The Interbank Market in Colombia and the Supply of Liquidity by the Banco de la República

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Abstract

This article describes some of the essential elements of both the Colombian interbank money market and the liquidity management (of local currency) by the Banco de la República. In addition, the paper proposes a simple model that incorporates some of those essential elements so that it can serve as a benchmark for the formal analysis of the Colombian interbank market in the future. The article explains both the differences among the main operations in this market and the mechanisms used by the Banco de la República to manage liquidity in the financial system. It also describes the Banco de la República's expansionary daily auction and the determination of the corresponding quota (maximum amount to be lent to the financial system).

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1. INTRODUCTION

The system by which private financial institutions (e.g., banks) lend or borrow resources among them is commonly known as the interbank market. It is an important market for the management of liquidity in the financial system and for the application and transmission of the central bank's monetary policy.

The global financial crisis has recently resulted in greater focused attention on the interbank market by theoretical literature, especially given the need to analyze how to maintain or restore normal functioning in times of high uncertainty or when liquidity problems occur.[1]

The interbank market in each country may exhibit particular characteristics as a result of differences in the degree of the financial system's development and the rules regulating it. This work is an attempt to respond to the specific need in the case of Colombia for a document that compiles and presents these characteristics in detail. Moreover, since some similarities can generally be identified (e.g., most of the operations carried out in the market are short-term amounting to a week or less; and the operational goal of central banks is generally the interbank overnight rate), it is therefore thought that the Colombian interbank market may be of interest to a wider audience. This is especially true if one takes into account that research on this market is relatively scarce in emerging economies, as remarked by Green et al. (2016). Based on the above,

[1] Green et al. (2016) review recent theoretical and empirical literature on the interbank market. Some examples of theoretical works dedicated to the analysis of this market in times of crisis are Cassola and Huetl (2010); Hauck and Neyer (2010); and Freixas, Martin and Skeie (2011).

this present work has two specific purposes. The first is to describe some of the fundamental characteristics that make up the Colombian interbank market.[2] The second is to propose a model that gathers some basic elements of that description in order to take an initial step toward a formalization of the analysis of the market. In future research, by relaxing one or more of the model's assumptions, we can further study some of these particularities.[3]

Theoretical models have been proposed for the purpose of analyzing the interbank market in previous literature. Examples include the works of Allen, Carletti and Gale (2009) and Bianchi and Bigio (2014), for general cases; or Hauck and Neyer (2014), in the case of the euro.

Allen, Carletti and Gale (2009) use a two-period model in which banks have access to short- and long-term risk-free assets and face uncertainty about the liquidity demands of their clients. Given there is no possibility of hedging against these shocks, it is socially beneficial to have a central bank that, by means of open market operations, fixes the short-term rate and reduces the excessive price volatility of the assets. Bianchi and Bigio (2014) construct a dynamic and stochastic general equilibrium model (DSGE) in which banks face liquidity risks, which ends up affecting the supply of credit in the economy. The authors analyze how different shocks to monetary policy and the banking system alter the inverse relationship between the benefits of lending and the need to address liquidity risks. Hauck and Neyer (2014), with the purpose of replicating several stylized facts of the European interbank market, construct

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[2] Note that although it is conventional to call it an interbank market, it actually incorporates not only banks, but also credit institutions in general (banks, financial corporations, commercial financing companies and special financial institutions).

[3] For example, after the publication of this research as a working document, González et al. (2014) constructed a model with some similar elements and incorporated uncertainty in the likelihood that banks would obtain resources as a result of the central bank's liquidity supply sessions.

a static model (a period) in which banks face liquidity shocks and try to respond to them by trading in the interbank market; however, aggregate deficits can only be resolved by the central bank through secured loans. In Colombia's case, González et al. (2014) propose a model similar to ours that includes liquidity risks. For studies of a more empirical nature, consult Capera, Lemus and Estrada (2013) or León, Cely and Cadena (2015).

The model proposed in this paper is highly tractable and replicates some of the basic characteristics of the Colombian interbank market, for example, the fact that the market rate during the period studied (2005-2015) has been largely equal to or less than central bank's policy rate. It is a two-period model in which the banks must meet reserve requirements and satisfy their liquidity needs, for which the interbank market, liquidity supply, and central bank expansion and contraction facilities are available.

Our work here is made up of four sections. Section 2, which describes the details of the interbank market and the supply of liquidity in Colombia, was divided into three subsections. The first explains the differences among the main operations of this market and describes the electronic systems with which these transactions are carried out or recorded. This subsection concludes by exposing some of the particularities that are observed in Colombia's case.

The second subsection describes the management of liquidity by the Banco de la República, that is, the mechanisms with which the Banco de la República provides liquidity or reduces excess liquidity in the financial system. In addition, it shows how the position of the daily interbank rate has been related since 2005 to the monetary policy rate taking into account the net position of the Banco de la República with respect to the financial system.

The third subsection describes three different general methodologies for the provision of liquidity by a central bank to the financial system and explains which in particular corresponds to the case of Colombia. To provide liquidity to the financial

system, the Banco de la República sets a quota (that is, a maximum amount of resources to be loaned). This subsection also explains the reasoning behind these quotas and how they are calculated based upon estimations fo the monetary base supply and demand.

Section 3 picks up some of the basic elements mentioned in the first sections and builds a simple model with the intention of serving as a possible initial reference point for later formal studies of the Colombian interbank market. Section 4 offers conclusions.

2. DESCRIPTION OF THE INTERBANK MARKET AND SUPPLY OF LIQUIDITY IN COLOMBIA

2.1 The Interbank Money Market

In Colombia, financial institutions can receive and lend resources (pesos) in the short term through transactions agreed to by telephone or made through electronic trading systems. Although the flexibility exists for carrying out operations with terms lasting longer than a day, there is a high concentration of overnight transactions, which is to say that most operations must be completed by the following business day.

In accordance with Colombian regulations, money market transactions include repo operations, sell/buy-back operations and interbank funds operations, among others.[4] Transactions between financial institutions constitute the interbank money market and in this paper are classified in accordance with the requirements for collaterals as collateralized or non-collateralized markets.

Non-collateralized or unsecured market operations, i.e. interbank funds, are executed by telephone and the grand

[4] Chapter XIX of the Basic Memorandum of the Financial Supervision Body of Colombia (SFC) also considers temporary security transfers and the inter-associated funds. This paper focuses on repos, simultaneous operations and interbank funds.

majority have one-day terms. The weighted average rate for overnight transactions is known as the interbank market rate (TIB, for its Spanish initials). In this market, the majority of the participants (more than 60%) are banking establishments. The remaining participants correspond to financial companies, commercial financing companies, and special financial institutions.[5] Due to the fact that there is no need of providing collaterals in this market, the entities mitigate the counterparty risk by establishing credit quotas.

On the other hand, the operations of the collateralized market can be negotiated by telephone or through Colombia's interbank electronic payment systems known as the SEN and MEC for their initials in Spanish and which will be explained in detail later. In this market, as its name implies, operations are backed by one or more securities, called collateral. Restrictions and haircuts imposed on collateral determine if operations are classified as closed repos or sell/buy-back operations. The difference between these two types of operations is explained below.

In both repo and sell/buy-back operations, one of the parties (the creditor) lends money to the other (the debtor) and in return receives ownership of one or more securities as collateral. On the day of maturity (in the case of overnight transactions the next business day), the lending entity receives the funds and gives the security that will be held as a collateral at the same time as the debtor entity repays the loan and recovers the collateral. If the debtor entity fails to repay the loan, the creditor, as the owner of the security, may recover the loan by selling the security at the market price.

Due to the fact that from one day to the next the prices of securities used as collateral may decrease, the lender is exposed to the risk of not fully recovering the money it loaned. As a result, when the loan agreement is set by the two parties, a discount to the market price of the security may be established in such a manner so that if the creditor sells it on the market the

[5] Bancoldex, Findeter, Finagro, Financiera de Desarrollo Nacional.

creditor will not be affected if the security price has fluctuated unfavorably. This discount, known as a *haircut*, only applies to repo and not sell/buy-back operations.

In repo operations, in addition, restrictions can be established on the mobility of the securities and, if so, the transaction is known as a closed repo.[6] In sell/buy-back operations, it is not possible to establish restrictions on the securities' mobility and securities may be switched for others while the operation is in the process.

Given the latter, one could say that closed repo[7] and sell/buy-back operations appear to originate from different needs. Usually, a repo transaction is held when an entity is seeking resources (Colombian pesos) and agrees to repurchase the security it delivers as collateral. In the case of sell/buy-back transactions, sometimes the transactions are motivated by the need for a particular security, and the entity that seeks it is willing to *lend* money at a low rate in order to receive the security. The foregoing takes into account that there are no restrictions on the mobility of the securities and that, in addition, the debtor entities specify which securities they can deliver as collateral and the lending entities specify which securities they prefer to receive.

As has been mentioned, repos and sell/buy-back operations can be agreed to via the electronic trading systems SEN and

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[6] In accordance with Chapter XIX of the Basic Accounting Memorandum of the Superintendencia Financiera de Colombia or the SFC, which is the government agency responsible for regulating the financial system, closed repo operations are operations in which it is agreed that the securities cannot be switched out, meaning that the same securities must be used in the agreed transfer of securities unless there is an explicit agreement permitting their substitution. Pursuant to this regulation, repo or repo operations shall be presumed to be closed unless expressly agreed otherwise.

[7] Although regulations address both open and closed repos, only closed repos are executed in Colombia, so this paper refers to them only.

MEC that belong to the Banco de la República and the Colombia Stock Exchange respectively. The SEN system has two negotiation scenarios called steps. The first step does not establish credit quotas and entities that belong to the market makers program for public debt, as well as the Division of Finance and Public Credit and the Banco de la República, can participate. In the second step, credit quotas are established and there is a larger universe of participants, which contains all entities of the first step. Currently, closed repos and sell/buy-back operations are authorized in the first step but only sell/buy-back operations take place. In the second step, no operations are undertaken. For its part, the MEC authorizes the participation of various entities and establishes aggregate credit quotas. In this system, the entities engage in closed repos and sell/buy-back operations.

The figures that follow show negotiated amounts and interest rates for operations executed by the Banco de la República and both collateralized and non-collateralized interbank market money operations.

Figure 1 shows the average negotiated amounts of non-collateralized operations, SEN sell/buy-back operations, MEC repo and sell/buy-back operations, and Banco de la República contraction and expansion operations. While it can be seen that the central bank's contraction operations correspond to relatively small amounts, the expansion operation amounts are significantly higher that those traded on the interbank market, both collateralized and non-collateralized. The volumes traded on the non-collateralized market are lower than the sell/buy-back operations, but higher when compared to the volume of repo transactions.

Figure 1

AVERAGE AMOUNTS OF OPERATIONS OF THE BANCO DE LA REPÚBLICA (EXPANSION AND CONTRACTION) AND INTERBANK MARKET (COLLATERALIZED AND NON-COLLATERALIZED)

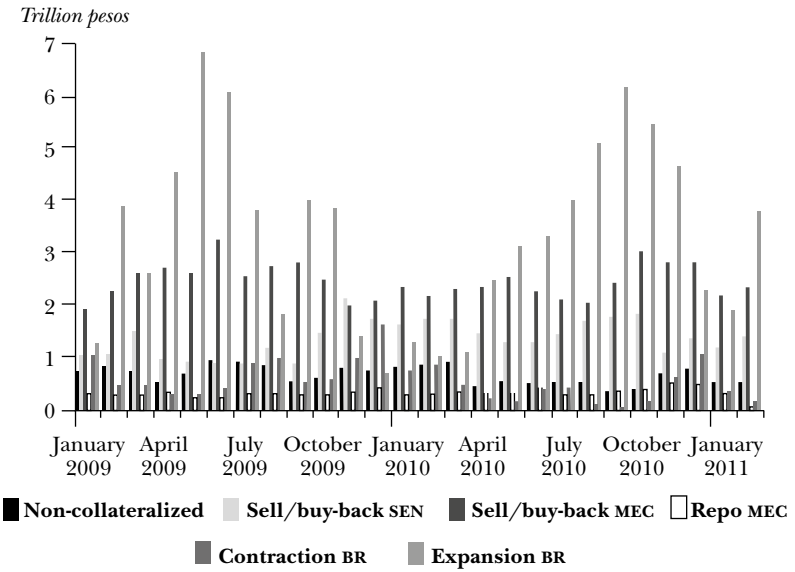
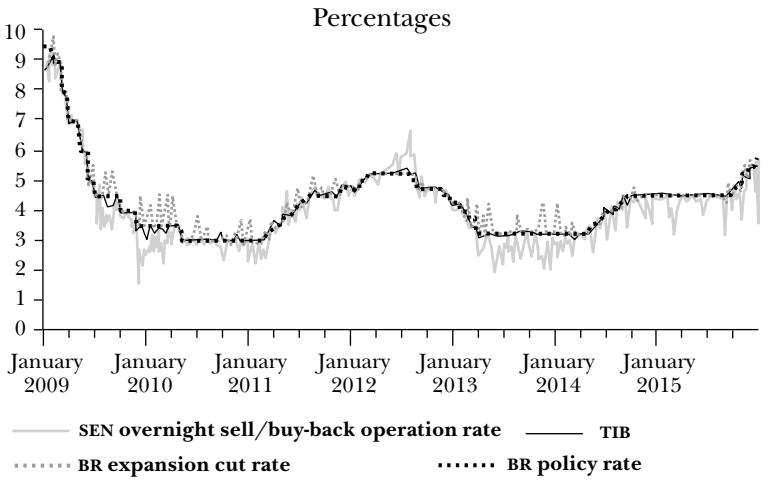


Figure 2 shows the daily interbank rate (TIB), the Banco de la República reference rate, the bank's cut rate for expansion repos auctions, and the rate for SEN sell/buy-back operations.[8] It is generally observable that the daily interbank rate is higher than the sell/buy-back operations rate and behaves according to the fact that the lending entity in the sell/buy-back transactions occasionally loans money at a low rate when it is motivated to obtain a specific security.

[8] At the time this paper was prepared, there was no recent information on rates and amounts of interest on MEC repo and sell/buy-back operations.

Figure 2

TIB - POLICY RATE OF BANCO DE LA REPÚBLICA - AUCTION CUT RATE OF BANCO DE LA REPÚBLICA - SEN SELL/ BUY-BACK OPERATIONS RATE



In 4.7% of the transactions carried out between January 2009 and December 2015, the cut rate for the Banco de la República expansion repos auction was higher than the reference rate.[9] Most of the time (94.3%) this is explained by the fact that the bank's expansion auction quota was filled. In the remaining 5.7% of the cases, the quota was not filled, but it is possible that the entities feared that would happen and as a result quoted at high rates to be sure their positions were approved.

Some stylized facts of the Colombian money market are described below. In the first place, the Banco de la República is generally a net creditor with respect to the financial system,

[9] Expansion auctions are the mechanism used by the Banco de la Republica to supply liquidity to the financial system, up to an established maximum level (quota). A more detailed description of the bank's auctions and the quotas applied to them can be found in Sections 2.2 and 2.3.

which is to say that the rate of expansion of the money supply (that is, when the central bank loans funds) is higher than the contraction of the money supply (when the central bank receives deposits), which can be attributed to the fact that the aggregate market has a deficit which is covered by funds provided by the central bank. However, even in this scenario, it is often observed that entities with surplus resources prefer to lend to the central bank instead of giving credit to other entities that have liquidity needs. The latter then end up going to the bank auction or to the lending or expansion facility.[10] The fact that the Banco de la República carries out expansion and contraction operations in one day, lending pesos at a higher rate than the interbank market and raising pesos at a lower rate could indicate inefficiencies in the interbank market.

Second, even in times of high liquidity (when the Banco de la República is a net debtor), entities participate in the bank's expansion operations. This is because financial institutions establish counterparty quotas that are generally restrictive and can not be changed quickly.[11] Another reason why entities go to the central bank to cover liquidity shortages—in spite of the fact that there may be an excess of resources in the market—is that a single operation with the central bank allows them to capture the resources they need without having to negotiate with various financial institutions. According to some market participants, participating in the Bank's expansion and contraction operations reduces their operational burden.

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[10] The borrowing (or contraction) and lending (or expansion) facilities are a mechanism used by the Banco de la Republica, instead of auctions, to reduce or expand, respectively, liquidity in the financial system. Unlike auctions, these facilities operate without limits on amounts, however the resources are received (loaned) at a rate below (above) the reference rate.

[11] Counterparty quotas refer to the amount that a financial institution sets as the maximum level to lend to another specific entity. These quotas, in general, are revised annually and require committee approval to be modified.

Thirdly, market risk can be mitigated with haircuts of repos. However, as can be seen in Figure 1, this market has not been developed equally to the sell/buy-back operations market. Some entities attribute this to the fact that these operations adjust themselves according to the needs of the agents.

2.2 Liquidity Management by the Banco de la República

Currently, under normal conditions, the Banco de la República supplies liquidity (daily) to the financial system on a transitory basis (with a one-day term) through the expansion auction[12] and the expansion facility,[13] mopping up excess liquidity via the contraction facility.[14] The auction is one price; each one of the open market operations placing agents[15] offers the interest rate it is willing to pay, which may not be lower than the reference rate or monetary policy rate (minimum rate of expansion). At the expansion facility, the open market operations placing agents can go for an unlimited amount[16] and the interest

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[12] Which happens from 1:00 p.m. to 1:15 p.m. and the operations are guaranteed. This timetable has been in force since June 2005. Previously, the auction was held from 11:30 a.m. to 12:00 p.m. The change was made to adjust it to the trading hours of the TES and foreign exchange markets, thus reducing the liquidity drawbacks in the last hour of operations. The time was reduced because open market placing agents took an average of two minutes quoting their positions, thereforeit was considered to be unnecessary to retain such a wide time interval for the auctions.

[13] Which happens from 4:00 p.m. to 4:30 p.m. and the operations are guaranteed.

[14] It takes place from 4:00 p.m. to 4:30 p.m. These transactions correspond to unsecured interest-bearing deposits.

[15] Includes credit institutions and market-maker brokerage firms that belong to the market makers program for public debt.

[16] Currently, the average obligation for transitory expansionary open market operations for the last 14 calendar days may not exceed: for credit institutions, 35% of the average balance of deposits, and for broker-dealers, the value of the technical assets.

rate they must pay is the established policy rate plus 100 basis points. Contraction facility operations are carried out at the monetary policy rate minus 100 basis points and the amount that the open market placing agents may deposit is unlimited.

In May 2007, the Board of Directors of the Banco de la República approved the use of a new mechanism as a complement to monetary contraction operations: non-reserve interest bearing deposits.[17] Unlike the borrowing and lending facilities, these deposits are not enabled daily. In general, they are used when the Banco de la República projections indicate that there will be excess liquidity and therefore the resources brought into contraction will be greater than those granted in the expansion operations. Under these conditions, the consideration is that the Banco de la República will have a net debtor position with respect to the financial system. Reasons excess liquidity may occur are generally: purchases of dollars not sterilized by the central bank or a reduction of treasury deposits at the central bank. The latter case can occur with domestic public debt (TES) expirations or coupon payments.

Non-reserve interest-bearing deposits were initially issued for terms of 7, 14, 30, 60 and 90 days. The mechanism consisted of conducting 90-day non-reserve interest bearing deposit auctions for the total contraction amount, and the resources not awarded in the auctions were offered at remaining terms of 60, 30, 14 and 7 days until the quota expired. Given a shortage of demand for longer terms, non-reserve interest bearing deposits are now offered for terms of 14 and 7 days.

In recent years, the Banco de la República has generally had a net creditor position[18] with respect to the financial system

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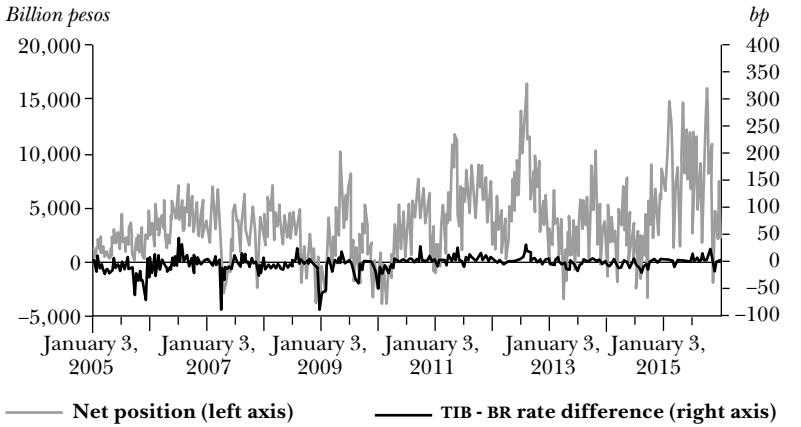
[17] At its January 2010 meeting, the Banco's Board of Directors approved the use of its own bonds as a contraction mechanism. However, these instruments have not been used to date.

[18] This position is calculated by subtracting the contraction balances (contraction facility plus non-reserve interest bearing deposits) from the Banco de la República's expansion balances. If the position is positive, the Bank is a net creditor, and if the position is negative, the Bank is net debtor.

Figure 3

NET POSITION OF BANCO DE LA REPÚBLICA IN MONEY MARKET



(Figure 3). In these scenarios, the daily interbank rate has been very close to the monetary policy rate. However, in those episodes in which the Banco de la República has been a net debtor, the daily interbank rate has been considerably below the policy rate. In the period January 2005 to December 2015, the daily interbank rate has been above the cutoff expansion auction rate in 45% of all cases (4 basis points on average).

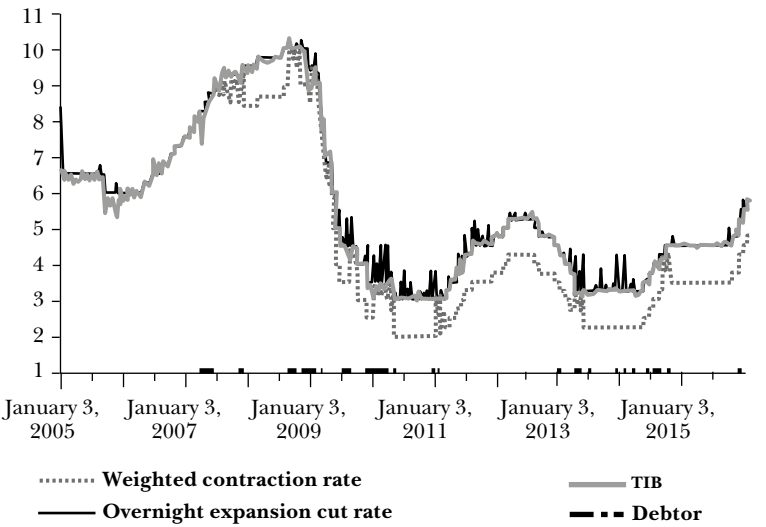
As Figure 4 shows, despite the heavy supply of non-reserve interest bearing deposits which pay an interest rate very close to the monetary policy rate,[19] in periods during which the central bank has been a net debtor, the daily interbank rate has been, on average, 19 basis points below the policy rate. This is due to the fact that in periods of ample liquidity, in spite of the central bank's offer of non-reserve interest bearing deposits, the demand for these instruments is not high enough to

[19] The 7- and 14-day non-reserve interest bearing deposits are auctioned at a maximum rate equal to the policy rate minus 4 basis points and minus 3 basis points respectively.

Figure 4

BANCO DE LA REPÚBLICA OPERATIONS RATES AND TIB

Percentages



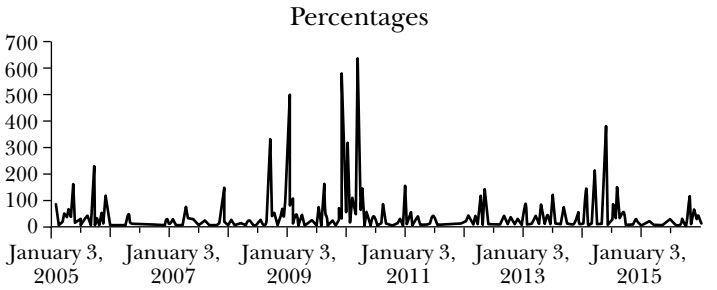
Note: The weighted contraction rate is the (weighted by amount) rate that Banco de la República is paying each day. The series debtor when it is at 1 indicates that Banco de la República is a net debtor of the financial system.

compensate for the excess liquidity in the market so that agents bring an important amount of resources to the contraction facility. Despite the fact that the non-reserve interest bearing deposits offer a rate approximately 100 basis points higher than the contraction facility, agents in some cases prefer the latter as the former are not liquid (not negotiable). In any case, if the non-reserve interest bearing deposits are not offered by the Banco de la República in periods when the bank is a net debtor, the daily interbank rate could present a considerable deviation from the policy rate, since the only floor in this case would be the contraction facility rate.

Figure 4 also reflects the friction that exists in the Colombian interbank market. For example, during periods of excess

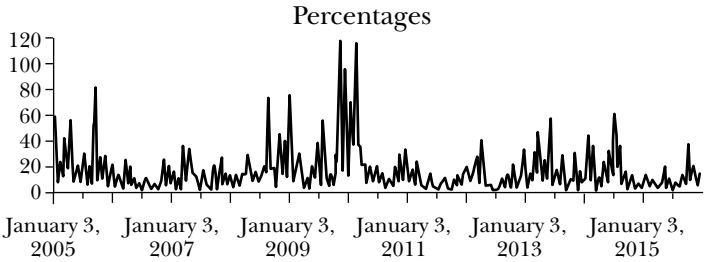
Figure 5

INTERBANK MARKET AMOUNT / EXPANSION AUCTION SUPPLY

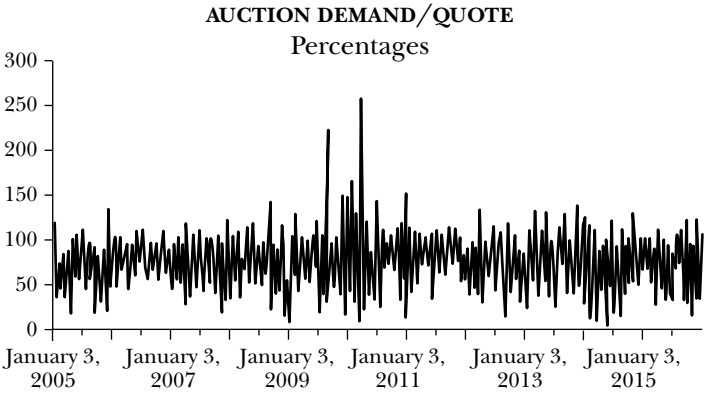


For better visualization, the observation of 27 February, 2010 (2,772%), was eliminated.

AMOUNT OF THE INTERBANK MARKET / ONE-DAY EXPANSION AUCTION QUOTA



AUCTION DEMAND/QUOTE



liquidity in the economy and when the central bank is a net debtor with respect to the financial system, the expansion auctions have been over demanded and the cut rate ends up being higher than the monetary policy rate.

The interbank market is open from 7:00 a.m. to 8:00 p.m.;[20] however, most operations are concentrated between 11:00 a.m. and 12:30 p.m. On average, during the period studied, the amount traded in the interbank market corresponds to 26% of the amount provided by the Banco de la República in the one-day expansion auction, and 13% of the auction's quota. Figure 5 shows the evolution of these two relationships and the demand of the expansion auction in relation to the fixed quota. This last relationship was 72% on average.

2.3 Liquidity Quotas: Goals and Calculation Methodology

According to economic theory, the interest rate set by the central bank affects inflation through the so-called monetary policy transmission channels. Thus, in countries that have adopted an inflation targeting regime, the central bank has models which take into account monetary transmission channels for establishing an interest rate policy that is consistent with the proposed target for inflation. Subsequently, the central banks, using different methodologies, carry out liquidity supply or contraction operations in order to maintain the market interest rate at the established goal. In this way, if the models have a good fit and the assumptions do not change, the level of the policy rate, along with the different transmission channels, should drive inflation to the desired target.

In operational terms, the central bank must define the policy rate (i^*) and the market interest rate (i) to drive the two towards a similar value ($i \approx i^*$).[21] In the case of Colombia, i^* is the interest

[20] Agents may perform interbank transactions as long as the Deposit Account System (CUD) funds transfer service is open.

[21] Other market interest rates should be affected by the monetary policy transmission channels, for example, by credit.

rate of one-day repo operations of the Banco de la República with the financial system and i is the interbank market interest rate (non-guaranteed) for the day (daily interbank rate).

The next operational step is to define the method for the supply of liquidity so as to obtain $i \cong i^*$. In general terms, three methodologies can be presented:

- Single rate: The central bank announces a single rate i^* at which it receives and lends unlimited funds to the financial system.
- Two rates: The central bank lends unlimited funds at a rate i^* and receives any amount of resources at a lower rate, for example, $i^* - \varepsilon$.
- A single rate and auction: The central bank announces a daily auction for the amount μ at a rate i^*.[22] If the market lacks liquidity ($i > i^*$), an expansion auction (resources are lent to the financial system) is held for the amount μ, that is sufficiently large so that the rate for that day is reduced to i^*. In the opposite case ($i < i^*$), a contraction auction is carried out (resources are borrowed from the financial system) and the amount must be equal to that required to increase the rate i to a level that's similar to that set by monetary policy.

With a single-rate methodology, the transaction operating costs would be assumed by the central bank while the financial system would face an opportunity cost requiring the placement of guarantees. Under this system, incentives for an interbank funds market at rates set by monetary policy would be quite low. As the issuer would have zero risk, banks with excess liquidity would prefer to resort to the central bank at a rate i^* or charge an additional risk premium ($i^* + \rho$) to another bank that needs the resources. However, banks lacking liquidity will not be disposed to pay said premium (ρ), since the central bank offers unlimited lending at i^*. Therefore, $i = i^*$ and credit between banks could occur but at terms different from that of the rate i^*.

[22] In the case of a contraction auction and an expansion auction on the same day, μ refers to the absolute value of the difference between the two amounts.

In the case of two rates and using the same reasoning as before, the interbank rate would oscillate between $i^* - \varepsilon \leq i \leq i^*$. The amplitude of the range would conform to *1)* the need to cover operating costs and make a profit, as the central bank would gain a margin of ε in the transactions, *2)* preferences for promoting the interbank market: the bigger ε, the greater the incentive on the part of banks to lend between them within the established range.

Now, if the range of rates is very broad (large ε), a misleading signal could be created regarding the market and problems could occur with the effort to meet the inflation target. In effect, the interbank rate could end up at the extremes for long periods and be very different from the policy rate.[23] Another consequence of the one- and two-rate methodologies is that, given that the central bank offers unlimited resources to the market, excess leverage can be incentivized in the financial system to trade securities or currency in the stock market. This, besides making possible bubbles greater, can generate unwanted volatility in the markets and provoke financial system vulnerabilities.

The system of quotas implemented by the Banco de la República to provide liquidity to the Colombian financial system is based on a rate and an auction. At the end of each afternoon, the Banco de la República announces a broad but fixed quota of liquidity for the following day at a rate i^*.[24] On the following morning, prior to the auction held by the Banco de la República (1:00 p.m.), banks execute financial transactions on the interbank market making offers and demands depending upon each bank's liquidity needs for that day. Although generally the quotas offered by the Banco de la República are sufficient to meet the financial system's daily liquidity requirements, uncertainty in the money demand, the probability (although small) that the bank's quota will be filled, and the existence of

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[23] Note that this conclusion would be very similar to the case where $(i^* - \varepsilon \leq i \leq i^* + \varepsilon)$.

[24] We can see in Section 2.2, the demand for liquidity represented 72% of the quota.

counterparty quotas (see footnote 10), all provide sufficient incentives for the interbank market to operate both before and after the auction.

With respect to the previous two methodologies, the rate and auction system has two advantages. The first is that it incentivizes interbank operations, which provide solvency and risk signals about the different entities participating in the market. The interbank market provides greater opportunity for monitoring the financial system since, besides the official supervising entity, all of the participants are incentivized daily to monitor each other. Thus, sudden increases in the rate or quota restrictions between banks may be signs of problems at some credit institutions.

Another advantage of the single rate and auction methodology is that it reduces the possibility of excess leverage by the financial system which can be used for stock market speculation. In effect, the auction amount is an estimate of the money demand, given bank reserve requirements and cash demand. This estimate does not include, for example, unexpected increases or decreases in the demand for money for the purchase or sale of assets on the stock market (currency or public or private debt securities.) A greater availability of resources could exacerbate external or internal transitory shocks that occur in the exchange market.

In conclusion, the main objective of a rate and auction system is to avoid the occurrence of large and prolonged deviations in interbank rates with respect to monetary policy, arriving at $i \cong i^*$, while reducing the possibility of speculation in the market as a result of excess liquidity. The one-day repo quota, besides providing necessary liquidity for banks to meet their liquidity needs, is a mechanism that incentivizes the interbank market which plays an important role in the analysis and supervision of the financial system.

In order to achieve this, one must understand the interbank market's supply and demand conditions which determine the

market's interest rate. The figure that follows illustrates how the rate is arrived at and the methodology used by the Banco de la República to calculate liquidity quotas. Later, in Section 3, the interbank rate formation is shown using a simplified model that includes elements particular to Colombia.

2.3.1 Calculation of Banco de la República Quotas

The monetary base (cash plus bank reserves) is the most liquid monetary aggregate with which to explain how the daily interbank rate is arrived at. On the demand side, this aggregate is primarily determined by the needs of credit institutions to meet the reserve requirement R^*. The demand for cash, besides responding to fundamentals, also responds to other seasonal factors such as holidays, salary pay days, etcetera.

With respect to the base supply, the principal changes can be due to losses and gains in the Banco de la República's transactions with agents, the bank's purchase and sale of currency and government bonds, changes in government deposits with the bank, and the expiration of liquidity operations by the bank and other entities.

As Figure 6 illustrates, if the base demand exceeds supply,[25] the daily interbank rate will be $i > i^*$ (point A1). In this case, the Banco de la República must supply the necessary surplus *(E)* to the interbank market to bring the daily rate to the monetary policy level $i \cong i^*$. The opposite case, $i < i^*$, happens when offers are greater than the demand[26] (point A2), a situation in which the Banco de la República must carry out net contraction operations for an amount equal to C.

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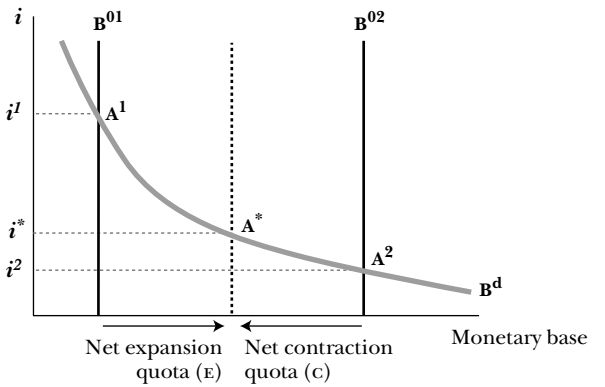
[25] For example, why banks have a reserve level R that is less than the requirements ($R < R^*$) and in the daily interbank market, the liquidity needed to meet such demand does not exist.

[26] For example when credit institutions have liquidity levels above their reserve requirements ($R > R^*$).

Figure 6

MONETARY BASE AND INTERBANK RATE (TIB)



Therefore, a projection of monetary demand and the base supply is necessary in order to establish liquidity quotas. A 14-day estimate is prepared and banks must comply during this biweekly period with the Banco de la Republic reserve requirements. Subtracting the monetary base demand and supply projections determines the size of the auction so that the interbank rate approaches the monetary policy rate.

Base Demand Estimate for 14 days

To project the demand base both cash and reserve estimates must be made. Models covering the period of a week are used to project cash demand applying certain seasonal conditions as previously mentioned.

Estimating reserve demand is more difficult. To arrive at a projection of reserve demand, the reserves of individuals banks must be projected (R_i^*) after which they are added together to obtain the total reserve requirement (R^*). To achieve success, it is essential to understand the following definitions that govern the calculation of R^*:[27]

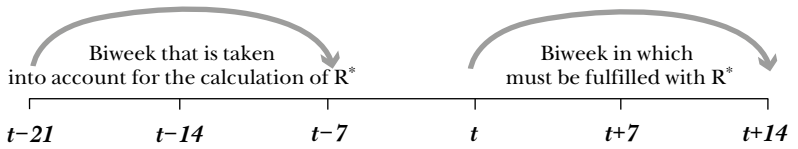
[27] Resolution 5 issued by the Banco de la República Board of Directors in 2008 explains the calculation of the required

- The reserve required of each bank (R_i^*): The amount required by the Banco de la República for each credit institution which must be made up of deposits or cash on hand. The calculation of R_i^* is made at the end of Tuesday and the methodology, as well as the period during which the reserve requirement must be met, are explained by the following points.
- Biweekly: The year is divided into 26 two-week periods with concrete starting and ending dates set by the Banco de la República. Each biweekly period begins on a Wednesday and ends on a subsequent Tuesday, that is, 14 days later. The biweekly period includes the starting and ending day. For example, in Figure 7, each segment of t (days) corresponds to the start of a week that ends on Tuesday and started on the previous Wednesday.
- Reserve ratios: They are the differentiated rates that apply to the average level of each type of deposit in order to arrive at the reserve level required for such deposits. For savings and checking accounts, for example, the reserve is 11%, for certificates of deposit with terms less than 18 months, the ratio is 4.5%. The sum of these calculations (reserve by average deposit level) results in R_i^*.
- The period for calculating the average deposit level for applying the reserve ratio: When a biweekly period ends (t= Tuesday), the average amount of deposits is calculated for the biweekly period ending the previous week, or $t-7$ (Figure 7).

reserve and gives some reserve percentages that are no longer operable. Resolution 11, also in 2008, provided reserve percentages that are still applicable.

Figure 7

PERIODS OF CALCULATION OF THE REQUIRED RESERVE (RI*)



Note: each t corresponds to the end of one week ending on Tuesday and beginning the previous Wednesday.

- Period for meeting R_i^*: Each entity i must meet on average with R_i^* in the biweekly period starting the day after the date of calculation, which is to say the biweekly period made up of $t+1$ and $t+14$.
- Reserve required R^*: It is obtained by adding the reserve requirements of all banks ΣR_i^*.

Thus, for the calculation of R^*, the financial authority requires the credit institutions to provide information on the daily level of each type of deposits observed in the period between $t-20$ and $t-7$ (Figure 7).[28]

Another aspect to be taken into account in the estimation of reserve demand is that some entities usually end up with levels greater than their required reserve. Therefore, the Banco de la República maintains a continuous monitoring of the available reserve (R_i^d), which is defined as the average amount that an entity i has in deposits with the Banco de la República and cash on hand calculated over the period of reserve compliance. Thus, it is said that an entity is over-reserved if $R_i^d > R_i^*$. In the opposite case, the entity is under-reserved if, $R_i^d < R_i^*$.

[28] Since the date upon which the Banco de la República makes the calculation is prior to the complete 14 day period, surveys are undertaken to arrive at a preliminary estimate for the days remaining (generally four days). Once the financial authority has all of the necessary information, the value can be determined and banks must comply with it.

Therefore, in order to obtain the final estimate of reserve demand, we add the average historical amount of over-reserves to R^*.

Monetary Base Estimate for 14 Days

From the monetary base observed at the start of the calculation the following operations are projected that have an effect on the monetary base:

- Permanent liquidity operations the Banco de la República will undertake in the period. The purchase of assets (government bonds, foreign currency, buildings, etcetera) expands the monetary base while the sale of these same classes of assets (or the expiration of government bonds) contracts it.
- The change in deposits at the Dirección General de Crédito Público y del Tesoro Nacional (DGCPTN), Banco de la República.[29] A decrease (increase) in these deposits implies an increase (decrease) in the monetary base.
- Banco de la República losses and gains from operations. For example, some expenditures that expand the base are: payment of yields on deposits by the financial system at the Banco de la República, payroll payments, operational expenses, etc. On the revenue side, the collection of returns from credit operations with the financial system (repos) is a class of operations that contracts the base.
- Credit or debit transactions with the financial system prior to the estimate and expiring during the period for which the base is being projected. For example, repos or interest-bearing deposits that come to term.

When all of these operations are netted out, this result

[29] Since the end of June 2005 it was agreed that to better manage liquidity in the economy, government revenue and tax authorities would deposit all of their excess liquidity with the Banco de la República at market rates.

indicates how much to increase or reduce the money supply base. As already mentioned, if this projection of supply is subtracted from the base demand estimate, we obtain the average quota of the daily auction that must be made by the Banco de la República during the biweekly period. The aforementioned calculations of the liquidity quotas are presented to the bank's monetary and exchange intervention committee (CIMC), which is made up of members of the Banco de la República Board of Directors and a delegate from the federal tax authority.

3. MODEL

Based on the description and analysis presented in the previous section, this section presents some of the basic elements on how the interbank rate for the unsecured market is determined in the Colombian case and constructs a simple model with the intention of serving as an initial reference point for further studies.

Despite its simplicity, the model replicates some general facts of the unsecured interbank market. However, it does not reproduce some phenomena that occasionally occur but that are of equal importance to the analysis of this market. Relaxing some assumptions will deepen the analysis of these particularities in future studies.

It is a two-period model. In each period the central bank supplies the amount of money requested by the commercial banks (banks, hereinafter) at the policy rate i^*.[30] In the course of the two periods, each bank must deposit money into the central bank to meet a reserve requirement equal to R, but has the freedom to decide how to divide the deposits to satisfy the requirement. This way, each bank may decide to deposit

[30] The model does not impose initial limits on the amount of money the central bank can provide to banks and therefore is not considering the liquidity quotas described in the previous sections. In this sense, the model is more in line with the two-rate methodology described in the previous section. As explained

nothing, or deposit a part of R or deposit all of R in the first period and the remaining fraction in the second period. It is assumed that there is a continuum of banks with measure 1 and, as a result, the added value for any variable x^j can be obtained accordingly: $X \equiv \int_0^1 x^j dj$.

In each period t and for each bank j, the following events occur in the order described:

1) Bank j begins the period with a quantity of money m_{t-1}^j.

2) Bank j goes to the interbank market and borrows a quantity of money b_t^j (or lends it, if the value is negative, $b_t^j < 0$) at an interbank rate of i_t, determined endogenously in the model. The sum of what banks lend must be equal to the sum of what they borrow in this market: $B_t \equiv \int_0^1 b_t^j dj = 0$.

3) Bank j accesses the central bank's liquidity supply and requests a quantity of money $a_t^j \geq 0$ at the policy rate i^*.[31]

4) Bank j has the possibility of using the central bank's expansion and contraction facilities to request funds (at a rate $i^e > i$) or to deposit funds (at a rate $i^c < i$), respectively.

5) Bank j deposits a quantity of funds $s_t^j \geq 0$ with the central bank, at a zero rate to comply with the reserve requirement.

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in Section 2.2, in general the liquidity quota established by the Banco de la República is sufficiently large and is not usually filled. As a result, most of the time the Banco de la República's supply of liquidity acts as if it was following a two-rate methodology.

[31] As mentioned in Section 2.2, although the interbank market is open from 7 a.m. to 8 p.m., most of its operations are concentrated between 11 a.m. and 12:30 p.m., i. e., in advance of the auction held by the Banco de la República. For this reason, in the sequence of events of the model of the supply of liquidity of the central bank is subsequent to the operation of the interbank market.

All loans and deposits are made without guarantees (both for banks and the central bank) and for a one-period term, that is, the resources requested (borrowed) are necessarily paid (received) in the next period. There is no counterparty risk and as a result, it is a model in which there is no default.

The money deposited in period one, s_1^j, is available for use by bank *j* in period two. It should be noted that before the first period there has been no deposit and that in the second period it is mandatory to comply with the requirement, therefore $s_0^j = 0$ and $s_1^j + s_2^j = R$.

For simplicity, a limited horizon is analyzed, and, additionally, it is assumed to be equal to the lapse in time for fulfilling the reserve requirement (two periods). However, a bank is allowed to start with liquidity shortages (m_0^j can be negative). During the two model periods, the banks do not have access to other funding sources and therefore will have to only use resources from the initial amount of money, loans on the interbank market and funds provided by the central bank.

In each period, bank *j* decides how much to loan or borrow on the interbank market (b_t^j), how much to ask for from the central bank $(a_t^j \geq 0)$, how much to deposit with the central bank to meet reserve requirements (s_t^j) and, where necessary, where to make use of the contraction or expansion facilities, all towards the goal of maximizing profits from operations (Π_t^j), i. e.:

- The interest paid on funds borrowed from the central bank at the monetary policy rate.
- Interest paid (charged) on the money requested (borrowed) on the interbank market.
- Interest paid on the money requested at the expansion facility.
- Interest charged on the money deposited at the contraction facility.

The aforementioned can be represented as:

$$\Pi_t^j = -a_t^j i^* - b_t^j i_t - i^e K_t^j I[K_t^j > 0] - i^c K_t^j I[K_t^j \leq 0],$$

where I [.] is a function that takes the value of 1 if the condition within the parenthesis is true and 0 if it is false.

$$K_2^j \equiv (R - s_1^j) - (\mathrm{m}_1^j + a_2^j + b_2^j).$$

The term in the first parenthesis is the amount of money that the bank is required to deposit in the second period to meet the reserve requirement. The term in the second parenthesis is the sum of the amount of money at the beginning of the period (which depends on the decisions taken in the first period) plus the money obtained in the operations of the same period. If $K_2^j > 0,$ bank j will have a shortage to meet the reserve requirement and will, therefore, have to request funds at the expansion facility. If $K_2^j \leq 0,$ bank j will have an excess and will deposit it at the contraction facility.

$$K_1^j \equiv s_1^j - (m_0^j + a_1^j + b_1^j).$$

The term in the second parenthesis is the sum of the amount of money at the beginning of the period (m_0^j, which is exogenous) plus the money obtained in the operations of the same period. In the first period, bank j takes into account that its decisions will affect operations in period two and for that reason maximizes $\Pi_1^j(a_1^j, b_1^j, s_1^j) + \Pi_2^j(m_1^j(a_1^j, b_1^j), s_1^j)$.

3.1 Solution

The model can be solved by backward induction, although this requires an extensive amount of algebra and review of multiple possible cases. For the reader's simplicity and ease, below are some basic propositions which, as explained in each case, can be easily deduced from the structure of the model. Comments are offered on each proposition's relationship with what is seen in practice.

Proposition 1. *During no period will the interbank rate be neither* a) *strictly above the policy rate nor* b) *strictly below the contraction rate*:

$$i^c \leq i \leq i^*$$

a) If $i_t > i^*$, no bank demands money on the interbank market since it is cheaper to request it from the central bank's liquidity supply. As a result, there is an excess offer on the market and the interbank rate falls. *b)* If $i_t < i^c$, all of the banks ask for the maximum quantity of funds possible on the interbank market, since they make a profit by then taking this money to the contraction facility. As a result, the there is an excess of demand on the market and the interbank rate increases.

In practice, this has been generally true during the period studied, as can be seen in Figure 2, principally because more expansion than contraction auctions have been used. A model that is analogous to that presented in this section that includes a contraction session instead of a supply of liquidity, would imply that the interbank rate would fluctuate between the policy rate and that of the expansion facility. The model, however, does not capture episodes in which the auction cut rate is different from the policy rate, which can occur for example when the auction quota is filled, although these cases are rare.

Proposition 2. *The banks resort to central bank liquidity only if the interbank rate is equal to the policy rate* ($i_t = i^*$).

For Proposition 1 we know that $i_t \leq i^*$. Given that the moment the banks go to the interbank market, each one knows its liquidity needs and there are no surprises during the period, therefore when $i_t < i^*$, the bank asks for all of the money it needs on the interbank market. Only if $i_t = i^*$, will the bank be indifferent as to whether it resorts to the interbank market and the central bank liquidity supply.

In practice, this can occur occasionally and only in the case of some banks. The presence of uncertainty about liquidity needs, and about the possibility of whether the auction quota will be filled, or the existence of counterparty quotas between banks makes this result not true in many cases.

Proposition 3. *The banks never deposit more money than is strictly required in order to meet the reserve requirement.*

Since no interest is received for the money deposited to comply with this requirement, any excess will generate higher profits being taken to the contraction facility. In practice, this would be completely true in a context of no uncertainty regarding liquidity needs. However, due to the presence of uncertainty, the banks, to avoid the possibility of noncompliance, prefer to exceed the required quantity although by a small amount.

Proposition 4. *The banks never resort to the expansion facility.*[32]

Since banks know their liquidity needs and there are no surprises during the period, they know exactly how much money they need and therefore prefer to always request it from the central bank's liquidity supply at the policy rate or on the interbank market at the daily rate (remember that $i_t \leq i^* \leq i^e$).[33]

In practice, although banks avoid resorting to the expansion facility to avoid higher costs, the existence of unexpected shocks to their liquidity needs makes it necessary on occasions to do so. These shocks are not included in the model.

To verify the validity of the following proposition as well as some of the results presented below, it should be noted that the present work does not include the analysis of two cases particular to the behavior of the banks: *1)* that, with the interbank rate equal to the contraction *($i^c=i_t$)*, the banks request more money than necessary with the only goal of taking it to the contraction facility (note that this operation would not result in any loss or gain), and *2)* that, with the interbank rate being equal to *($i^*=i_t$)*,

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[32] Therefore, $(R - s_1^j - m_1^j - b_2^j) - a_2^j \leq 0$ and $(s_1^j - m_0^j - b_1^j) - a_1^j \leq 0$. The terms in parentheses correspond to the liquidity needs of bank *j* at the moment of resorting to the central bank's liquidity supply in the second and first periods respectively.

[33] As explained at the beginning of the section, this is mainly a result of the absence of uncertainty about the demand for liquidity in the model. If shocks were included, they would modify the demand in a surprising manner, and the banks would see on some occasions the need to resort to the expansion facility, as occurs in practice.

the banks with an excess of liquidity lend more money than they have left creating a shortage and thus they then resort to the central bank's liquidity supply in order to cover the shortage (note that in this case there are no gains or losses either).

Proposition 5. *The banks do not request more funds than are required to cover their liquidity needs in any given period.*[34]

Since the money solicited must be returned at the start of the second period and given that it costs the bank more than it would receive for the same funds at the contraction facility, any amount requested, as well as any additional amount than required for the period, would only mean losses.

In practice, and as in the previous proposition, the higher cost incentivizes the banks to avoid requesting more funds than needed, but the uncertainty regarding their exact needs in each period and the need to be precautionary make it possible for these types of cases to occur and to occur with relative frequency.

3.1.1 Second Period Results

Case 1: $i_2 = i^*$. Banks with a liquidity shortage ask for a part or all on the interbank market and the rest in the central bank's liquidity supply. Banks with surpluses in liquidity will lend everything on the interbank market and bring nothing to the contraction facility. This happens only when the aggregate balance of available money at the beginning of the second period is less than or equal to the liquidity requirements for the same period:

$$\int_0^1 m_1^j dj \equiv M_1 \leq R - S_1,$$

where $S_1 \equiv \int_0^1 s_1^j dj$; otherwise there would be an excess supply in the market.

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[34] Taking Proposition 4 into account as well, therefore for the second period: $(R - s_1^j - m_1^j - b_2^j \leq a_2^j = 0$ or $0 < a_2^j = R - s_1^j - m_1^j - b_2^j)$ and $(b_2^j < 0$ o $0 \leq b_2^j \leq R - s_1^j - m_1^j)$. For the first period: $(s_1^j - m_0^j - b_1^j \leq a_1^j = 0)$ or $0 < a_1^j = s_1^j - m_0^j - b_1^j)$ and $(b_1^j < 0$ or $0 \leq b_1^j \leq s_1^j - m_0^j)$.

Case 2: if $i^c < i_2 < i^*$. The banks take the surpluses or the shortages to the interbank market and do not resort to the central bank's liquidity supply or facilities. This happens only when the aggregate balance of available money at the beginning of the second period is equal to the liquidity requirements for the same period:

$$M_1 = R - S_1;$$

otherwise, there would be an excess supply or demand in the market.

Case 3: if $i_2 = i^c$. Banks that end up with surpluses lend a part (or all) of the available funds on the interbank market and take the rest to the contraction facility. Those banks that end up with shortages resort only to the interbank market. This happens only when the aggregate balance of available money at the beginning of the second period is larger or equal to the liquidity requirements for the same period:

$$M_1 \geq R - S_1;$$

on the contrary, there would be an excess of demand in the market.

3.1.2 First Period Results

For the analysis of the results of the first period, it must be taken into account that the amount of money that bank j starts with, m_0^j, is taken as exogenous. The initial quantity in the second period, m_1^j, will be determined by the operations held in the first period considering the following factors:

- The money deposited to meet the reserve requirement s_1^j is available to use in period two.
- The money deposited at the contraction facility, plus interest, is received during period two.

- The money requested from the central bank's liquidity supply, plus interest, must be paid in period two.[35]
- The money requested (loaned) on the interbank market, plus interest, must be paid (charged) during the second period.

Therefore:

$$m_1^j = s_1^j - (1+i^c)K_1^j - (1+i^*)a_1^j - (1+i_1)b_1^j,$$

where $K_1^j = s_1^j - (m_0^j + a_1^j + b_1^j)$, as defined above.[36]

Note that on the first day the bank is not obligated to deposit anything in order to comply with the reserve requirement and can wait until the second period to do so.

What is the optimal amount to deposit in the first period (s_1^j)?

Suppose that the bank decides to deposit $s_1^j = \gamma_j R, \ \left(0 < \gamma_j \leq 1\right)$ and that it would have to borrow that amount. Would the bank be willing to do so? This request would end up in a loss equal to $\gamma_j R i_1$ in the first period and a loss expected to be equal to $\gamma_j R i_1 E_1[i_2]$ in the second. If, on the other hand, the bank waits until the second period to deposit this part, the loss would be $\gamma_j R E_1[i_2]$. So, it can be seen that if $i_1(1+E_1[i_2]) < E_1[i_2]$, the bank will prefer to borrow in the first period and not wait until the next period. Since this is true for any amount of money requested for the purpose of meeting the requirement, if $i_1(1+E_1[i_2]) < E_1[i_2]$ the bank asks for all of the funds necessary to meet the requirement from the first period ($\gamma_j = 1$).[37] According to analogous reasoning, it can be shown that if the bank has excess funds, it prefers to deposit them in the first period to comply with the reserve requirement if $i_1(1+E_1[i_2]) < E_1[i_2]$.

The intuition behind the above results is that if the interbank

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[35] In the case where funds are requested at the expansion facility, they must be paid during the second period as well plus interest. However, for Proposition 4, we know that the model presented in this paper, this never happens.

[36] Note that for Proposition 4, $K_1^j \leq 0$. See also footnote 32.

[37] If $i_1(1+E_1[i_2]) = E_1[i_2]$, then $s_1^j \in [0,R]$, which is to say, the banks are indifferent with respect to how much to deposit in the first

rate for the first period is low enough compared to the expected rate for the second period then it is better to borrow money to meet the reserve requirement in period one, because it is expected that it will be more expensive to request that money in the second period. If the bank has a surplus, it prefers to use it to meet the reserve requirement because in the next period it will have that money available to lend it at a higher interbank rate.

Case 1: $i_1=i^*$. Banks with shortages of funds ask for a part (or all) on the interbank market and the rest from the central bank's liquidity supply.

Banks with excesses lend it all on the interbank market. This option occurs only if:

$$M_0 \leq S_1.$$

Case 2: If $i^c < i_1 < i^*$ the banks take their surpluses or shortages to the interbank market and do not resort to the central bank's liquidity supply or facilities. This option occurs only if:

$$M_0 = S_1.$$

Case 3: If $i_1=i^c$ banks that end up with surpluses lend a part (or all) of the available funds on the interbank market and take the rest to the contraction facility. Those banks that end up with shortages resort only to the interbank market. This option occurs only if:

$$M_0 \geq S_1.$$

3.1.3 Summary of Results (Equilibrium Possibilities)

For the purpose of expressing the solution in terms of R we use $s_1^j = \gamma_j R$, where γ_j takes values of between zero and one as appropriate. Suppose that *1)* commercial banks are aware of the

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period in order to meet the reserve requirement.

initial aggregate state of liquidity, which is to say they acknowledge M_0, and *2)* in cases where $i^c < i_t < i^*$ $E_{t-1}[i_t]$ is the middle point of that interval, which is to say $E_{t-1}[i_t] = (i^* + i^c)/2$.

The results can be summarized in terms of the values that the initial aggregate amount of money, M_0, can take and the relation between the value of the policy rate i^*, and the rate of contraction i^c or the first-period interbank rate i_1. We use the following definitions to abbreviate the results:

$$\Gamma \equiv \int_0^1 \gamma_j dj, \eta \equiv \frac{1-\Gamma(1-i^c)}{1+i^c}, \mu \equiv \frac{1}{1+i^c}, \omega \equiv \frac{i^*}{1+i^*}, \lambda \equiv \frac{(i^*+i^c)/2}{1+(i^*+i^c)/2}.$$

Note that $\omega > \lambda$. It is assumed that the rate of contraction is always less than 1 $(i^c < 100\%)$ and, thus $\mu > \eta$. In the process of obtaining the results, it is established that $0 \leq \Gamma \leq 0.5$ and, thus, $\eta \geq 0.5$.

Table 1 presents the summary of the possible balances, according to the initial conditions. To understand how it should be read, take as an example the case where $M_0 < \mu R$ and $\omega < i^c$ (last column of the first part of the table). In this case, it is established that when the initial amount of money is less than a fraction μ of the reserve requirement R and the margin between the policy rate and the contraction rate is relatively low, banks prefer not to deposit anything in period one to meet the reserve $(S_1 = 0)$. Liquidity in the first period is high and the interbank rate is equal to the contraction.[38] In the second period, banks must request all of the money in order to comply with the reserve requirement and liquidity is low. Therefore, the interbank rate during this period is equal to the policy rate. As another example, note that when the liquidity level is very high $(M_0 > \mu R)$, the interbank rate in the two periods is equal to the contraction

[38] Note that although $i_1 = i^c$ and $i_2 = i^*$, the interbank rate for the first period is not low enough to persuade banks to meet the reserve requirement in the first period. This occurs because $\omega < i^c$ and, therefore, the margin between the policy rate and contraction rate is very small.

Table 1

MODEL RESULTS ACCORDING TO INITIAL CONDITIONS

M_0	$> \mu R$	$= \mu R$	$= \eta R$	$< \eta R$	$= \mu R$
i^* vs. i^c	NR	$\lambda < i^c$	$\lambda = i^c$	$\omega = i^c$	$\omega < i^c$
S_1=	0	0	ΓR	ΓR	0
i_1=	i^c	i^c	i^c	i^c	i^c
i_2=	i^c	$i^c < i_2 < i^*$	$i^c < i_2 < i^*$	i^*	i^*
M_0	=R/2	$= \Gamma R$	=0	<0	
i^* vs. i_1	$\lambda = i_1$	$\omega = i_i$	$\omega < i_1$	NR	
S_1=	=R/2	ΓR	0	0	
i_1=	$i^c < i_1 < i^*$	$i^c < i_1 < i^*$	$i^c < i_1 < i^*$	i^*	i^*
i_2=	$i^c < i_2 < i^*$	i^*	i^*	i^*	

NR. It does not require satisfying a condition in this case.

rate i^c, while when liquidity is very low ($M_0 < 0$) it will be equal to the policy rate i^* during the two periods as well.

The analysis presented in this section is not intended to accurately reflect all the particularities of the Colombian interbank market mentioned in the previous sections. Instead, and as discussed above, it is a simple model whose purpose is to serve as an initial reference point for later work. To that purpose, the simplifying assumptions (i. e., homogeneity of the banks, an interbank market without friction, the absence of unexpected factors affecting liquidity needs, the absence of counterparty risk) clearly contribute to making the model workable, permitting us to obtain analytical results.

Subsequent studies will find guidance in works done in the euro area which may be the case most similar to the Colombian.[39] For the euro area, there are studies that look at the effect of the heterogeneity of financial institutions on the interbank market (Neyer and Wiemers, 2004) or, among other factors, frictions in the interbank market in the form of participation costs in the market (Hauck and Neyer, 2014).

A common feature of the documents about the interbank market is the inclusion of random shocks that unexpectedly change banks' liquidity needs (i. e., Moschitz, 2004; Välimäki, 2004; Pérez and Rodríguez, 2006; Allen, Carletti and Gale, 2009; Bucher, Hauck and Neyer, 2014). The inclusion of these random factors makes it difficult or even impossible to obtain analytical results, but instead justifies mechanisms such as the use of the expansion facility by banks (in contrast to this present document) or the analysis of elements of important uncertainties in the understanding of liquidity problems in the interbank market, especially in times of crisis.

4. CONCLUSION

Private financial institutions borrow or loan funds between them on what is known as the *interbank market*. When loaning or borrowing resources, at the time of the transaction a bank may or may not provide one or more securities as a guarantee. In Colombia, the volume of transactions in the guaranteed interbank market is greater than that of the unsecured market. The Banco de la República is the largest provider of liquidity to the financial system and its expansion operations (when the bank loans money to the financial system, always requiring a guarantee) are significantly larger than those of the interbank market. In contrast, the bank's contraction operations (that is when the Banco de la República borrows money from the financial system) are small.

[39] A description of how monetary policy is applied in the euro zone can be found in ECB (2011).

For this reason, in general the expansion balances exceed the contraction balances which is to say that the Banco de la República has a *net creditor* position with respect to the financial system. In these cases, the non-guaranteed interbank daily rate is generally very close to the policy rate set by the Bank of the República. By contrast, when the Banco de la República has a *net debtor* position with respect to the financial system, the interbank daily rate is considerably below the policy rate due to the excess liquidity in the market.

The interest rate in the guaranteed interbank market may show significant deviations from the policy rate when no restrictions are placed on the mobility of securities that are provided as collateral. In these type of operations, referred to as sell/buy-back, cases may arise in which the main motivation of operations is not the search for resources on the part of soliciting institutions but instead is the need for a particular security on the part of the entities lending money. For this reason, it is observed that the interest rate of the sell/buy-back operations can on occasion be well below the policy rate.

The Banco de la República provides resources to the financial system through a system we could call "a rate and an auction," system and in which if the market lacks (or has an excess) of liquidity, the banks announce an expansion auction (or a contraction auction) at a determined rate (policy rate) and for a limited quota or amount. This system attempts to avoid the occurrence of large deviations in the interbank daily rate with respect to the policy rate at the same time that it reduces the possibility of speculation in the market as a result of excess liquidity. However, the quota set by the Banco de la República for the expansion auctions is broad (the demand for resources is on average 72% of the quota), so that on very few occasions the quota is filled and, as a result, the Banco de la República's liquidity supply behaves most of the time as a two-rate system in which the entire amount demanded by the financial system is lent at the policy rate and excess liquidity is mopped up at a lower rate (the rate of the contraction facility).

Based on this, the paper here creates a model in which the central bank operates a two-rate system. As a result, the interbank rate in the model takes values that are less or equal to the policy rate (as occurs the majority of the time in Colombia's case) and never is less that the contraction facility rate. Keeping the interbank rate equal to or below the policy rate, and the way that financial institutions distribute funds deposited at the Banco de la República over time in order to meet liquidity requirements, will depend upon the amount of initial liquidity in the market and relative level of the policy rate with respect to the contraction rate.

The model presented here has many simplifications and does not intend to precisely reflect all of the particularities observed in the Colombian interbank market. However, the intention is for this paper to serve as a point of initial reference for future works.

References

Allen, Franklin, Elena Carletti and Douglas Gale (2009), "Interbank Market Liquidity and Central Bank Intervention," *Journal of Monetary Economics*, Elsevier, Vol. 56, No. 5, pp. 639-652.

Bianchi, Javier, and Saki Bigio (2014), *Banks, Liquidity Management and Monetary Policy*, NBER Working Papers, No. 20490, National Bureau of Economic Research.

Bucher, Monika, Achim Hauck and Ulrike Neyer (2014), *Frictions in the Interbank Market and Uncertain Liquidity Needs: Implications for Monetary Policy Implementation*, DICE Discussion Paper, No. 134 [rev.], University of Düsseldorf.

Cassola, Nuno, and Michael Huetl (2010), *The Euro Overnight Interbank Market and ECB's Liquidity Management Policy during Tranquil and Turbulent Times*, Working Paper Series, No. 1247, European Central Bank.

Capera, Laura, Juan Sebastián Lemus and Dairo Estrada (2013), *Relaciones crediticias y riesgo de contagio en el mercado interbancario no garantizado colombiano*, Temas de Estabilidad Financiera, No. 077, Banco de la República, Colombia.

ECB, European Central Bank (2011), *The Implementation of Monetary Policy in the Euro Area*, February.

Freixas, Xavier, Antoine Martin and David Skeie (2011), "Bank Liquidity, Interbank Markets, and Monetary Policy," *Review of Financial Studies*, Society for Financial Studies, Vol. 24, No. 8, pp. 2656-2692.

González, Camilo, Luisa Silva, Carmiña Vargas and Andrés M. Velasco (2014), *Uncertainty in the Money Supply Mechanism and Interbank Markets in Colombia*, Ensayos sobre Política Económica, Vol. 32, No. 73, Banco de la República, July, pp. 36-49.

Green, Christopher, Ye Bai, Victor Murinde, Kethi Ngoka, Isaya Maana and Samuel Tiriongo (2016), "Overnight Interbank Markets and the Determination of the Interbank Rate: A Selective Survey," *International Review of Financial Analysis*, Elsevier, Vol. 44(C), pp. 149-161.

Hauck, Achim, and Ulrike Neyer (2010), *The Euro Area Interbank Market and the Liquidity Management of the Eurosystem in the Financial Crisis*, DICE Discussion Papers, No. 09, University of Düsseldorf.

Hauck, Achim, and Ulrike Neyer (2014), "A Model of the Euro System's Operational Framework and the Euro Overnight Interbank Market," *European Journal of Political Economy*, Elsevier, Vol. 34, June, pp. S65-S82.

León, Carlos, Jorge Cely and Carlos Cadena (2015), *Identifying Interbank Loans, Rates, and Claims Networks from Transactional Data*, Discussion Paper, No. 2015-029, Center for Economic Research, Tilburg University.

Moschitz, Julius (2004), *The Determinants of the Overnight Interest Rate in the Euro Area*, ECB Working Paper Series, No. 393, September, European Central Bank.

Neyer, Ulrike, and Jürgen Wiemers (2004), "The Influence of a Heterogeneous Banking Sector on the Interbank Market Rate in the Euro Area," *Swiss Journal of Economics and Statistics*, Vol. 140, No. 3. September, pp. 395-428.

Pérez, Gabriel, and Hugo Rodríguez (2006), "The Daily Market for Funds in Europe: What Has Changed with the EMU?," *Journal of Money, Credit and Banking*, Vol. 38, No. 1, February, pp. 91-118.

Välimäki, Tuomas (2004), *Variable Rate Liquidity Tenders*, Macroeconomics, EconWPA, No. 0405010, May.