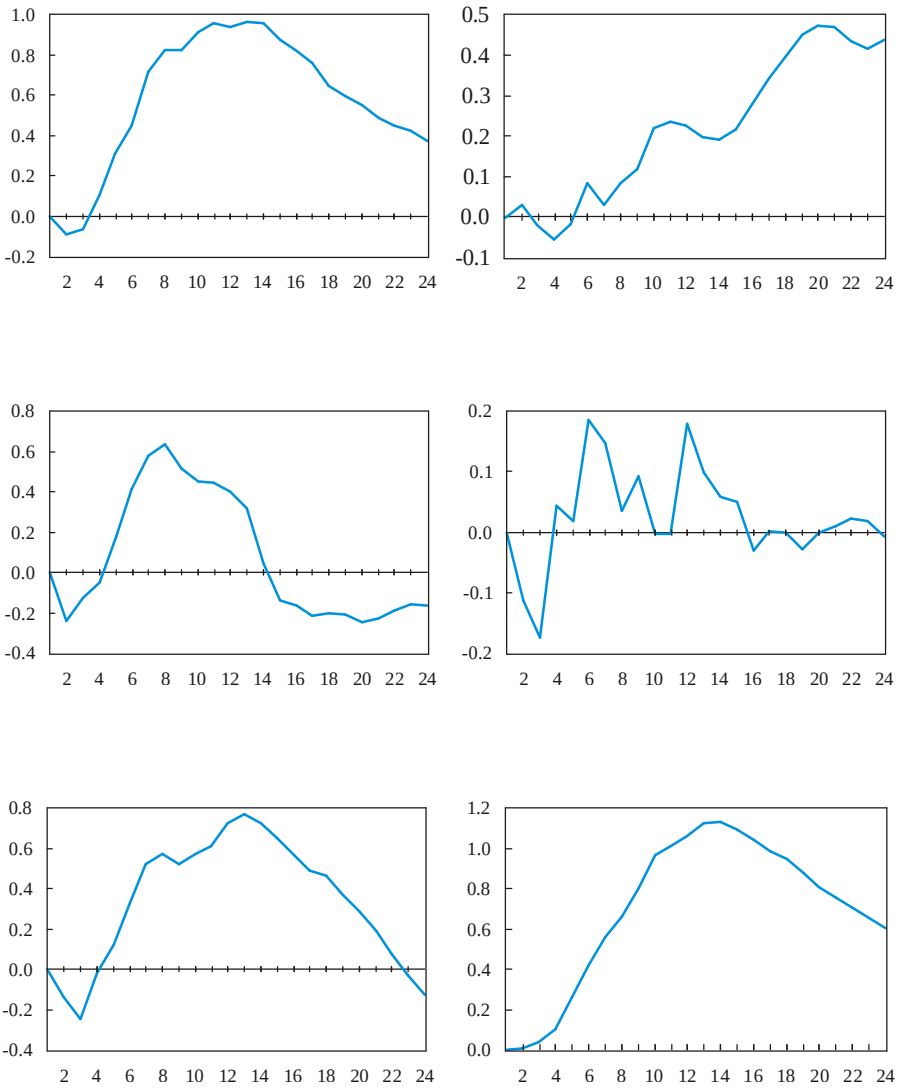
Graph A.5

Banks' CD Rate Response to one Standard Deviation Increase in the Industrial Production Index (21 banks)



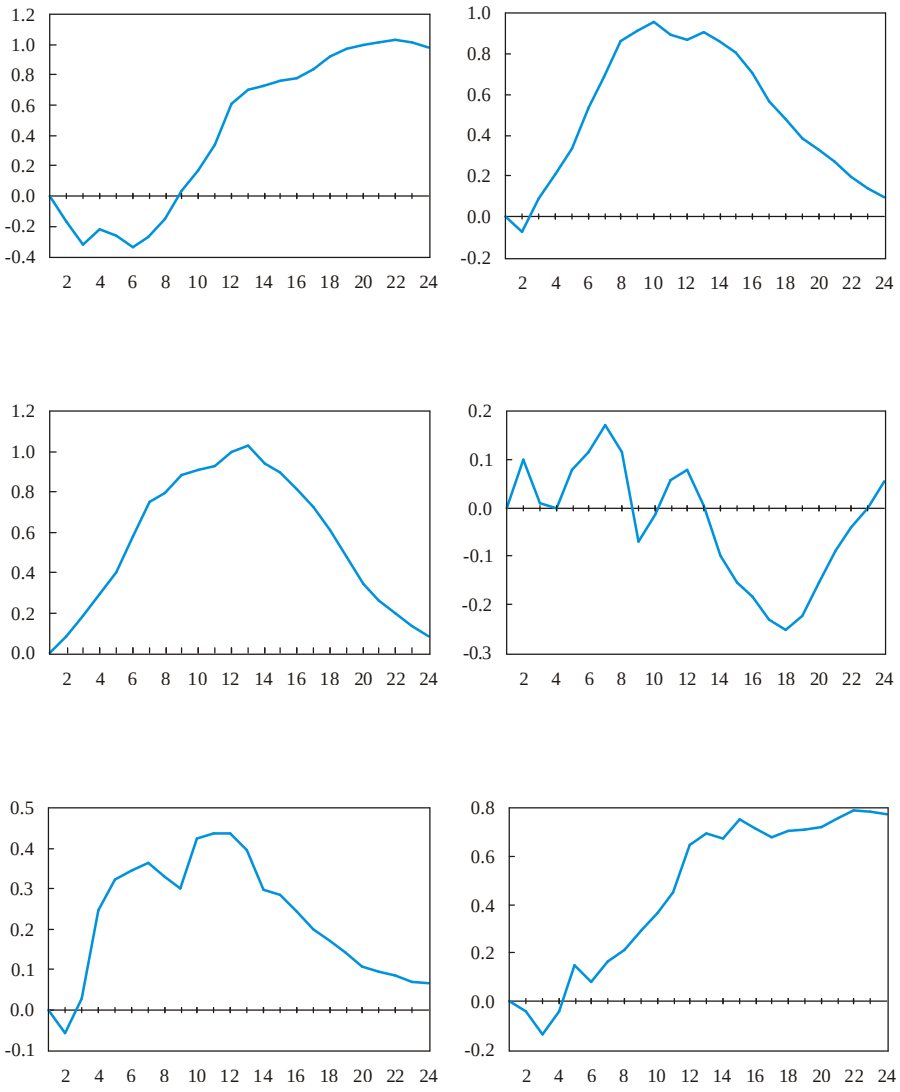
Graph A.5 (continued)

Banks' CD Rate Response to one Standard Deviation Increase in the Industrial Production Index (21 banks)



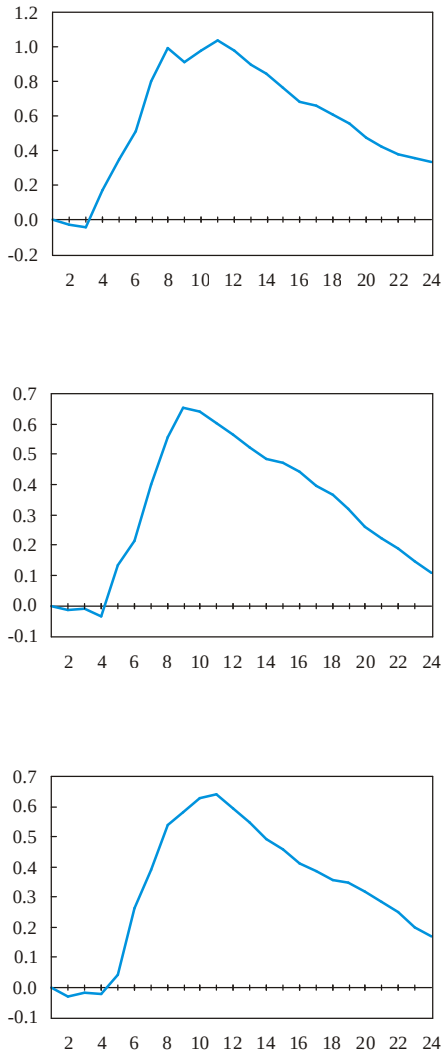
Graph A.5 (continued)

Banks' CD Rate Response to one Standard Deviation Increase in the Industrial Production Index (21 banks)



Graph A.5 (continued)

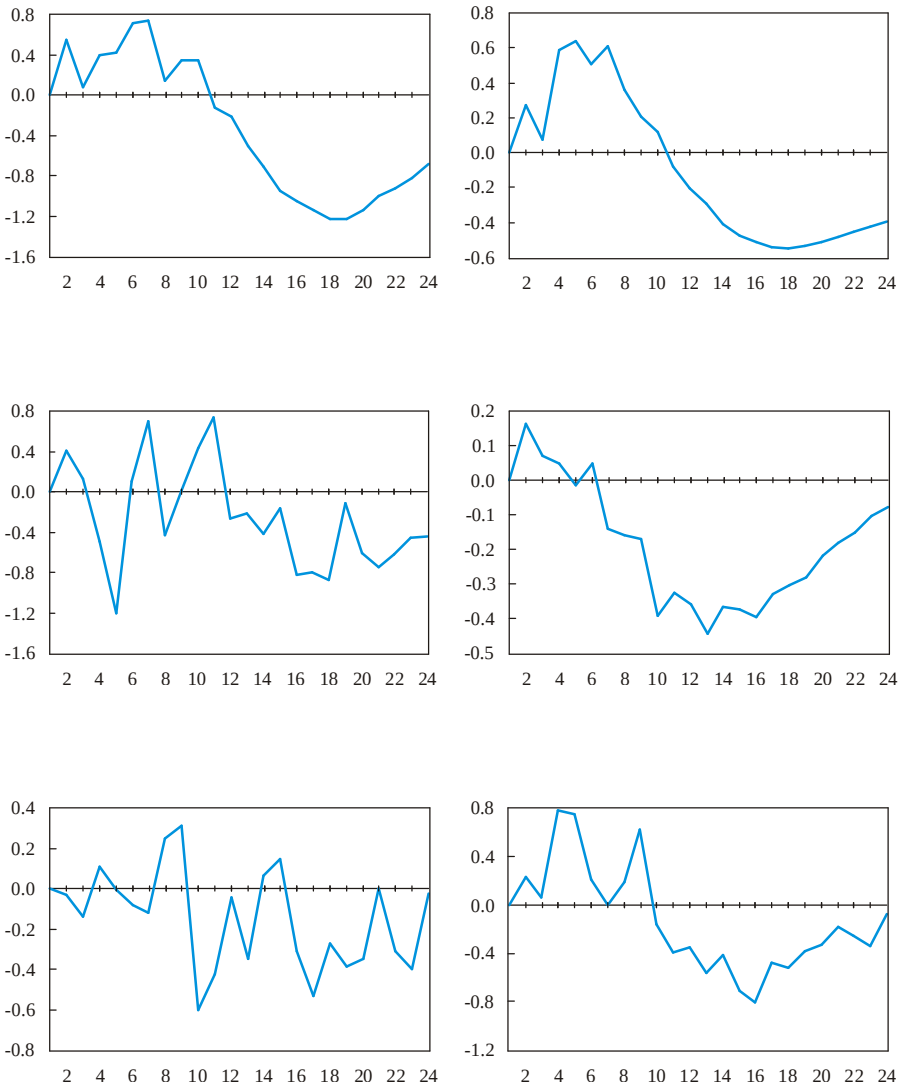
Banks' CD Rate Response to one Standard Deviation Increase in the Industrial Production Index (21 banks)



Source: authors' calculations.

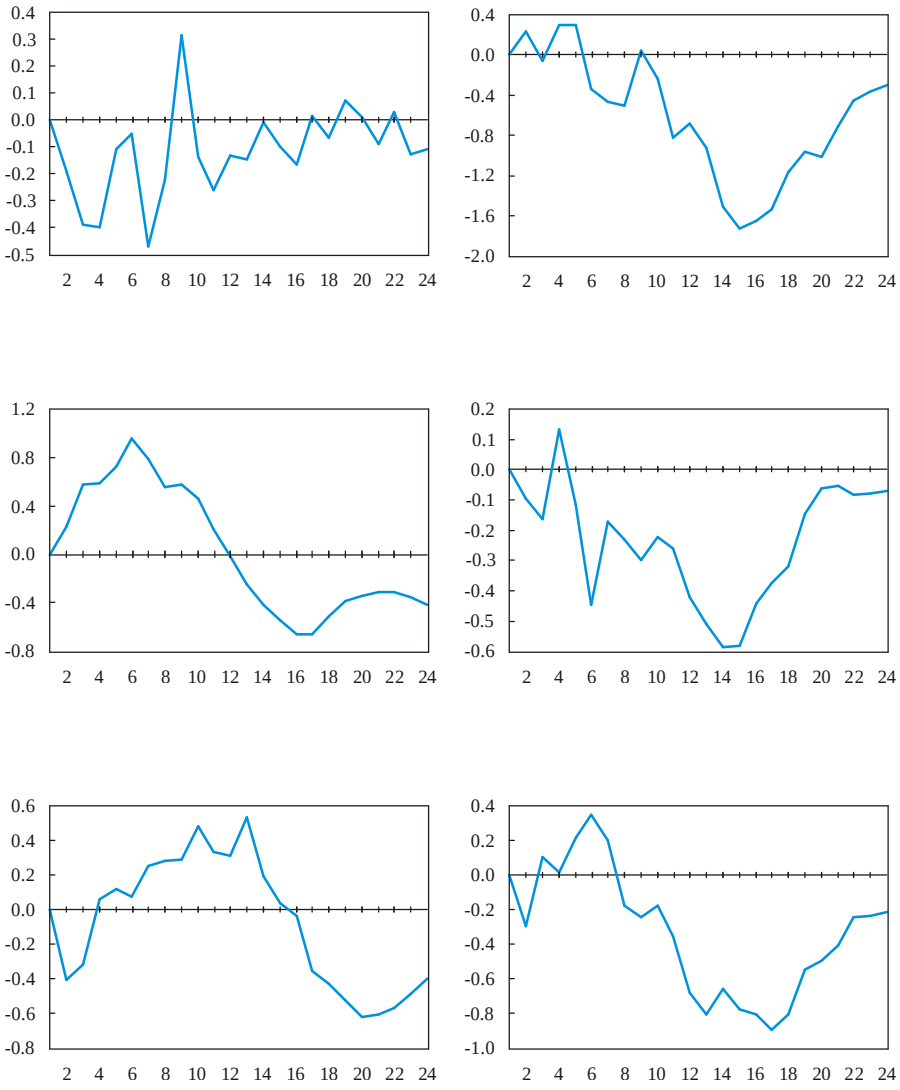
Graph A.6

Banks' Credit Rate Response to One Standard Deviation Increase in the Industrial Production Index (15 banks)



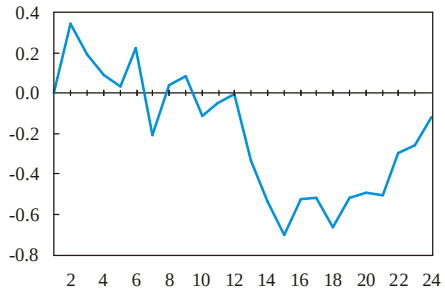
Graph A.6 (continued)

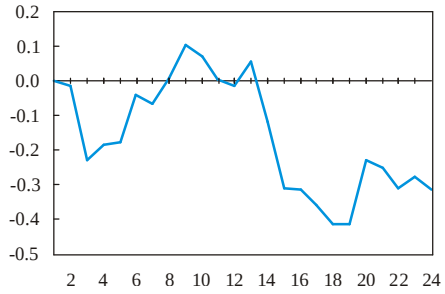
Banks' Credit Rate Response to One Standard Deviation Increase in the Industrial Production Index (15 banks)

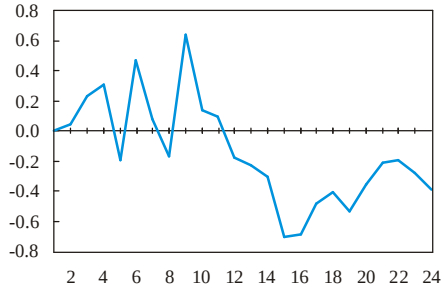


Graph A.6 (continued)

Banks' Credit Rate Response to One Standard Deviation Increase in the Industrial Production Index (15 banks)







Source: authors' calculations.

Table A.1

Variance Decomposition Exercise for CD Rate (21 banks)

Period	S.E.	CD rate	Interbank	*p*	IP	Size	CAR	Loans/ deposits	*w*
1	1.0	37.7	49.3	1.9	0.2	7.4	2.9	0.2	0.4
12	5.5	7.9	62.0	3.7	9.1	1.3	5.6	10.1	0.2
24	7.4	6.6	56.2	6.6	6.1	2.5	12.3	9.2	0.4
1	0.9	83.5	6.5	2.2	1.2	1.3	0.2	5.0	0.0
12	3.9	10.9	13.0	10.3	29.2	1.4	6.8	27.3	1
24	8.6	7.4	7.7	5.7	26.4	3.2	3.9	37.9	7.8
1	1.0	33.0	58.3	0.3	0.3	7.7	0.2	0.2	0.0
12	6.4	29.6	38.6	12.9	9.4	3.8	0.7	1.0	4.0
24	9.5	25.5	21.3	20.3	15.8	9.5	0.6	3.1	4.0
1	1.2	31.3	55.9	0.4	2.9	0.0	0.3	7.1	2.2
12	4.9	9.6	19.7	23.0	0.6	16.2	2.1	22.8	6.0
24	6.8	7.1	11.7	25.6	1.4	25.2	3.1	19.2	6.6
1	0.5	41.6	24.1	6.5	7.1	3.3	0.6	0.0	16.7
12	4.6	7.5	28.6	2.6	49.1	4.6	2.8	2.2	2.4
24	8.1	5.1	14.2	2.5	43.7	21.9	8.0	1.9	2.7
1	1.24	56.65	42.07	0.07	0.0	0.02	0.15	0.99	0.04
12	4.5	21.1	35.2	7.0	9.1	1.1	18.1	4.3	4.2
24	5.9	14.0	23.9	17.5	10.4	7.9	16.5	4.9	4.9
1	0.8	40.0	55.5	0.0	2.0	1.5	0.3	0.0	0.7
12	4.8	14.9	25.3	5.6	36.9	1.0	6.9	3.3	6.0
24	7.8	14.7	9.6	10.9	30.0	2.6	6.6	6.2	19.3
1	0.5	66.2	10.9	2.9	2.9	1.1	4.4	0.9	10.7
12	3.0	11.1	38.1	5.7	5.3	5.3	0.8	4.8	29.0
24	6.6	11.7	14.2	1.3	14.5	6.7	1.1	1.2	49.4
1	0.8	60.1	30.5	5.2	1.3	1.7	0.9	0.2	0.1
12	6.2	5.7	26.9	7.8	23.3	4.9	1.0	19.4	10.9
24	8.6	3.0	20.8	11.3	16.7	8.0	0.8	31.4	7.8
1	1.0	37.6	41.7	0.2	0.5	5.1	9.5	5.1	0.3
12	5.5	28.1	47.1	6.7	1.0	0.8	13.7	1.1	1.6
24	6.6	22.1	35.3	14.1	0.7	3.7	14.0	8.2	1.8
1	0.5	64.0	24.9	5.3	4.3	0.0	0.3	1.0	0.2
12	4.7	23.1	24.5	9.1	21.9	8.9	3.0	5.5	4.0
24	7.4	14.6	14.7	4.1	19.7	26.5	15.2	3.2	2.0

Table A.1 (continued)

Variance Decomposition Exercise for CD Rate (21 banks)

Period	S.E.	CD rate	Interbank	*p*	IP	Size	CAR	Loans/ deposits	*w*
1	0.7	42.2	54.0	0.3	2.0	0.0	0.6	0.6	0.3
12	6.5	3.3	37.0	1.9	9.0	6.5	0.4	13.8	28.1
24	9.3	3.3	25.5	2.5	9.7	14.7	0.4	18.0	25.8
1	0.6	43.2	33.1	10.2	1.7	0.0	3.7	8.0	0.1
12	4.9	9.3	23.3	2.2	41.6	20.0	1.8	0.3	1.4
24	8.7	4.3	8.2	1.2	42.3	33.3	7.7	1.1	1.9
1	1.0	69.0	22.8	0.0	1.3	0.9	1.0	5.1	0.0
12	7.0	2.3	42.1	10.7	36.2	3.9	1.1	1.7	2.0
24	9.7	1.3	39.1	13.7	35.9	2.6	3.1	1.1	3.1
1	1.0	45.0	45.6	4.8	0.1	2.6	0.9	0.7	0.3
12	4.4	3.9	56.7	13.2	6.5	2.9	4.4	8.3	4.0
24	7.1	2.9	40.5	5.5	26.7	13.9	2.6	4.8	3.2
1	0.6	63.5	15.7	6.2	1.5	7.9	3.0	1.7	0.5
12	5.4	2.7	61.9	2.8	18.5	0.8	9.7	2.4	1.3
24	7.6	1.7	47.9	7.9	18.3	6.7	15.5	1.3	0.8
1	0.8	58.8	30.1	5.6	1.8	0.2	1.3	2.0	0.2
12	6.7	9.5	30.8	8.2	28.3	3.9	0.2	11.1	7.9
24	9.9	7.9	27.5	12.3	26.8	6.3	0.7	11.7	6.8
1	1.2	18.0	76.8	1.0	0.2	2.8	0.1	1.0	0.0
12	4.3	8.8	38.9	15.2	1.9	7.3	3.2	14.6	10.1
24	6.9	4.7	20.7	9.8	2.4	5.7	4.3	8.5	43.9
1	0.9	65.5	14.5	12.7	0.1	3.3	0.0	0.6	3.3
12	5.3	7.3	49.9	13.5	5.6	1.4	2.4	6.0	13.9
24	7.3	4.1	30.3	21.8	5.7	10.0	3.5	12.4	12.2
1	1.3	27.2	62.8	3.5	0.9	2.6	0.0	0.3	2.8
12	4.9	3.2	42.7	7.6	8.9	3.9	2.1	10.6	21.0
24	7.2	2.0	36.7	9.1	16.4	8.0	7.3	7.0	13.5
1	1.5	29.2	61.2	6.5	2.4	0.0	0.0	0.0	0.5
12	6.8	14.0	23.4	2.6	21.6	6.1	20.5	11.0	0.6
24	9.7	10.4	13.4	5.2	22.4	3.1	14.4	26.1	4.9

Source: authors' calculations.

Table A.2

Variance Decomposition Exercise for Credit Rate (15 banks)

Period	S.E.	Interbank	Credit rate	Size	CAR	IP	*p*	*w*	*j*	Loans/ deposits
1	3	55	34	0	0	0	0	0	1	10
12	5	48	12	1	1	2	8	10	6	12
24	6	40	11	1	1	10	10	12	5	11
1	3	55	34	0	0	0	0	0	1	10
12	5	48	12	1	1	2	8	10	6	12
24	6	40	11	1	1	10	10	12	5	11
1	3	5	80	2	0	2	0	1	10	1
12	5	41	28	6	6	5	3	5	4	2
24	6	36	24	6	7	13	3	5	4	2
1	2	81	17	0	1	0	0	1	0	1
12	4	43	14	13	3	3	15	3	1	5
24	5	35	12	12	6	3	15	11	2	5
1	2	56	40	0	0	0	0	0	1	2
12	5	27	19	4	4	1	18	16	7	4
24	6	21	15	14	4	12	13	12	4	5
1	3	87	11	0	0	0	0	0	1	0
12	5	34	10	2	4	3	27	2	10	9
24	6	32	10	2	5	4	27	1	9	11
1	2	87	11	0	0	0	0	0	2	0
12	5	46	17	2	12	1	11	1	4	6
24	6	40	14	10	8	1	10	2	3	12
1	2	55	38	0	1	0	2	0	1	3
12	5	31	24	2	6	2	18	3	7	7
24	6	32	13	5	6	3	12	3	18	10
1	3	23	68	6	1	1	0	0	0	0
12	5	45	19	4	0	11	4	14	3	0
24	6	42	15	3	3	16	4	12	3	2
1	3	24	76	0	0	0	0	0	0	0
12	5	28	42	1	1	3	18	2	5	1
24	6	25	38	2	1	6	19	2	4	2
1	3	85	12	0	1	0	0	0	0	0
12	6	38	27	1	1	0	20	2	9	2
24	6	32	23	1	1	7	22	2	9	2

Table A.2 (continued)

Variance Decomposition Exercise for Credit Rate (15 banks)

Period	S.E.	Interbank	Credit rate	Size	CAR	IP	*p*	*w*	*j*	Loans/ deposits
1	3	30	62	2	0	3	2	0	1	0
12	5	60	5	2	1	13	11	2	1	5
24	6	52	4	3	1	16	11	3	2	8
1	2	54	39	0	2	2	0	1	0	3
12	4	35	24	2	4	3	11	9	9	2
24	6	30	13	3	6	5	22	10	6	3
1	3	3	70	0	0	1	1	7	13	4
12	6	29	9	1	8	7	15	12	18	2
24	6	27	10	3	7	6	18	11	18	2
1	2	53	42	0	0	0	2	0	1	1
12	5	26	18	15	9	2	24	2	2	1
24	6	17	9	26	6	11	18	2	7	3

Source: authors' calculations.