8. Boxes

Box 1: Analysis of The Relationship Between the Rate Spread and the Liquidity Demand in the Financial System[80]

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Introduction

This box aims to analyze the relationship between the rate spread between the overnight IBR and the MPR, and the liquidity demand in the financial system.[82] To achieve this objective, the differences in monetary policy implementation among Colombia, the United States, and the European Union are analyzed. Secondly, it is evaluated whether the methodology proposed by the IMF (Chen, et al., 2023) to analyze the relationship between the rate spread and the demand for reserves in the United States and the European Union could be applied to the Colombian context. Finally, an update of the estimates provided in Box 3 of the 4Q22 Financial Markets Report (Cardozo et al., 2022) is provided, which assessed the main determinants of the IBR-MPR interest rate spread in Colombia prior to the COVID-19 pandemic. This exercise also includes other explanatory variables, such as TES purchases by *Banrep* and DGCPTN deposits at *Banrep*, which may play an important role in the dynamics of the rate spread.

Implementation of Monetary Policy in Colombia

Monetary policy implementation in Colombia is similar to a system of scarce reserves or an interest rate corridor around the target rate. Under this framework, depository institutions, or banks, are incentivized to maintain the minimum amount of reserves necessary, ensuring there is an opportunity cost for holding reserves, since the overnight interest rate is above the deposit facility rate, which is the rate at which the central bank pays for the reserves deposited by banks (BIS, 2024). In this scheme, the central bank provides the necessary reserves to cover the liquidity needs of the financial system.

In Colombia, the main monetary policy instrument is the monetary policy interest rate, where *Banrep* supplies or withdraws liquidity from the economy to ensure that the IBR is very close to the monetary policy interest rate. *Graph B1. 1* illustrates the operation of the scarce reserves system, showing a negatively sloped reserve demand curve, the supply of reserves by *Banrep*, and

[80]This paper is of a provisional nature; opinions and possible errors are the sole responsibility of the authors, and its contents are not binding on *Banco de la República* or its Board of Directors.

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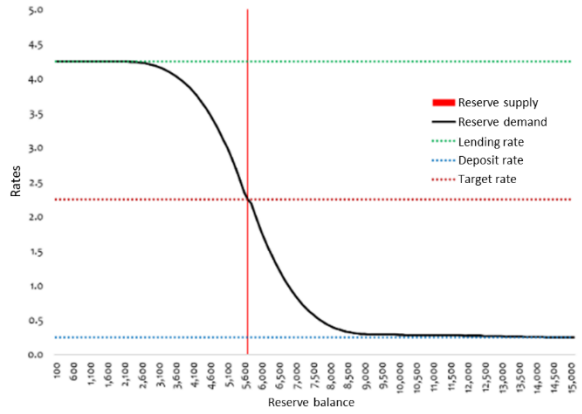
[82] This box analyzes the demand for reserves of the financial system, which corresponds to the reserve requirement, or deposits held by financial institutions at *Banco de la República*. Resources in excess of these minimum requirements are referred to as excess reserve requirements.

an interest rate corridor with an upper threshold equal to the rate at which reserves are lent to the financial system, the midpoint of the corridor equal to the MPR, and a lower threshold equal to the rate at which financial system deposits are remunerated at *Banrep*. As shown in the graph, *Banrep* adjusts the monetary base supply to bring the short-term interest rate to the mid-point of the exposed interest rate corridor.

During the COVID-19 pandemic, Colombia's monetary policy may have had some similarities to the ample-reserves regime adopted by the Fed and the European Central Bank (ECB), as a substantial amount of liquidity was injected into the economy to counteract the negative effects of the pandemic on the financial sector and markets.[83] Unlike the scarce reserves system, in an ample reserves framework, the central bank provides reserves exceeding liquidity needs, and thus balances in central bank accounts are remunerated at the deposit facility rate, incurring no opportunity cost, with the overnight rate being equal to or often below the deposit facility rate. In this case, the size of reserves can be very large (BIS, 2024).

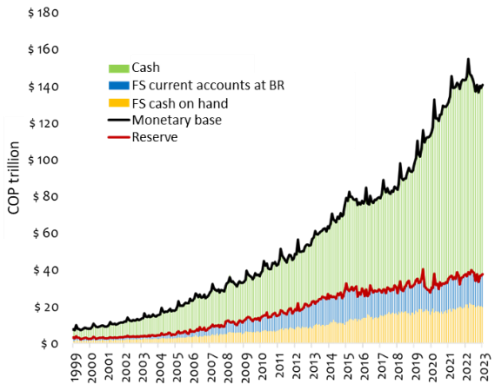
***Graph B1. 2* exhibits the progress of the monetary base in Colombia, highlighting that, unlike the Fed and the ECB, the bank reserves did not see a significant increase after the global financial crisis, while other components of the monetary base, such as cash, explain the dynamics of this monetary aggregate.**

Graph B1. 1 The Corridor System



Source: Authors' calculations.

Graph B1. 2 The Monetary Base in Colombia



Source: *Banrep.*

[83] The Fed and the ECB introduced liquidity facilities and conducted large-scale asset purchases to improve conditions in financial markets and stimulate the economy during the global financial crisis (GFC). These policy instruments, in addition to influencing financial market conditions, also added a substantial amount of reserves to the banking system. Thus, the GFC changed the operational framework of monetary policy in the United States and the European Union to an ample-reserves regime (Alfonso *et al.*, 2022). In this implementation framework, changes in the money supply and interest rates are unrelated and serve different functions.

IMF Methodology

Estimated Reserve Demand

A set of bank reserve demand functions is estimated following the work of Chen, *et al.* (2023). These specifications allow identifying reserve levels for which the volatility of short-term interest rates is minimal. The general form of the model is given by: $r_i = f(g(R_i))$, where r_i is the short-term interest rate (e.g., IBR), $R_i$is the excess reserves or reserve surplus, and $g(R_i) = c + w_r R_i$. The function $f(\cdot)$ can take different forms, and in particular, the following are considered:

Table B1. 1 Reserve Demand Functions

Curve	Function
Logistics	$r_i = \alpha + \frac{k}{1 - \beta e^{g(R_i)}} + \varepsilon_i$
Reduced logistics	$r_i = \alpha + \frac{1}{1 - \beta e^{g(R_i)}} + \varepsilon_i$
Double exponential	$r_i = \alpha + \beta e^{\rho e^{g(R_i)}} + \varepsilon_i$
Exponential	$r_i = \alpha + \beta e^{g(R_i)} + \varepsilon_i$
Arc tangent	$r_i = \alpha + \beta \arctan(g(R_i)) + \varepsilon_i$
Linear	$r_i = g(R_i) + \varepsilon_i$

For Colombia, different specifications used by Chen *et al*. (2023) are estimated, with the scaled IBR as the dependent variable, based on the excess bank reserves as a share of total financial system assets.[84,85] The sample used in the estimates corresponds to biweekly data from 22 January 2008 to 21 November 2023.

***Graph B1. 3* exhibits the results of the reduced logistic function[86], revealing that the scaled IBR does not deviate with changes in excess reserves, indicating an inelastic estimated reserve demand function.** Since other variables may influence the relationship between the rate spread and excess reserves, net purchases of TES by *Banrep* are included as a control variable, as they are a key factor in the liquidity dynamics of the financial system. *Graph B1. 4* presents the results of this specification and yields robust results compared to those reported in *Graph B1. 3*.

[84] Different specifications were also estimated, including bank reserves and the monetary base, as explanatory variables, yielding results similar to those estimated with excess reserves.

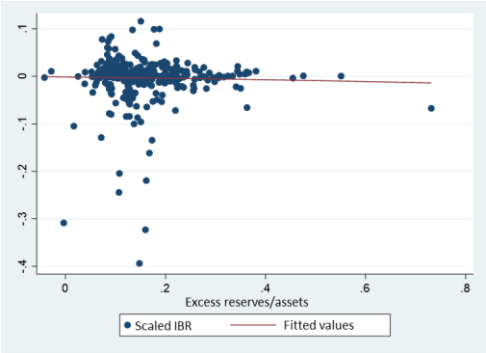
[85] A scaled version of the IBR is used as follows:

$$IBR\ scale = \frac{IBR - MPR}{Expansion\ window\ - Contraction\ window}$$

where MPR is the monetary policy rate, while the expansion and contraction windows correspond to MPR $\pm$100 bps, respectively.

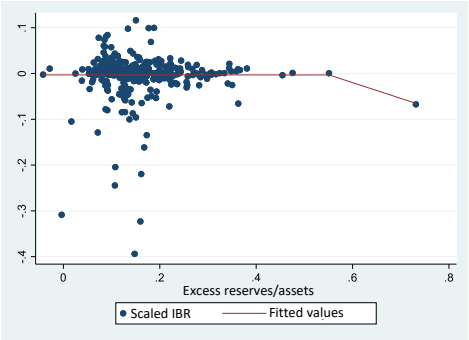
[86] The results are robust for the other parametric and non-parametric specifications included in Table BX.1, as well as when using the interbank interest rate (TIB in Spanish) as the short-term interest rate.

Graph B1.3 Reduced Logistic Function



Source: Authors' calculations.

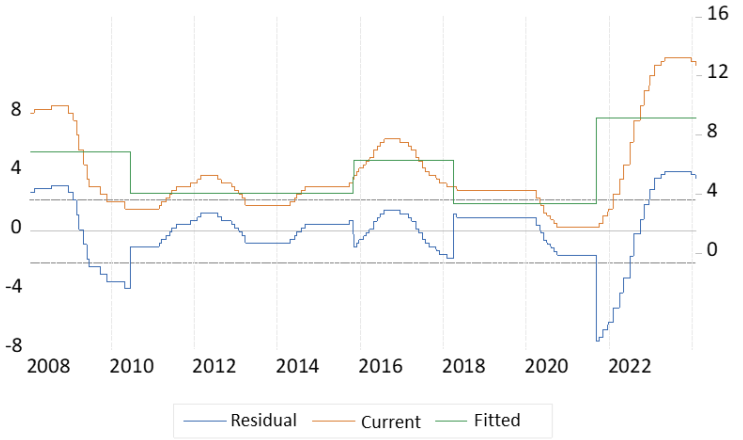
Graph B1.4 Reduced Logistic Function with Net Purchases of TES



Source: Authors' calculations.

The relationship between the rate spread and excess reserves may change during periods of expansion and contraction. To identify potential regime shifts in the monetary policy rate, a structural break model using Ordinary Least Squares (OLS) is employed.[87] *Graph B1. 5* illustrates the structural breaks observed in the monetary policy rate during the analyzed period. Consequently, reserve demand models are estimated for each identified regime shift to analyze whether the relationship between the rate spread and excess reserves varies depending on the monetary policy stance.

Graph B1.5 OLS Model with Structural Breaks for the Monetary Policy Rate



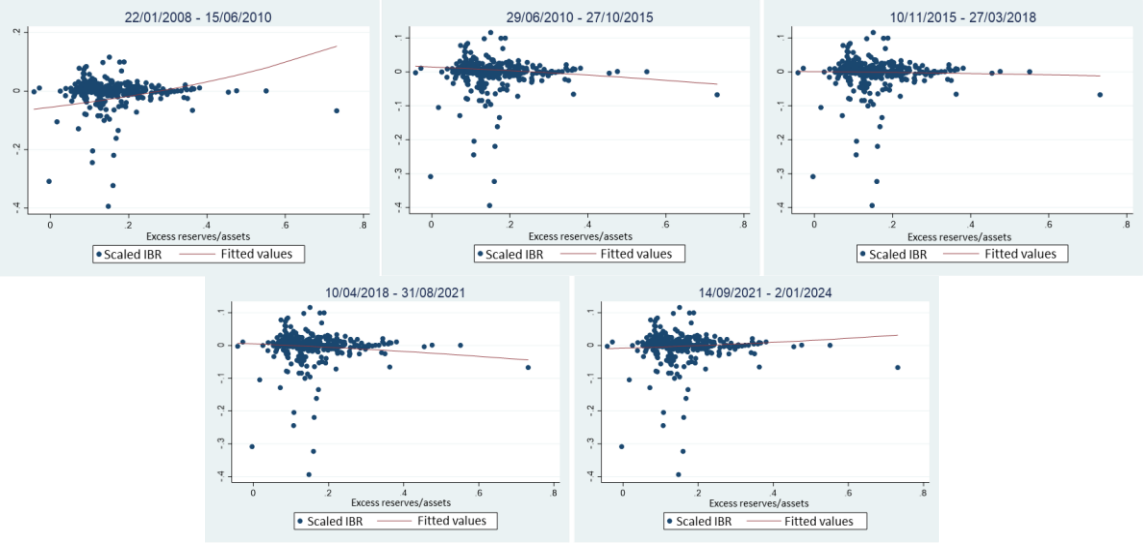
The results do not indicate significant changes in the relationship between the rate spread and excess reserves for each period identified in the structural break OLS model. *Graph B1. 6* presents the results for the reduced logistic function. These results are robust when including net purchases of TES as a control variable and for each of the other parametric and non-parametric specifications described in *Table B1. 1*.

In contrast to the findings by Chen *et al*. (2023) for the United States and the European Union, where a reserve demand curve is identified that captures the relationship between short-term

[87] This model also considers consistent or robust errors to heteroscedasticity and autocorrelation (HAC).

interest rates and excess reserves in different scenarios, no such relationship is found between these two variables in the Colombian case using this methodology.

Graph B1.6 Reduced Logistic Function for Periods of Monetary Policy Rate Regime Change



Estimation of the Determinants of the Rate Spread Between the IBR and the MPR

Since the analysis of the relationship between the rate spread and excess reserves using the IMF methodology does not fit well with the Colombian case, it is necessary to evaluate other determinants and methodologies that might explain the dynamics of the rate spread in Colombia.

Literature indicates that there are different variables[88], in addition to those related to central bank open market operations that meet liquidity needs and, therefore, can also influence money market interest rates and explain their dynamics relative to the policy rate. This adds complexity to the estimation of the relationship between rate spread and liquidity demand.

The exercise on the main determinants of the rate spread between the IBR and the MPR presented in Box 3 of the Financial Markets Report for 4Q22 (Cardozo *et al*., 2022) is updated by incorporating other explanatory variables, such as the DGCPTN deposits at *Banrep* and *Banrep*'s net purchases of TES.[89] In particular**,** an EGARCH model was estimated for the rate spread between the IBR and the MPR, with a mean equation as presented in Equation 1. The description of the variables included is provided in *Table B1. 2*. Upon updating this exercise with data through November 2023, a structural break was identified on 30 March 2020 in the relationship between the rate spread and the control variables included in the model.

[88] For more details, see Wert, 2003; Linzert & Schmidt, 2011; González *et al*., 2013; Martin *et al*., 2020.

[89] This specification is in reduced form and, therefore, has some limitations. Since simple correlations between the dependent variable and the explanatory variables are being evaluated, potential specification and endogeneity biases can be observed. For example, this model does not include an equation that determines the performance of TES purchases and sales by *Banrep*.

$$
\begin{aligned}
(IBR - MPR)_t &= \beta_0 + \phi_1(IBR - MPR)_{t-1} + \phi_1(IBR - MPR)_{t-2} + \beta_1 \times portfolio \\
&+ \beta_2 \times deposits_t + \beta_3 \times \left(\frac{repos}{reserve}\right)_t + \beta_4 \times excess\_reserves_t \\
&+ \beta_5 \times \left(\frac{TES}{amount}\right)_t + term + \beta_7 \times limit\_utilization_t \\
&+ \beta_8 \times deposits\_TGN_t + \beta_9 \times TES\_purchases_t + \beta_{10} \times vol \\
&+ \beta_{11} \times emd + \beta_{12} \times wed + \beta_{13} \times dee \\
&+ \beta_{14} \times d30Mar2020
\end{aligned} \quad \textbf{(1)}
$$

Table B1. 2 Variables Included in the IBR-MPR Rate Spread Model

Variable	Description
IBR-MPR	rate spread
portfolio	real annual loan portfolio growth
deposits	real annual growth of demand deposits
repos/reserve	ratio of repos to bank reserves
Excess reserves	daily excess reserves percentage
TES/amount	ratio of available TES to the presented amount
term	weighted term by the balance of the expansion repos
limit_utilization	ratio of the utilized limit to the liquidity amount offered by *Banrep* in its repo operations
deposits_TGN	DGCPTN deposits at *Banrep*
TES_purchases	net purchases of TES by *Banrep*
vol[90]	conditional volatility of the IBR-MPR spread
emd	month-end dummy
wed	weekend dummy
dee	extreme event dummy which is equal to 1 when the absolute value of the rate spread is greater than 2 standard deviations from the rate spread
d30Mar2020	dummy variable corresponding to the structural break point of 30 March 2020

Estimates[91] using the full sample suggest that an increase in the repo-to-reserve ratio, higher loan portfolio growth, a greater percentage of excess reserves, increased limit utilization, and higher TGN (National Government Treasury) deposits at *Banrep* are associated with a larger spread between the IBR and the MPR. For example, the effects of loan portfolio growth on the IBR-MPR spread may be associated with procyclicality or particular relevance of the credit channel. A higher level of excess reserves, especially during the early days of the reserve period (González *et al*., 2013), may affect the rate spread, as institutions are willing to assume higher interest rates to meet their liquidity demand.

On the other hand, a higher weighted term of expansion repos, higher deposit growth, a higher TES-to-amount ratio, and higher TES purchases reduce the IBR-MPR spread. Results related to maturity may suggest a substitution effect between term resources and overnight resources.

[90] Volatility corresponds to the standard deviation of the conditional variance of the rate spread.

[91] Table B1. 3 reports the results for the full sample from 02 January 2008 to 24 November 2023 (column 1), for the period before the structural break of 30 March 2020 (column 2), and for the period after this regime change (column 3).

Similarly, a greater volume of TES available as collateral for repo operations results in less pressure on the IBR-MPR rate spread. Column 1 shows that all variables are statistically significant, except for the limit utilization variable, and that the signs of each variable are as expected. It is also observed that excess reserves have played an essential role in determining the rate spread and that DGCPTN deposits had a significant impact on the rate spread before March 2020. The volatility of the rate spread is significant before March 2020, but loses relevance afterward.[92]

Table B1. 3 Determinants of the IBR-MPR Rate Spread (EGARCH Model (1,1))

	(1)	(2)	(3)
Constant ($\hat{\beta}_0$)	-0.0123	-0.0074	-0.358
$(IBR - MPR)_{t-1}$	0.9777^{***}	0.9977^{***}	0.8430^{***}
$(IBR - MPR)_{t-2}$	-0.0659^{***}	-0.0812^{***}	-0.0380
$portfolio_t$	0.0054^{***}	0.0063^{***}	0.0002
$deposits_t$	-0.0333*	-0.0171	-0.0574
$\left(\frac{repos}{reserve}\right)_t$	0.0025^{***}	0.0033^{***}	0.0084^{***}
$excess\_reserves_t$	0.0142^{***}	0.0136^{***}	0.0149^{***}
$\left(\frac{TES}{amount}\right)_t$	-0.0052^{***}	-0.0059^{***}	-0.0021^{***}
$term_t$	-0.0009^{***}	-0.0032^{***}	-0.0018^{**}
$limit\_utilization_t$	0.0003	0.0000	-0.0019^{*}
$deposits\_TGN_t$	0.0239^{***}	0.0263^{***}	0.0098
$TES\_purchases_t$	-0.0003^{***}	-0.0000	-0.0002
vol	0.0555^{***}	$0{,}0799^{***}$	0.0259
emd	-0.1026^{***}	-0.0619^{**}	-0.2806^{***}
wed	-0.1033^{***}	-0.1088^{***}	-0.0685^{**}
dee	-1.7124^{***}	-2.2508^{***}	-6.7679^{***}
$d30Mar2020$	28.5831^{***}	(n.a.)	(n.a.)
R^2 adjusted	0.9617	0.9688	0.7894
Q2(36) statistic ARCH test	0.9996	0.9998	0.9824

Notes: One asterisk indicates that the coefficient is significant at 90%, two at 95%, and three at 99%. (n.a.) denotes not applicable.

Conclusions

This box presents an analysis of the relationship between the rate spread and reserve demand in Colombia. The IMF approach (Chen et al., 2023) is used to analyze the impact of excess reserves on the rate spread, and subsequently, evaluate other determinants affecting its dynamics.

The methodology used by the IMF (Chen *et al.*, 2023) does not yield the same results for the Colombian case, as monetary policy implementation in Colombia is framed within an interest

[92] Additional exercises were carried out by interacting excess reserves with TES purchases, and no evidence was found that TES purchases increase the effect of excess reserves on the rate spread. Likewise, when interacting the TGN deposits variable at *Banrep* with other control variables, it is observed that an increase in deposits does not increase the sensitivity of the rate spread to the repo-to-reserve ratio, although it increases the impact of excess reserves on the spread.

rate corridor or a scarce reserves regime, unlike the United States and the European Union, which adopted an ample reserves framework following the GFC. The results are robust when estimating the models proposed by the IMF across different periods of monetary policy easing or tightening.

When evaluating other determinants of the rate spread, it is observed that, although between 2018 and 2019 the spread between the IBR and the MPR was less responsive to the repo-to-reserve ratio, this response increased after March 2020, when a structural break in the relationship between the rate spread and its determinants ocurred. In addition, it is evident that excess reserves, the TES-to-amount ratio, and the term of expansion repos have had a significant impact on the rate spread in recent years.

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