Interest Rate Pass-Through in Colombia: A Micro-banking Perspective*

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Introduction

The importance of the banking sector as a key player in interest rate pass-through has been recognized recently in literature concerning monetary policy transmission mechanisms. The interest rate channel, which operates when banks pass on changes in the monetary policy rate to interest rates for the customer, depends on how banks react to different shocks and to the state of the economy.

Given a change in the policy rate, the degree of rigidity in short-term interest rates is largely explained by the different features of the financial structure, such as the degree of competition in the banking sector, the size of the bank, the types of clients, and the loan-risk level financial institutions face.

The financial structure also can influence interest rate pass-through by affecting the way financial markets respond to macroeconomic conditions. In this respect, a macroeconomic shock can impact market interest rates directly, at the same time as the policy rate is responding to that shock. Therefore, when determining policy, monetary authorities should consider how the banks behave under different economic conditions.

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The idea illustrated in this paper is that the way market interest rates respond to changes in the policy interest rate depends on how banks and financial markets react to the various shocks that affect the economy. A theoretical microeconomic model of the banking sector is used for that purpose and some evidence for the Colombian economy is presented.

I. Interest Rate Pass-through in Colombia

Several studies on Colombia have found that, despite a long-term relationship between the monetary policy rate and bank interest rates, interest rate pass-through is incomplete. Huertas et al. (2005) found that a 1% change in the monetary policy rate implies a change of 0.26% in the 90-day CD rate during the short-term and a change of 0.6% in the long-term. The same authors documented the importance of the banking sector in Colombia and its significance in interest rate pass-through, finding that, although bank credit was the most important source of financing for companies between 2000 and 2004, its weakening, given the growing importance of substitutes for banks as well as companies, can explain the loss of the credit channel's effectiveness.

However, bank loans and deposits are still an important component of private sector liabilities and assets: on average, the financial debt funded 42% of the assets of consumers and small companies during the 1996-2004 period. The proportion of small-business and household assets held as deposits in the financial system during the same period was 42%, on average.[1]

This evidence suggests the Colombian banking sector plays a relevant role as a provider of funds and as a deposit system for the private sector. Therefore, a complete analysis of the monetary transmission channels and interest rate pass-through must take into account bank behavior and the equilibrium in the loan and deposit markets.

Two particular episodes in the Colombian economy, where market rates differ substantially from the monetary policy rate, can illustrate the effect macroeconomic conditions and variables other than the policy rate have on banks' decisions and, consequently, on their interest rates (Graph 1). During the first period, between January 2000 and February 2001, the policy interest rate[2] was stable, while the market rates increased, possibly due to banks' increased perception of risk and the growing supply of government debt paper as an investment alternative. The result was fewer loans and deposits.

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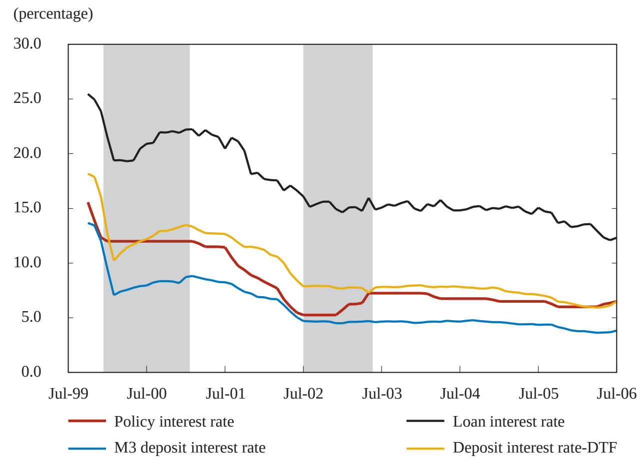
1 Source: Banco de la República's financial account.

2 The policy rate is the interest at which Banco de la República provides liquidity to the market through repo auctions.

In the second period, between July 2002 and May 2003, the market rates declined slightly, while the Central Bank's policy rate was left unchanged until December 2002, then raised 200 bp to curb inflationary pressures originating with the high depreciation in currency that affected the period. This divergent behavior between market rates and the policy rate can be explained, in part, by more growth in output, a better perception of risk on the part of the financial system, as well as the loss of value suffered by government securities. This increased the supply of loans and deposits, offsetting the upward pressure on interest rates stemming from growing country risk and high currency depreciation.

Graph 1

Nominal Interest Rates in Colombia



Source: Banco de la República.

II. A Micro-banking Model

Pursuant to Freixas and Rochet (1997), we developed a partial equilibrium micro-banking model that takes into account the existence of liquidity risk and market risk, as well as the impact of other economic variables on the supply of deposits and the demand for loans by the public to explain interest rate pass-through under a competitive structure in the banking sector.

Banking activity is modeled as the production of deposit and loan services. The technology for those services is represented by a cost function that depends on the volume of deposits and loans: $C(D,L)$, which is the same for all the banks.[3] Given that technology, we examined the behavior of a particular bank in a sector comprised of N risk-neutral banks that are price takers.[4]

Each bank faces a liquidity risk when its reserves are insufficient to cover the total amount of withdrawals demanded by its depositors. If we assume the level of reserves chosen by the banks and the amount of withdrawals depend on the level of deposits, so that $R = rD$ and $\tilde{X} = \tilde{x}D$, where $0 \leq r \leq 1$ and $\tilde{x} \in [0.1]$, the maximum amount of withdrawals will be equal to the total amount of deposits, and when $\tilde{x} \in (r.1]$, the banks have to borrow the shortfall from the Central Bank, incurring a cost $I(D,r) = r_p DE\left[\max\left(0, \tilde{x} - r\right)\right]$, where r_p is the policy interest rate. Specifically, when the proportion of withdrawals follows a uniform distribution between 0 and 1, $\tilde{x} \sim u(0,1)$, this cost is equal to $I(D.\, r) = r_p D / 2\,(1 - r)^2$.

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[3] The costs are assumed to be separable; that is, the existence of economies of scope is not taken into account.

[4] They accept the rate of loans, r_L , the rate of deposits, r_D, the return on government securities, r_T ,and the policy rate, r_p as given.

To understand how credit risk influences decisions on the banks' interest rates, we introduced a simple approach in which banks can recover only a fraction δ of the loans they grant. That portion depends positively on the economic conditions of the agents, measured by income (Y), and negatively on the loan interest rate (r_L). Therefore, only a portion $\delta(Y, r_L)$ of the loans are repaid and the agents pay interest only on that fraction. In this way, each bank has a net income given by: $r_L\delta\,(Y. r_L)L$ - $(1 - \delta(Y. r_L))L$. In addition to income from loans, banks have another source of earnings, given the possibility of investing their resources in an illiquid, but risk-free asset such as domestic government bonds (TES), with return r_T.

Each bank chooses the volumes of deposits (D), loans (L), reserves (R) and government securities (T) that maximize its profits, subject to the balance sheet constraint.

$$\underset{D,L,T,R}{Max}\ \pi = r_L\delta(.)L + r_T T - r_D D - (1-\delta(.))L - I(D,r) - C(D,L)$$

$$\text{s.t.}\begin{cases} R = D - L - T \\ R = rD \\ I(D,r) = \dfrac{r_p D}{2}(1-r)^2 \\ 0 \le \delta \le 1 \\ 0 \le r \le 1 \end{cases}$$

The first-order conditions of this problem are the following:

$$(1)\qquad r_D = (1-r)\left[\delta(.)(1+r_L) - 1 - \frac{r_p}{2}(1-r) - C_L^{'}\right] - C_D^{'}$$

$$(2)\qquad r_T = \delta(.)(1+r_L) - 1 - C_L^{'}$$

$$(3)\qquad r = 1 - \frac{\delta(.)(1+r_L) - 1 - C_L^{'}}{r_p}$$

where C_L' and C_D' are the marginal operating costs. To simplify the analysis, and pursuant to Freixas and Rochet (1997), it is assumed these costs are constant: So, $C_L' = \lambda_L$ y $C_D' = \lambda_D$.

Equation (1) implies that a competitive bank selects the ideal amount of deposits in such as way that the marginal net income, taking credit risk into account, $(1-r)\left[\delta(.)(1+r_L)-1\right]-r_D$. , is equal to the marginal cost, which pertains to the operational and illiquidity costs, $(1-r)\left[\frac{r_p}{2}(1-r)+\gamma_L\right]+\gamma_D$. With equation

(2), the marginal income from government bonds (r_T) must equal their marginal opportunity cost, $\delta(.)(1+r_L)-1-\gamma_L$. With equation (3), the optimal level of reserves depends on the opportunity cost of not lending these resources to the private sector, as well as the savings derived from not having to borrow the shortfall from the Central Bank.

Combining the equilibrium conditions of each of the markets with the balance sheets of the banks gives us the equilibrium interest rates. Therefore, the competitive equilibrium is characterized by equations (1) to (3) and the following conditions:

(4) $D = D^s\left(r_D, r_D^*, r_T, Y\right)$

(5) $L = L^d\left(r_L, r_L^*, Y\right)$

(6) $T = T^s - T_{-b}^d\left(r_D, r_D^*, r_T, Y\right)$

(7) $D(1-r) = L + T$

In that equilibrium, the banks' balance sheet is given by:

(8) $L^d\left(r_L, r_L^*, Y\right) = (1-r)D^s\left(r_D, r_D^*, r_T, Y\right) - T^S + T_{-b}^d\left(r_D, r_D^*, r_T, Y\right)$

where:

- *D*, *T*, *L* represent, respectively, the aggregate demand for deposits and government bonds and the loan supply in the banking system.

- The total supply of deposit from the agents, $D^s\left(r_D, r_D^*, r_T, Y\right)$ depends positively on the local deposit interest rate and income, and negatively on the foreign deposit interest rate and the rate of return on government bonds, which are imperfect substitutes for local deposits.

- The demand for loans on the part of the public, $L^d\left(r_L, r_L^*, Y\right)$, depends negatively on the local loan interest rate, and positively on the agents' level of income and the interest rates on foreign loans, which are assumed to be imperfect substitutes for local loans.

- The supply of government bonds (T^s) is exogenous and the demand for them on the part of agents in the economy other than the banks, $T_{-b}^d\left(r_D, r_D^*, r_T, Y\right)$, depends positively on the agents' income and the return on those securities, and negatively on the interest rate paid on the imperfect substitutes for this asset, such as local and foreign deposits.

The equilibrium interest rates in the deposit and loan markets are derived from equations (1), (2), (3) and (8) as implicit functions of the exogenous variables. Accordingly, $r_L = r_L\left(r_p, r_L^*, r_D^*, T^S, Y, \gamma_L, \gamma_D\right)$ and $r_D = r_D\left(r_p, r_L^*, r_D^*, T^S, Y, \gamma_L, \gamma_D\right)$. These functions are potentially non-linear, because they depend on the functional forms of the deposit supply and loan demand, as well as the distribution function of withdrawals, if these are not distributed evenly.

III. The Results

The comparative static analysis of equations (1) to (3) and (8) enables us to appreciate how shocks to the exogenous variables affect deposit and lending rates.

Result 1:
The effect of a shift in the monetary policy interest rate (r_p) on the equilibrium loan interest rate is positive, while the effect on the deposit interest rate is ambiguous.

(9)

$$\frac{dr_L}{dr_p} = \frac{\frac{\partial r_D}{\partial r_p}\left[(1-r)\frac{\partial D^s}{\partial r_D} + \frac{\partial T_{-b}^d}{\partial r_D}\right] - D^s(.)\frac{\partial r}{\partial r_p}}{\frac{\partial L^d}{\partial r_L} - \frac{\partial r_D}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_D} + \frac{\partial T_{-b}^d}{\partial r_D}\right] - \frac{\partial r_T}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_T} + \frac{\partial T_{-b}^d}{\partial r_T}\right] + D^s(.)\frac{\partial r}{\partial r_L}} > 0$$

An increase in the policy interest rate makes it more expensive for banks to cover a liquidity shortfall. This has two possible implications. On the one hand, the banks have incentives to maintain more reserves, via a smaller loan supply or more deposit demand. On the other hand, because the level of withdrawals depends on the total amount of deposits, the increased illiquidity cost reduces the banks' demand for deposits. The interaction of these two effects implies an increase in the loan interest rate and an ambiguous impact on deposit interest rates.

Result 2:
A change in foreign interest rates or in expectations of depreciation has a positive impact on equilibrium loans and deposit interest rates.

(10)

$$\frac{dr_L}{dr_L^*} = \frac{-\frac{\partial L^d}{\partial r_L^*}}{\frac{\partial L^d}{\partial r_L} - \frac{\partial r_D}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_D} + \frac{\partial T_{-b}^d}{\partial r_D}\right] - \frac{\partial r_T}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_T} + \frac{\partial T_{-b}^d}{\partial r_T}\right] + D^s(.)\frac{\partial r}{\partial r_L}} > 0$$

If foreign interest rates or expectations of depreciation increase, agents in the local economy witness a higher cost for borrowing abroad. This raises the demand for local loans and brings upward pressure to bear on the interest rate for such loans. The increased demand for loans is an incentive for banks to demand more deposits, at the same time as the agents reduce their supply, because higher interest rates make it more attractive for them to deposit abroad. Both these effects on the deposit market operate in the same direction, pushing up the interest rate.

Result 3:

The effect of a change in income level on equilibrium loan and deposit interest rates is ambiguous.

(11)

$$\frac{dr_L}{dY}=\frac{-\frac{\partial L^d}{\partial Y}+\frac{\partial r_D}{\partial Y}\left[(1-r)\frac{\partial D^s}{\partial r_D}+\frac{\partial T^d_{-b}}{\partial r_D}\right]+\frac{\partial r_T}{\partial Y}\left[(1-r)\frac{\partial D^s}{\partial r_T}+\frac{\partial T^d_{-b}}{\partial r_T}\right]+(1-r)\frac{\partial D^s}{\partial Y}-D^s(.)\frac{\partial r}{\partial Y}+\frac{\partial T^d_{-b}}{\partial Y}}{\frac{\partial L^d}{\partial r_L}-\frac{\partial r_D}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_D}+\frac{\partial T^d_{-b}}{\partial r_D}\right]-\frac{\partial r_T}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_T}+\frac{\partial T^d_{-b}}{\partial r_T}\right]+D^s(.)\frac{\partial r}{\partial r_L}}$$

An increase in income raises the supply of deposits and the demand for loans on the part of the public, implying a decline in the deposit rate and an increase in the loan rate. To satisfy the increased demand for loans, banks raise their demand for deposits, pushing up their interest rate. Moreover, because the agents are in a better economic situation, a higher percentage of loans will be repaid, thereby reducing credit risk and giving banks an incentive to offer more loans. This will exert downward pressure on the loan interest rate. In all, the ultimate effect of a change in income is ambiguous.

Result 4:

An increase in the supply of government securities (T^s) *implies an increase in the equilibrium level of loan and deposit interest rates.*

(12)

$$\frac{dr_L}{dT^s}=\frac{-1}{\frac{\partial L^d}{\partial r_L}-\frac{\partial r_D}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_D}+\frac{\partial T^d_{-b}}{\partial r_D}\right]-\frac{\partial r_T}{\partial r_L}\left[(1-r)\frac{\partial D^s}{\partial r_T}+\frac{\partial T^d_{-b}}{\partial r_T}\right]+D^s(.)\frac{\partial r}{\partial r_L}}>0$$

An additional supply of government securities implies a reduction in the supply of deposits made by companies and households, and a decline in the supply of loans from commercial banks, all of which pushes up interest rates. The impact on the deposit interest rate is reinforced if banks increase their demand for deposits to fund the purchase of government bonds.

In general, the response from bank interest rates to exogenous shocks may not be linear and can depend on macroeconomic variables that affect the elasticities of deposit supply and the demand for loans. In other words, this response can be complex and may depend on the state of the economy.

IV. Econometric Evidence

The theoretical model described in the previous section implies that market interest rates are influenced by factors other than the policy rate. Therefore, an estimate of interest rate pass-through must take into account the role played by other macroeconomic variables, which can affect equilibrium in the loan and deposit markets.

Two econometric approaches were developed to test this hypothesis. To begin with, once the possible long-term relationship between market and policy interest rates is proved, error correction models are estimated, in which the macroeconomic variables suggested by the theoretical model are included as explanatory variables of the short-term dynamics of the market rates. With the second approach, it is assumed that some of the macroeconomic variables may be endogenous in a general equilibrium context, which is why a VARX is estimated. Then, Granger causality tests are performed to verify the significance of the macroeconomic variables in the market interest rate equation, and the impulse-response functions are examined to check the reaction of those rates to different shocks.

Tables 1 and 2, show the estimates of different models for two measurements of the deposit interest rate (DTF and M3).[5] In most cases, variables other than the policy interest rate and the residual of the long-term equation are significant in the error correction equations and have the expected signs. Accordingly, and based on the estimates, it is possible to conclude that the short-term momentum in deposit interest rates is influenced by other macro variables, as the theoretical model suggests.

Nevertheless, to assess the impact of exogenous shocks on market rates, one must consider not only their direct influence, but also the indirect effects occasioned by other macro variables that are endogenous in a general equilibrium context. To capture these dynamics, a VARX was estimated for a set of variables in first differences. Tables 3 and 4 show the Granger causality tests for two deposit interest rates with two specifications: one with the price change in government bonds as a proxy for the profitability of these securities and the other without. The results of these estimates demonstrate that most of these variables Granger-cause the market interest rates.[6]

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5 The M3 interest rate is a weighted average of the interest rates on different types of deposits (savings, 90-day CDs and 360-day CDs).

6 Although these results might be biased, because the long-term relationship between interest

The impulse-response functions for DTF and M3 interest rates show a positive short-term reaction to changes in the policy rate, as well as reactions to other shocks in the direction theory predicts.

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rates is not taken into account, the size of the sample does not allow us to use a more adequate technique, such as a VEC.

TABLE 1

UNI-EQUATIONAL ERROR CORRECTION MODELS FOR THE M3 INTEREST RATE

	Model 1 [a/]	Model 2 [b/]
Constant	0.003631	-0.007897
	(0.032964)	(0.029407)
Residual (-1)	-0.092387	-0.113488
	(0.045228)	(0.041106)
Ddepreciation (-1)		0.008027
		(0.002196)
Ddepreciation (-4)		0.006092
		(0.002350)
Dpolicy (-1)	0.272142	0.243948
	(0.118982)	(0.109475)
Dpolicy (-2)	0.620527	0.576526
	(0.108078)	(0.099845)
Ddepreciation (-2)	0.626833	
	(0.283245)	
DEMBI (-4) [c/]	0.742623	0.686215
	(0.289368)	(0.295535)
Dlibor (-4)		-0.382553
		(0.120717)
R-squared	0.675	0.746
Adjusted R-squared	0.654	0.722
S.E. of regression	0.257	0.23
Sum squared residuals	5.042	3.945
Log likelihood	-2013	8.049
Durbin-Watson statistic	1.461	1.517
Akaike information criterion	0.195	-0.001203
Schwarz information criterion	0.371	0.233599
F-statistic	31.676	31.099

Note: Standard error in parenthesis
a/ This model does not consider variables that may be endogenous. Sample period 1999:11- 2006:08. Included observations: 82 after adjustments.
b/ This model includes other variables that may be endogenous in a more general model.
Sample period 1999:11 - 2006: 08. Included observations: 82 after adjustments
c/ This corresponds to the difference of the logarithm.
Source: The authors' calculations.

TABLE 2

UNI-EQUATIONAL ERROR CORRECTION MODELS FOR THE DTF

	Model 1 [a/]	Model 2 [b/]	Model 3 [c/]
Constant	0.009737 (0.031609)	-0.001069 (0.035462)	-0.035902 (0.018883)
Residual (-1)	-0.089976 (0.035600)	-0.111681 (0.038843)	-0.067593 (0.024334)
DDTF (-1)	0.370943 (0.054701)	0.372018 (0.064409)	
DDTF (-3)	-0.331074 (0.075088)		
DDTF (-5)	0.184179 (0.068342)		
DDTF (-6)	-0.218319 (0.060558)		
Ddepreciation (-2)		0.005167 (0.002568)	
DIPI (-5)		-1.565 (0.776674)	
DITES (-4)			-1.644 (0.806510)
Dpolicy (-1)	0.450261 (0.116271)	0.643074 (0.125013)	0.504782 (0.072874)
Dpolicy (-5)	0.432154 (0.119869)		
DEMBI (-1) [d/]	0.715486 (0.275240)	0.663275 (0.327687)	0.602965 (0.169135)
DEMBI (-2)	0.740617 (0.300513)		
DEMBI (-4)	0.860633 (0.298002)		
Dlibor (-2)			-0.538332 (0.193260)
Dlibor (-3)	-0.378509 (0.129826)	-0.344157 (0.154815)	
Dlibor (-6)			0.442744 (0.173628)
R-squared	0.829	0.749	0.757
Adjusted R-squared	0.801	0.726	0.725
S.E. of regression	0.232	0.287	0.113
Sum squared residuals	3.681	6.132	0.582
Log likelihood	9.637	-10.035	43.013
Durbin-Watson statistic	2.149	1.811	1.813
Akaike information criterion	0.059	0.439	-1.385
Schwarz information criterion	0.416	0.674	-1.122
F-statistic	30.051	31.676	23.447

Note: Standard error in parenthesis
a/ This model does not consider variables that may be endogenous. Sample period 2000:01 - 2006:08. Included observations: 80 after adjustments.
b/ This model includes other variables that may be endogenous in a more general model.
Sample period 1999:11 - 2006: 08. Included observations: 82 after adjustments
c/ In addition to the variables considered in Model 2, we also took into account a measurement of the return on government securities. Sample period 2002:05 - 2006:08. Included observations: 52 after adjustments
d/ Corresponds to the difference of the logarithm.
Source: The authors' calculations

TABLE 3

GRANGER CAUSALITY TESTS ON THE M3 INTEREST RATE

Null Hypothesis	Test-value	Probability
Model 1 [a/]		
Ddepreciation not Granger-cause DM3	25.78	0.0002
DIPI not Granger-cause DM3	10.43	0.1077
Dinflation not Granger-cause DM3	27.80	0.0001
DEMBI not Granger-cause DM3	18.80	0.0088
Dpolicy not Granger-cause DM3	87.14	0.0001
Dlibor no Granger-cause DM3	12.78	0.0778
Model 2 [b/]		
Null Hypothesis	**Test-value**	**Probability**
Ddepreciation not Granger-cause DM3	1.84	0.7656
DIPI not Granger-cause DM3	10.88	0.0279
Dinflation not Granger-cause DM3	5.84	0.2113
DITES not Granger-cause DM3	15.66	0.0035
DEMBI not Granger-cause DM3	23.86	0.0001
Dpolicy not Granger-cause DM3	52.19	0.0001
Dlibor no Granger-cause DM3	12.62	0.0133

a/ VARX (6.6) six lags for the endogenous and exogenous variables
b/ VARX (4.3) four lags for the endogenous and exogenous variables
Source: The authors' calculations.

TABLE 4

GRANGER CAUSALITY TESTS ON DTF

Null Hypothesis	Test-value	Probability
Model 1 [a/]		
Ddepreciation not Granger-cause DDTF	26.56	0.0002
DIPI not Granger-cause DDTF	3.62	0.7284
Dinflation not Granger-cause DDTF	11.02	0.0878
DEMBI not Granger-cause DDTF	13.58	0.0592
Dpolicy not Granger-cause DDTF	88.14	0.0001
Dlibor not Granger-cause DDTF	3.70	0.8136
Model 2 [b/]		
Null Hypothesis	**Test-value**	**Probability**
Ddepreciation not Granger-cause DDTF	9.93	0.0191
DIPI not Granger-cause DDTF	7.87	0.0489
Dinflation not Granger-cause DDTF	5.67	0.1288
DITES not Granger-cause DDTF	22.19	0.0001
DEMBI not Granger-cause DDTF	14.48	0.0059
Dpolicy not Granger-cause DDTF	12.28	0.0154
libor not Granger-cause DDTF	7.38	0.1171

a/ VARX (6.6) six lags for the endogenous and exogenous variables.
b/ VARX (3.3) four lags for the endogenous and exogenous variables.
Source: The authors' calculations.

V. A Small Open-economy Macro Model

The macro variables that could affect market interest rates are regarded as exogenous in a partial equilibrium model, such as the one described earlier. However, these variables can become endogenous once the functioning of the economy as a whole is considered. So, shifts in policy can have both a direct and indirect effect on market rates through shifts in income depreciation, inflation or expectations. By the same token, some shocks to the economy can have a direct effect on market interest rates, given a constant policy rate.

There is a policy implication with the previous arguments: *namely, the Central Bank's policy rule should take into account the direct effects of other (exogenous and endogenous) macro variables on market interest rates.* It also should consider the complex relationship between market and policy rates. If these factors are empirically relevant, any failure on the part of the Central Bank to include them in its reaction function may increase the risk of missing the targets and/or may result in excessive volatility in interest rates and output levels.

These ideas can be illustrated with a simplified version of the microeconomic model presented earlier. In particular, we assumed there is no credit risk or public debt, only a liquidity risk for banks. Deposit interest rates are determined by the equilibrium conditions in the deposit and credit markets and by the balance sheet of the banking sector:

(13)

$$D(i_D - \pi^e, i^* + \hat{e}^e - \pi^e, Y)\ \left(1 - r(i_D - \pi^e, i_p - \pi^e)\right) \ = \ C(i_D - \pi^e + m, i^* + \hat{e}^e - \pi^e, Y)$$

Where $D(.)$ and $C(.)$ are deposit supply and loan demand functions, respectively; $r(.)$ is the portion of deposits that banks optimally choose to hold as reserves; Y is the output level; i_D is the nominal deposit rate; i_p is the policy rate; m is a constant intermediation spread that depends on operating costs; i^* is the foreign nominal interest rate; and $\hat{e}^e$ and π^e are expectations of depreciation and inflation, respectively. As in the micro model, the following assumptions were made about the functional forms:

$$D_{i_D} > 0,\ D_{i^*} < 0,\ D_Y > 0$$
$$C_{i_D} < 0,\ C_{i^*} > 0,\ C_Y > 0$$

and the following features of the function $r(.)$ were obtained: $r_{i_D} < 0$. $r_{i_p} > 0$.

Based on a long-term equilibrium situation where $\pi = \pi^e = \pi^{TARGET}$, and assuming the Central Bank is strictly committed to the inflation-targeting policy (moving its policy rate so the inflation target is met in every period), and assuming the public fully believes in that policy, a transitory shock to the foreign interest rate implies that $\frac{d\pi}{di^*} = \frac{d\pi^e}{di^*} = 0$. Therefore, the required policy rate adjustment, when the Central Bank knows all the parameters and the economic structure, will be:

(14)

$$\frac{di_p}{di^*} = \left(D\ r_{i_p}\right)^{-1}\left[\left(D_{i^*}(1-r)-C_{i^*}\right)\left(1+\frac{d\,\hat{e}^e}{di^*}\right)+\left(D_{i_D}(1-r)-D\ r_{i_D}-C_{i_D}\right)\frac{di_D}{di^*}+\left(D_Y(1-r)-C_Y\right)\frac{dY}{di^*}\right]$$

where di_D/di^* is the deposit rate adjustment required to keep inflation on target and dY/di^* is the change in output resulting from the shock to the foreign interest rate, i^*; the responses of i_D and i_p and all the subsequent macroeconomic effects. Likewise, $d\,\hat{e}^e/di^*$ is the movement in expectations of depreciation that follows the shock to i^*, the responses of i_D and i_p and all the subsequent macroeconomic effects.

Three results were obtained from this equation:

(i) The "direct" response of the policy rate to the required adjustment in the market rate is not necessarily equal to 1. The expression $\left(D_{i_D}(1-r)-D\ r_{i_D}-C_{i_D}\right)/\left(D\ r_{i_p}\right)$ Dr is generally positive, but may not be constant, as it changes with the levels of Y, i_D, i^* and with other variables that affect the elasticities of loan demand, deposit supply and demand for reserves.

(ii) In addition to the "direct" response to the required adjustment in the market rates, the policy rate may respond independently to this shock. The term $\left(D_{i^*}(1-r)-C_{i^*}\right)/\left(D\ r_{i_p}\right)$ is generally negative, implying a negative reaction from the policy rate to a shift in foreign interest rates. Intuitively, if the market rates react directly to the shock, the policy rate need not be adjusted too much. This effect can be offset or reinforced by the shift in expectations of depreciation that result from the shock itself.

iii) Policy interest rates also may respond to the change in output that follows the shock. In this case, the effect on policy rates is ambiguous, since changes in output impact both loan demand and deposit supply, causing market rates to move in opposite directions.

Graph 2 shows the simulations of a transitory shock to the foreign interest rate in a small, open-economy model with backward-looking expectations, imperfect capital mobility and a banking sector faced with liquidity risk. Additionally, the simulations assume the Central Bank sets its policy rate in such a way that $\pi = \pi^{TARGET} = 0$.

The aspect to be emphasized in the simulations is the behavior of policy and market interest rates. Although both rates have the same dynamics, their ratio shows the reaction of the policy interest rate to the foreign shock is proportionally lower than the response of the market rate. This is because the shock to the foreign interest rate has an independent impact on market rates, so the reaction of the policy rate required to keep inflation on target need not be as large as the reaction required of the deposit rate.

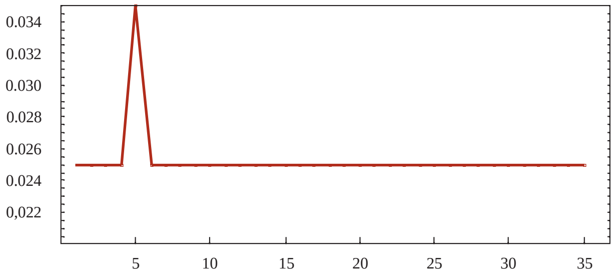
VI. Conclusions

Unlike the traditional approach to monetary policy, which regards the banking sector as a passive aggregate, this article focuses on the implications of modeling commercial banks as independent entities that optimally react to conditions in their environment.

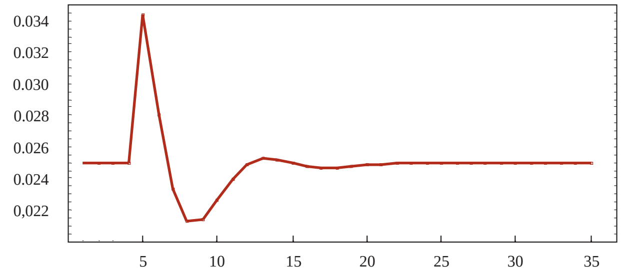
Based on a microeconomic model of the banking firm and the credit and deposits markets, two important results were found and should be considered when estimating interest rate pass-through. First, it was found that certain macroeconomic variables other than the policy rate are relevant in determining equilibrium interest rates. Secondly, it was found that the relationship between the policy rate and the market rates may not be "one-to-one", and is possibility not linear. This implies that the response of market interest rates to changes in the policy interest rate may be a complex process that depends on the state of the economy.

Finally, the small macro model illustrates how important it is for the Central Bank to understand the behavior of commercial banks with respect to interest rate pass-through. In particular, consideration of the direct impact of exogenous shocks on the financial system can affect the appropriate policy response. Depending on its empirical relevance, this hypothesis implies the Central Bank could fail to meet its targets or introduce excessive volatility into interest rates and output, if the behavior of the financial system is ignored.

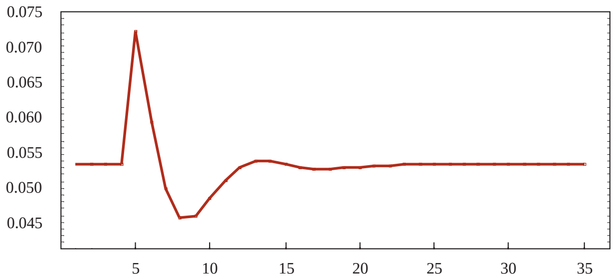
A) Foreign Interest Rate



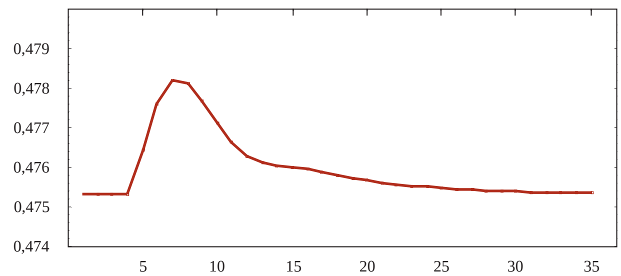
B) Local Interest Rate



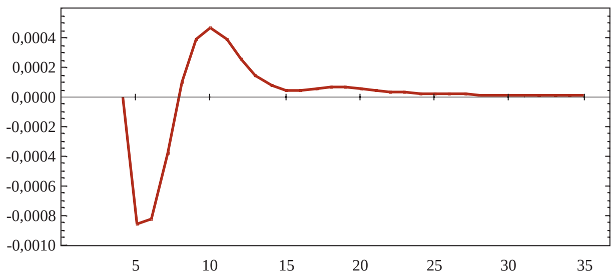
C) Policy Interest Rate



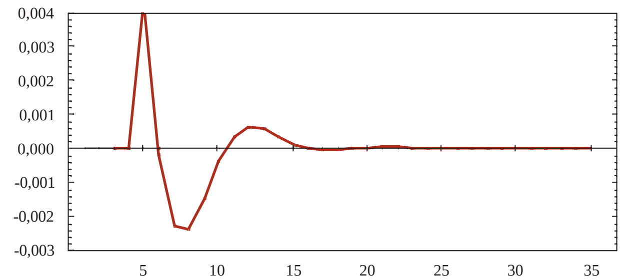
D) Local /Policy Interest Rate Ratio



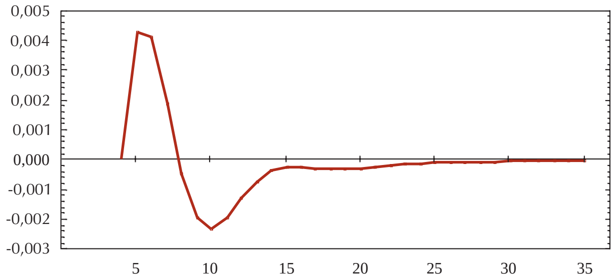
E) Output Gap



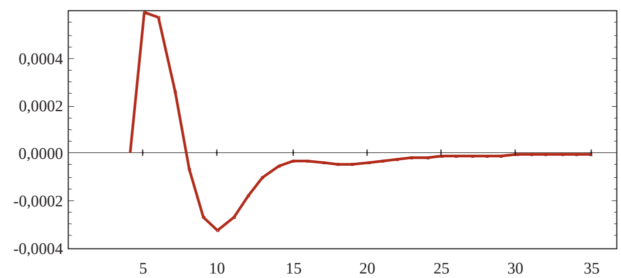
F) Nominal Depreciation



G) Real Exchange Rate



H) Trade Balance



Source: The authors' calculations.

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