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The Effects of US Unconventional Monetary Policies in Latin America

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

Pamela A. Cardozo Ortiz
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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).

Banco de la República, Colombia The authors would like to thank Sandra Benítez, Camilo González, Diego Rojas and an anonymous reviewer for their valuable comments and feedback. The opinions expressed here and any errors contained herewith are the sole responsibility of the authors and are not the responsibility of the Banco de la República of Colombia or its Board of Directors. Contacts: <jparrapo@banrep.gov.co>, <lpatinec@banrep.gov.co>.

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JEL *classification: E43, E52, E58, G21.*

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)

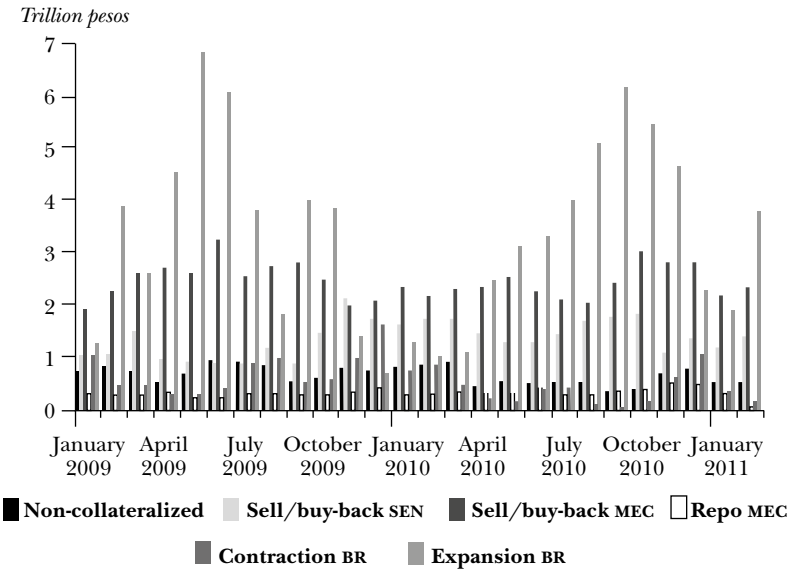
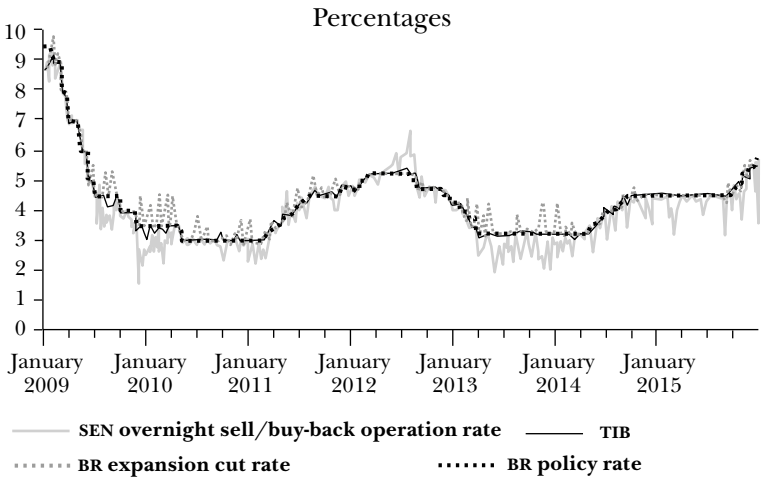


Figure 2 shows the daily interbank rate (TIB), the Banco de la República reference rate, the bank's cut rate for expansion repos auctions, and the rate for SEN sell/buy-back operations.[8] It is generally observable that the daily interbank rate is higher than the sell/buy-back operations rate and behaves 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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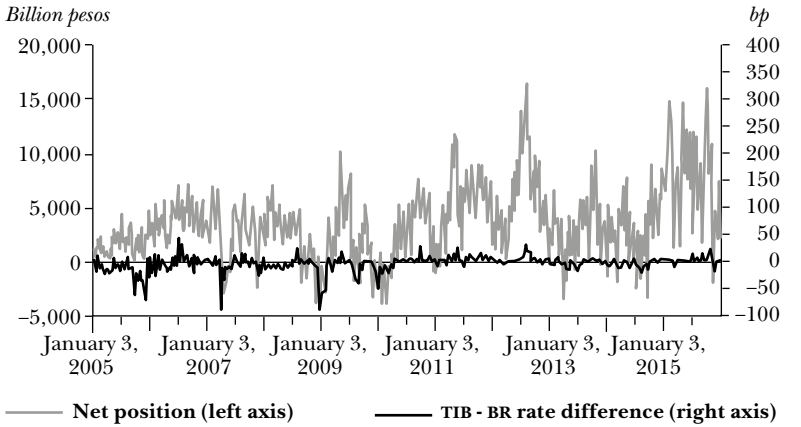
[17] At its January 2010 meeting, the Banco's Board of Directors approved the use of its own bonds as a contraction mechanism. However, these instruments have not been used to date.

[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).

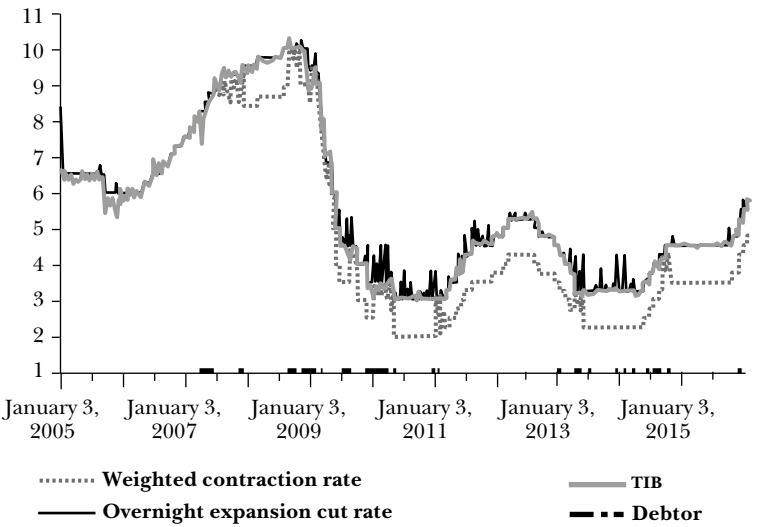
As Figure 4 shows, despite the heavy supply of non-reserve interest bearing deposits which pay an interest rate very close to the monetary policy rate,[19] in periods during which the central bank has been a net debtor, the daily interbank rate has been, on average, 19 basis points below the policy rate. 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



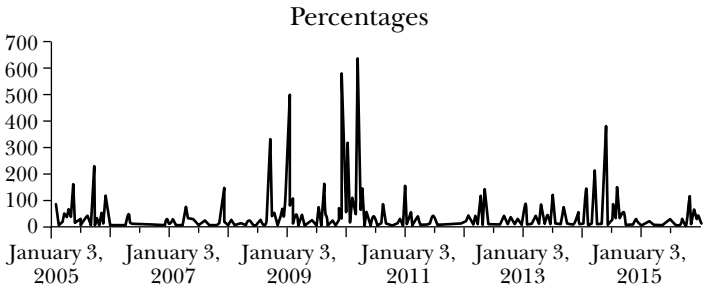
Note: The weighted contraction rate is the (weighted by amount) rate that Banco de la República is paying each day. The series debtor when it is at 1 indicates that Banco de la República is a net debtor of the financial system.

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

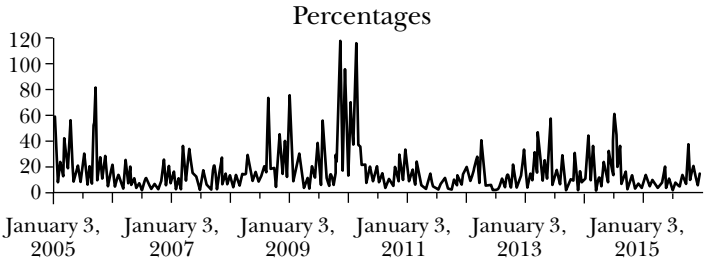
Figure 5

INTERBANK MARKET AMOUNT / EXPANSION AUCTION SUPPLY

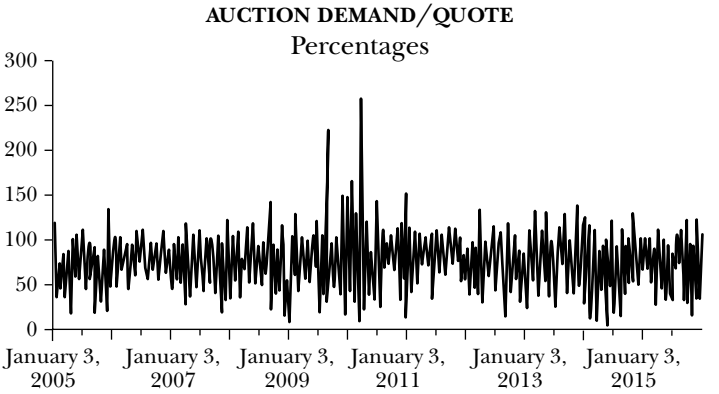


For better visualization, the observation of 27 February, 2010 (2,772%), was eliminated.

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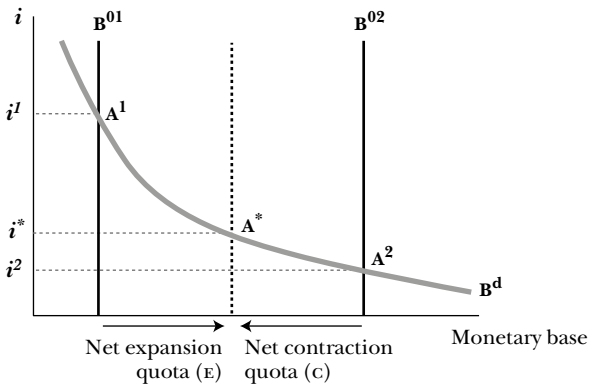
[25] For example, why banks have a reserve level R that is less than the requirements ($R < R^*$) and in the daily interbank market, the liquidity needed to meet such demand does not exist.

[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]

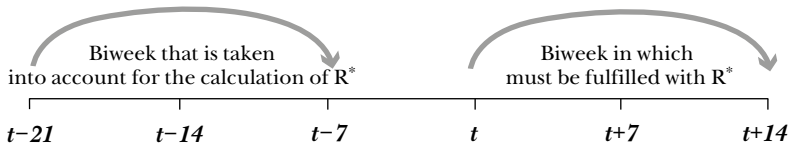
[27] Resolution 5 issued by the Banco de la República Board of Directors in 2008 explains the calculation of the required

- 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.

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Financial Development and the Volatility of Growth: Time Series Evidence for Mexico and United States

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Abstract

This paper reports time series evidence on the influence of financial deepening on growth and its volatility, for the cases of Mexico and the USA. The paper contributes to the existing empirical literature in two relevant aspects. First, it focuses on two closely interconnected economies but quite different in terms of economic and financial development. Second, it uses time series methods to examine the relation between financial development and the volatility of growth. We find that, in the case of the USA, financial and money deepening seem to affect real output growth, but finance does not show a significant relation with growth

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volatility. In the case of Mexico, economic growth seems to precede financial deepening, while money deepening and output growth interact. We also find some evidence that financial deepening reduces the volatility of growth. This, in turn, leads to more rapid output growth. Further, faster growth in the USA may result in faster growth in Mexico not only directly, a fact that is well known, but also through a reduction of Mexico's growth volatility.

Keywords: financial development, monetary and credit deepening, growth, volatility, VAR models, Granger-causality, GARCH models.

JEL classification: C22, C32, F43, O40.

1. INTRODUCTION

For at least a couple of centuries, the influence of financial development on economic growth has attracted vigorous debate among economists. Despite numerous approaches –within the current consensus– on what circumstances may actually produce these effects, there is growing empirical evidence that financial variables have significantly influenced the rate of economic growth.

On the one hand, the theoretical literature has identified alternative mechanisms through which the performance of the financial system influences the fundamental determinants of economic growth. In particular, the accumulation of physical and human capital and technological innovation are spurred by the roles of the financial sector both in mobilizing and pooling savings, mostly from households (surplus units), and in reallocating this purchasing power to investment projects with high marginal rates of return (deficit units) as well as in improving the stock of information about investment opportunities and firm performance, the monitoring of managers and exercise of corporate control, and the pooling, exchanging, diversifying and mitigating of idiosyncratic and systemic risk. The financial development also helps in completing the institutional scaffolding of markets and in creating social capital.

On the other hand, the empirical literature suggests that a better performance of the financial system leads to higher

output growth rates, although the specific channels for these effects are not fully specified (Beck, Levine and Loayza, 2000). Further, both the theoretical and the empirical contributions recognize and discuss issues about reverse causality; indeed, economic growth also influences financial development.

In turn, there is a literature –albeit not as developed– that examines the influence of financial deepening on the volatility of the growth process. Here as well, theoretical contributions have identified mechanisms through which finance may influence volatility. In particular, by diversifying production risks, smoothing responses to liquidity shocks, contributing to the mobilization of savings –as precautionary reserves– and improving the stock of information, the efficient performance of the financial sector may diminish the volatility of output growth. Empirical contributions seem to support the theoretical predictions in this case as well.

The objective of this paper is to assess the influence of financial deepening on the rate and volatility of output growth in the cases of Mexico and the USA, using time series methods. The paper attempts to contribute to the existing empirical literature in two important aspects. First, it focuses on two closely interconnected but quite different economies in terms of economic and financial development.[1] Second, the paper investigates not only the relation between finance and the rate of growth but also the links between finance and the volatility of growth. While the former relation has been investigated, generally using Granger-causality tests, the later

[1] While the financial sector in the USA has been characterized by a high degree of development and penetration as well as a high level of competition along history, despite bank concentration at the state level in some periods, in the case of Mexico the formal financial system, even after public policies to the effect, has not been able to reach most of the population and the informal financial sector has thrived (Haber et al., 2008). High banking concentration and financial exclussion of large segments of the population still presist, as in most developing countries (CNVB, 2011; Demirgüç-Kunt and Klapper, 2012).

issue has not yet been investigated with time series methodologies, at the country level.

The methodological approach includes the following tasks. In the first place, unit root tests are carried out to determine if the variables do exhibit stochastic trends. Next, cointegration and Granger-causality tests between finance and real economic activity are implemented in the context of VAR models with integrated variables. Finally, the relation between measures of financial development and the volatility of growth is investigated using GARCH models. In all cases, diagnostic checks, particularly autocorrelation tests, are implemented to make sure that the estimated models are well specified.

We find that, in the case of the USA, financial deepening is positively related to the rate of economic growth but that it is not significantly related to the volatility of the growth process. In contrast, in the case of Mexico, economic growth appears to precede financial deepening, although we also find some evidence of a connection in the opposite direction. In any case, financial deepening seems to have a positive impact on growth by reducing volatility, since we find growth and growth volatility to be negatively related. Further, higher growth rates in the USA may result not only in higher growth rates in the Mexican economy —a fact that is well known— but also in a less volatile growth process which, in turn, favors rapid growth in Mexico. Thus, this paper explicitly identifies a *volatility channel* for output growth in Mexico, which has important implications for understanding the links between these two economies. To the best of our knowledge, this finding, on the effect of US growth on growth volatility in Mexico, is novel.

The remainder of the paper proceeds as follows. Section 2 reviews some related theoretical and empirical literature. Section 3 describes the time series methodology used in the study. Section 4 presents and discusses the empirical results. The main conclusions are summarized in Section 5.

2. THEORETICAL AND EMPIRICAL BACKGROUND

2.1 Financial Development and Economic Growth

Interest in the relation between financial institutions and economic growth is not new. Earlier, when exploring the role of institutions, Hamilton (1791) and Bagehot (1873) and then Schumpeter (1934) and Hicks (1969) had looked into this relation. Attention to the connection between finance and growth increased in the second half of the last century (Gurley and Shaw, 1955 and 1960; Cameron et al., 1967; Goldsmith, 1969; McKinnon, 1973 and 1976; Shaw, 1973).[2] These authors supported the view that financial development has a positive impact on economic growth. Others, however, have questioned the role of finance in economic growth and have claimed that financial deepening is a consequence, not a cause, of economic growth (Robinson, 1952; Lucas, 1988). Towards the end of the century, however, interest in identifying a positive influence of financial development on economic growth resurfaced. After offering a complete review of the theoretical literature, Levine (2004) concludes that, despite the diversity of approaches, there is wide support for the view that financial variables have a significant impact on economic growth.

There is as well an ambitious collection of empirical contributions in the literature. Levine (2004) offers, again, a complete review. These contributions use different techniques and methods: growth regressions for a cross-section of countries (Goldsmith, 1969; King and Levine, 1993; Levine and Zervos,

[2] As Levine (1997) highlights, the pioneers analyzed the role of finance in economic growth with models that formalized the financial sector solely in terms of money and introduced a distinction between the financial and real sectors of the economy. Nevertheless, as these more recent contributions have highlighted, the financial sector is *real*. Based on their approach, Fry (1988) examines several models of growth with money, including Kapur (1976), Galbis (1977), and Mathieson (1980) as well as the contributions of Spellman and of González-Vega, included in McKinnon (1976).

1998; La Porta et al., 1999; Levine, Loayza and Beck, 2000), time series analysis (Jung, 1986; Demetriades and Hussein, 1996; Arestis et al., 2001; Shan et al., 2001; Ang and McKibbin, 2007) and panel techniques (Levine, Loayza and Beck, 2000; Beck, Levine and Loayza, 2000; Loayza and Ranciere, 2002; Calderon and Liu, 2003; Christopoulus and Tsionas, 2004; Hassan et al., 2009). Some studies explore these issues at the industry or firm level (Rajan and Zingales, 1998; Ahlin and Jiang, 2005; Aghion, Fally, and Scarpeta, 2006).[3] More recently, Greenwood et al. (2010) show that most countries could have increased their output growth had they had a more efficient financial sector. In general, while most studies using cross-country and panel data techniques find that economies with a better performing financial sector achieve higher rates of growth, the empirical time series literature is more controversial, since it focuses on very specific cases.

A potential challenge for the empirical analysis is reverse causality; the level of economic activity and technological change may influence, in turn, financial development. On the one hand, innovations in telecommunications and data management have reduced transaction costs and have encouraged the development of new financial products (Merton, 1992; Gup, 2003). On the other hand, economic development encourages savers and investors to channel resources to the financial system (Greenwood and Jovanovic, 1990). Fung (2009) empirically explores the potential convergence of financial development and economic growth. Middle-income and high-income countries tend to converge, not only with respect to their per capita GDP but also with respect to financial deepening. Countries with low incomes but with a healthy financial development catch up with middle-income countries, while those countries that lack a well-performing financial system are caught in a poverty trap.

[3] Some contributions combine the influence of finance with other determinants of growth, such as legal regime, property rights and political pluralism (Hassan et al., 2009); remittances (Giuliano and Ruiz-Arranz, 2009); or even international integration (Masten et al., 2008).

2.2 Financial Development and Growth Volatility

The literature on financial development and growth volatility is based on any one of the functions performed by financial intermediaries (Levine, 1997 and 2004). Basically, three strands of research can be identified. The first, based on portfolio theory, argues that financial development implies the creation of different instruments for risk diversification, which would encourage growth and reduce uncertainty (Greenwood and Jovanovic, 1990; Levine, 1991; Saint-Paul, 1992; King and Levine, 1993; Devereux and Smith, 1994; Obstfeld, 1994; Acemoğlu and Ziliboti, 1997). A more efficient financial sector would be able to fund a larger number of high-productivity projects, despite their riskiness, and in this way it would reduce growth volatility. Aggregate risk declines through portfolio diversification, while the lower risk encourages investors and the higher productivity of the projects enhances economic growth.[4] In contrast, with limited portfolio diversification, there is greater uncertainty related to high-productivity projects and economic growth is slower.[5]

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[4] Nevertheless, some authors claim that financial development may reduce the rate of output growth (Pagano, 1993; Devereux and Smith, 1994). The reason is that, in reducing risk, portfolio diversification would allow agents to reduce their precautionary savings, which may decelerate economic growth (Mirman, 1971). If the effect of the reduction in the rate of savings on growth is stronger than the effect of the investment in more productive projects, due to diversification, the rate of growth may diminish. Which effect dominates will depend on the elasticity of intertemporal substitution.

[5] While the papers based on a portfolio approach predict that less developed countries tend to invest in more secure but less productive sectors, Koren and Tenreyro (2004) argue that poor countries concentrate their production in a few sectors but with high specific risk (agriculture), thus rejecting the trade-off between volatility and productivity. These authors show, empirically, that as countries develop, they tend to move to less volatile productive activities.

Some papers analyze this question in more detail. Acemoğlu and Ziliboti (1997) examine the variance of productivity, which may depend negatively or positively on the number of projects implemented in the economy, concluding that the variance only diminishes with financial development if the productivity of risky projects is high enough and the degree of indivisibility of the projects is also high. Along the same lines, Greenwood and Jovanovic (1990) find that the variance of growth rates depends positively on the rate of return of projects, the intertemporal discount factor, and the amount of funds available for investment. Again, these authors obtain the result that the higher the amount of funds available for investment, more projects are implemented and risk diminishes since the portfolio would be better diversified. Aghion, Banerjee, and Piketty (1999) develop a theoretical model and show that, by mobilizing savings and facilitating the creation of reserves, the financial sector allows the economy to better absorb shocks, particularly negative shocks. González-Vega and Villafani-Ibarnegaray (2007) show, however, that the procyclical behavior of credit portfolios depends on the credit technology used as well as the characteristics of producers.

There are a number of empirical investigations based on the portfolio approach. Easterly, Islam and Stiglitz (2000) discuss the importance of financial development on growth volatility. While price and wage rigidities have been advocated to explain output fluctuations, these authors defend the hypothesis that the degree of development of the financial sector determines the stability of the economy. However, greater access to financial markets also allows firms to increase their financial leverage, which may imply higher risks and greater volatility. In their empirical analysis, they conclude that the relation between volatility and financial development is not linear. Thus, although greater financial development may well reduce volatility initially, at more advanced levels rising financial activity may amplify the effect of shocks on the economy. Related to this result, using a dynamic panel data model, Kunieda (2008) shows that the effect of financial development on volatility is

concave; in the early development stages there is less output volatility, with additional development, volatility is greater, while with a mature financial sector volatility declines again.

The second strand of research focuses on the effects of information asymmetries and incomplete markets on output volatility. Some examples are Bernanke and Getler (1989), Greenwald and Stiglitz (1993), Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Edwards and Végh (1997), Bernanke, Gertler and Gilchrist (1999), Jaffee and Stiglitz (2000), De Meza and Webb (2006).These market failures may lead to credit rationing and inefficiencies that may reduce growth and increase volatility. Also, a reduction in the borrowers' financial capacity (the maximum overhang of past debt they may feasibly carry) could reinforce and propagate the effects of real and monetary shocks.[6] In this respect, Beck et al. (2006) find some evidence that financial intermediaries could magnify monetary shocks, particularly in countries where firms have very limited access to capital markets. In turn, Denizer et al. (2000) find that, while more developed financial sectors lead to fewer fluctuations in real output, the importance of banks in the system is most robust in explaining the reduction of the volatility of consumption and investment. Similarly, Dynan et al. (2005), Cecchetti et al. (2006) and Jalil (2009) find evidence that financial development reduces the volatility of economic growth.

The third strand of theoretical work starts with Aghion et al. (2004), who argue that due to various market imperfections and restrictions, financial markets become less effective to facilitate the absorption of aggregate shocks, which leads to higher growth volatility. Their empirical results for a panel of countries during the 1960-2000 period show that less financial development is associated with higher exposure to shocks and

[6] Some of these papers argue that the financial system was determinant in magnifying the Great Depression of 1929. In particular, the lack of confidence in financial institutions and the insolvency of debtors were determinants of the persistence and severity of the Great Depression.

greater negative effects of volatility on growth. Aghion and Banerjee (2005) consider the same model and conclude that in closed economies fluctuations are triggered by the interaction between credit restrictions and interest rates, while in open economies the source of instability is the interaction between the real exchange rate and interest rates. Farías (2007) shows that, in the case of developed countries, the volatility of investment is greater with incomplete financial markets.

Aghion et al. (2006) find that exchange rate volatility may have a significant effect on long-run productivity in the case of countries with lower levels of financial development. Also, Aghion and Marinescu (2006) argue that countercyclical fiscal policies have positive effects on productivity growth, particularly in countries with low degrees of financial development. Federici and Caprioli (2009) find that a high degree of financial development is critical for the existence of transmission effects among countries following credit crises.

Using a standard real business cycle model for an open economy, Özbilgin (2010) shows that financial development and market integration are associated with a greater volatility of investment and output. Mallick (2009) finds that the long-run variance of real GDP is affected by the degree of financial development. In turn, Aysan (2006) finds that greater volatility increases the costs associated with financial market imperfections and induces higher interest rates and higher costs of loans. This, in turn, leads enterprises not to choose the most productive technologies (because they become more expensive), which leads to lower rates of economic growth.[7]

There is also some literature about the effects of volatility itself on the rate of economic growth. While the empirical

[7] Some papers highlight the importance of factors such as the structure of the financial sector, type of development, institutional mechanisms and competitiveness, or even macroeconomic instability, which may influence growth and volatility. See, for example, Denizer et al. (2000), Cetorelli and Gambera (2001), Freeman (2002), Clarke (2004), Claessens and Laeven (2005), Beck et al. (2006), Dehejia et al. (2007), Garret et al. (2007) and Mitchener et al. (2010).

contributions (Aizenman and Marion, 1993; Ramey and Ramey, 1995; Blattman et al., 2004; Koren and Tenreyro, 2004; Aghion et al., 2004) find a negative correlation between volatility and growth, theoretical treatments claim that the connection may be either positive or negative. Jones et al. (2000) conclude that the sign of the relation between volatility and growth depends on two effects. On the one hand, greater volatility reduces the risk-adjusted returns on investment, thereby discouraging investment and growth. On the other hand, greater volatility increases precautionary savings, which might affect economic growth positively. The net effect depends on the value of the elasticity of intertemporal substitution. In contrast, Black (1987) shows that investment in more specialized and risky technologies may lead to higher but more volatile growth rates, thus implying a positive link between growth and volatility.

3. EMPIRICAL TIME SERIES APPROACH

3.1 Characterization of the variables

First, we characterize the dynamics of real output and the measures of financial development, both in levels and growth rates, by applying various unit root tests. This inspection is critical, in order to avoid potentially misleading inferences. We implement four unit root tests, namely, the augmented Dickey-Fuller (Dickey and Fuller, 1979, 1981), Dickey-Fuller GLS (Elliot, Rothenberg and Stock, 1996), PP (Phillips and Perron, 1988), MZt (Ng and Perron, 2001) and the KPSS (Kwiatkowsky, Phillips, Schmidt and Shin, 1992) tests. As is well known, the null hypothesis for the first four tests is that the process has a unit root, while the last test considers stationarity as the null hypothesis.

3.2 Granger-causality Testing

In order to examine the Granger-causality between real economic activity and finance, we specify the following bivariate VAR model:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \Sigma_{j=1}^{p} \boldsymbol{A}_j \begin{bmatrix} y_{t-j} \\ x_{t-j} \end{bmatrix} + \begin{bmatrix} u_{y,t} \\ u_{x,t} \end{bmatrix}, \quad (1)$$

where y and x are, respectively, the logarithms of real GDP and a measure of financial development.[8] The matrices $\boldsymbol{A}_j$ are 2×2 coefficient matrices where the coefficients $A_{12,j}$ capture the effect of financial development on real output, while the coefficients $A_{21,j}$ indicate the opposite effect, from real output to financial development. The terms $u_{y,t}$ and $u_{x,t}$ are random shocks that satisfy the conventional assumptions of zero mean, constant variance and constant contemporaneous covariance.[9] The subindex $j = 1,2...,p$ indicates the number of lags. Given that these variables are likely to show stochastic trends, we follow the approach proposed by Lütkepohl and Reimers (1992), for the case of bivariate VAR models with *I(1)* variables. Thus, specification 1 can be rewritten in VEC form as:

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \Sigma_{j=1}^{p-1} \boldsymbol{\Gamma}_j \begin{bmatrix} \Delta y_{t-j} \\ \Delta x_{t-j} \end{bmatrix} + \boldsymbol{\Pi} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{y,t} \\ u_{x,t} \end{bmatrix}, \quad (2)$$

where the matrices $\boldsymbol{\Gamma}_j$ and $\boldsymbol{\Pi}$ are linear combinations of the A_j matrices defined in 1. Let r be the rank of $\boldsymbol{\Pi}$. For these purposes, Lütkepohl and Reimers (1992) establish that if $r = 1$ o 2, Granger non-causality from x to y, with the null hypothesis $A_{12,1} = A_{12,2} = ... = A_{12,p-1}$ in system 1, can be tested by means of a Wald test, which has an asymptotic Chi-squared distribution.[10]

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[8] We use the ratios of domestic credit, credit supplied by the banking sector, and money supply (M2 and M3), all in nominal terms, to nominal GDP, as indicators of financial development.

[9] It is tempting to consider other variables in the vector. However, in the absence of a well-structured model, we focus on just these two variables. In this way, the focus is on the bivariate marginal or unconditional distribution of real economic activity and indicators of financial development.

[10] If $r = 2$, the system becomes a *VAR(p)* in levels, as in Equation 1; while if $r = 1$, the system must be modelled as a *VEC(p−1)*

For the case when $r = 0$ (no cointegration), non-causality can be tested using results from the *VAR (p–1)* model in first differences given by Equation 2, with $\Pi = 0$. In this case, the Wald-test for the null hypothesis $\Gamma_{12,1} = \Gamma_{12,2} = \ldots = \Gamma_{12,p-1} = 0$ follows a $\chi^2_{(p-1)}$ distribution. The reverse causality can be evaluated in a similar way.

The rank r is determined using Jonhansen's (1988, 1991) trace and maximum eigenvalue tests. Following proposition 8.1 in Lütkepohl (2005), the number of lags p is determined using the Schwarz (SC) and Hannan-Quin (HQ) criteria, which are consistent in the previous setting.

3.3 A Time Series Model of Growth and Volatility

In order to evaluate the dynamics of growth and its volatility, we specify the following time series model with GARCH-in-mean effects:

$$\Delta y_t = \beta_0 + \beta_1 \Delta y_{t-1} + \phi \sigma^2_{y,t} + u_{y,t} + \theta_1 u_{y,t-1} \quad (3)$$

$$\sigma^2_{y,t} = \alpha + \gamma \sigma^2_{y,t-1} + \delta u^2_{y,t-1} + \xi D_t + \psi \Delta y_{t-1} + \varphi \Delta x_{t-1} \quad (4)$$

Equation 3 models output growth as an *ARMA (1,1)* process, augmented by a GARCH-in-mean effect (ϕ), which attempts to capture the effect of growth volatility on the rate of output growth. This specification is justified both on theoretical and empirical grounds. Theoretically, Campbell (1994) shows that, under certain assumptions, a stochastic growth model implies an *ARMA (2,1)* process for output (in logarithms). Thus, the first difference of the previous process, which is the growth rate of output, can be modeled as an *ARMA (1,1)* process.[11] In turn, from time series theory, it is well known that an invertible *MA* process is equivalent to an *AR* process of infinite order and,

model, as in Equation 2.

[11] Assuming, for example, that the persistence parameter of the technology shock process equals one.

therefore, empirically, an *ARMA (1,1)* process can approximate a relatively large *AR* process in a very efficient way.[12] In practice, it is important to show that the estimated residuals from Equation 3 do not display any significant autocorrelation pattern, thus avoiding spurious ARCH effects due to misspecification.

Equation 4 specifies the conditional variance of $u_{y,t}$ as a GARCH (1, 1) process and characterizes the dynamics of growth volatility.[13] The parameter φ captures the effect of financial development on the volatility of real GDP growth and ψ measures the feedback effect from growth to its own volatility. The variables Δy_{t-1} and Δx_{t-1} refer to the first lag of real GDP growth and the growth rate of a measure of financial development, respectively. Also, D_t is an indicator variable that takes the value of 1 if $u_{y,t-1} < 0$ and zero otherwise; thus, ξ is an asymmetry parameter. The error term is allowed to follow the generalized error distribution.[14]

The time series model given by Equations 3 and 4 is chosen for two main reasons. First, as it will be shown in the next section, the evidence on cointegration between real economic growth and measures of financial development is not strong, particularly in the case of Mexico; therefore, econometrically, it is reasonable and safer to formulate a model in terms of growth rates instead of levels. Second, most measures of financial development, despite their variability, do not exhibit time-varying volatility, making it impossible to use the well-known class of bivariate GARCH models.[15]

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[12] Schwert (1987) shows that there are compelling reasons to model economic time series as ARIMA processes and that, in practice, these processes fit the data well.

[13] It is worth mentioning that this class of models was initiated with the pioneering work by Engle (1982) and Bollerslev (1986).

[14] This distribution, which is more general than the normal distribution, was proposed by Nelson (1991). It is normalized to have zero mean and unit variance and can accommodate virtually any degree of kurtosis present in the data. Particular cases of this distribution are the normal distribution and the so-called double exponential distribution.

[15] Preliminarily, the dynamics of real GDP growth as well as the

In the case of Mexico, both the growth and volatility equations include the contemporaneous growth rate of USA. Namely, they are specified as:

$$\Delta y_t = \beta_0 + \beta_1 \Delta y_{t-1} + \omega \Delta y_t^{US} + \phi \sigma_{y,t}^2 + \theta_1 u_{y,t-1} \quad \text{3a}$$

$$\sigma_{y,t}^2 = \alpha + \gamma \sigma_{y,t-1}^2 + \delta u_{y,t-1}^2 + \xi D_t + \psi \Delta y_{t-1} + \varphi \Delta x_{t-1} + \zeta \Delta y_t^{US}. \quad \text{4a}$$

Thus, the growth of the US economy (Δy^{US}) is allowed to influence both the mean and the volatility of Mexico's growth process. It is well known that the effect of US growth on Mexican growth is positive ($\omega > 0$). For the effect of US growth on Mexico's growth volatility, a plausible hypothesis is that $\zeta < 0$, which may also be justified by the fact that Mexico's growth rate depends highly and positively on economic growth in its northern neighbor.

A reduction of growth in the USA is, undeniably, bad news for Mexico's future economic performance. This, in turn, increases uncertainty in the decision-making of Mexican economic agents, particularly but not exclusively about consumption and investment, thus inducing greater uncertainty about Mexican growth. Two possible mechanisms for this influence are exports to and remittances from USA, which are directly linked to economic performance in USA.[16]

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measures of financial development are characterized as *AR* processes and the possibility of volatility patterns over time is evaluated by means of LM tests. ARCH effects were found only for the growth of real GDP processes but not for the financial development measures. One exception was the growth of the ratio domestic credit to GDP (GDCRGDP) in the case of the USA.

[16] It should be noticed that inclusion of the extra regressors Δy_{t-1} and Δx_{t-1} in Equation 4, and $\Delta y_{t-1}, \Delta x_{t-1}$ and Δy_t^{US} in Equation 4a might result in negative values of the conditional variance. However, in the present case this problem does not arise.

4. EMPIRICAL RESULTS

4.1 Data Sources and Variables

We use quarterly data from the International Monetary Fund's *International Financial Statistics*. The data are available for 1957Q03-2016Q02 period for USA and for 1986Q02-2016Q01 period for Mexico. The primary variables are nominal domestic credit (NDCR), nominal credit supplied by the banking sector (CPBS), nominal money supply (M2 and M3), nominal gross domestic product (NGDP) and the GDP implicit deflator (GDPID).[17] With these variables, we construct four financial indicators and one measure of real activity, as shown in Table 1.

In the related empirical literature, the indicators DCRGDP and BSCGDP are considered measures of credit deepening, while M2GDP and M3GDP are referred to as money deepening. All of them are accepted measures of financial development. The growth rates of all variables are annualized percentages.

4.2 Unit Root Testing Results

Table A.1, in the Appendix, shows the unit root testing results. For the USA, there is strong evidence that all variables in levels (logarithms) are consistent with unit root processes. In addition, except in the cases of the BSCGDP (MZt test) and the DCRGDP (DF-GLS and MZt tests) measures, the results indicate that the growth rates of all variables are consistent with stationary processes. Thus, we may conclude that all variables in levels may be characterized as $I(1)$ processes.

In the case of Mexico, there is wide support for the unit root hypothesis for all variables in levels, although this is not the case for the first differences since, in various instances, the tests do not support stationarity, as expected. This is particularly

[17] In the case of Mexico, the information for NDCR and CPBS is only available for the 1997Q03-2016Q01 period and in the case of the USA, M2 and M3 are only available for the 1959Q03-2016Q02 period.

Table 1

DEFINITION OF VARIABLES

Levels		*Growth rates*	
Name	*Definition*	*Name*	*Definition*
RGDP	$\ln\left(\frac{NGDP}{GDPID}\right)$	GRGDP	$\Delta\ln\left(\frac{NGDP}{GDPID}\right)\times 400$
DCRGDP	$\ln\left(\frac{NDCR}{NGDP}\right)$	GDCRGDP	$\Delta\ln\left(\frac{NDCR}{NGDP}\right)\times 400$
BSCGDP	$\ln\left(\frac{CPBS}{NGDP}\right)$	GBSCGDP	$\Delta\ln\left(\frac{CPBS}{NGDP}\right)\times 400$
M2GDP	$\ln\left(\frac{M2}{NGDP}\right)$	GM2GDP	$\Delta\ln\left(\frac{M2}{NGDP}\right)\times 400$
M3GDP	$\ln\left(\frac{M3}{NGDP}\right)$	GM3GDP	$\Delta\ln\left(\frac{M3}{NGDP}\right)\times 400$

All variables are expressed in natural logarithms *ln* and Δ is the first-difference operator. All ratios are calculated using nominal values.

notorious in the case of the MZt test, which indicates that all variables are nonstationary in first differences.[18] Fortunately, in most cases, the alternative unit root tests reject the unit root hypothesis for the first differences and the KPSS test cannot reject the null hypothesis of stationarity of the first differences at the 5% level of significance, for all variables.

[18] These results are contradictory and they might be explained by the small sample sizes and the likely seasonal effects present in the data.

4.3 Granger-causality between Growth and Financial Deepening

Table 2 reports the results of the Granger-causality tests, based on VAR estimation results. For each case, the lag order corresponds to the Schwarz or Hannan-Quinn criteria, whichever is higher. The lag orders as well as the cointegration ranks, obtained using Johansen's trace and maximum eigenvalue tests, are shown in the Appendix, Table A.2. For practical reasons, the Granger-causality tests are performed for all ranks *(r = 2,1,0)*, following the methodology outlined in section 3.2.[19] As shown in Table 2, in the case of the USA, in several cases the results reject the hypothesis of Granger non-causality from the indicators of financial development to real GDP. However, the results confirm the hypothesis of Granger non-causality from real GDP to financial development. This is not surprising, given the mature stage of development already present in the US financial system and the importance of the equity and other markets beyond money and credit.

In the case of Mexico, the hypothesis of non-causality from the indicators of financial development to real GDP is also rejected, but in fewer cases (for M2 and M3 but not for the credit indicators); while the hypothesis of non-causality from real GDP to financial development is rejected in several cases. Thus, in contrast to the results obtained for the USA, in the case of Mexico the stronger direction of causality seems to go from real GDP to financial development. While these results might appear to support mostly the views of Robinson (1952) and Lucas (1988), in the case of Mexico, where the ratio of credit

[19] The first case ($r = 2$) implies that the variables are stationary in levels and so the testing is carried out using estimation results from a $VAR(p)$ in levels. The second case ($r = 1$) implies that the variables are $I(1)$ but they are cointegrated, so Granger non-causality is tested using a VEC model with $(p-1)$ lagged differences. The third case ($r = 0$) implies that the variables are $I(1)$ but they are not cointegrated, so Granger non-causality is tested in a $VAR(p-1)$ in first differences.

granted to the private sector to the GDP has been particularly low, market failures and distorting policies might have muted the potential influence of finance on growth, an issue that is not explored here. Similar results are, however, reported by Ang and McKibbin (2007) for the case of Malaysia and by Hassan et al. (2011) for the Sub-Saharan Africa and East Asia-Pacific regions.

4.4 Financial Deepening and the Volatility of Growth

Tables 3 and 4 show the estimation results of the model described in Section 3.3, for the cases of the USA and Mexico, respectively. A few remarks are warranted. First, the time spans are not the same in both cases; approximately, the number of observations for the USA doubles that of Mexico. Thus, in the Mexican case, the econometric results may not be as robust or reliable as in the case of the USA. Second, in the case of Mexico, the data showed marked seasonality and, therefore, seasonal dummies were included in the estimation. Third, in both cases, the asymmetry parameter ξ was not statistically significant and so we excluded it from all estimations. Finally, in all cases, after estimating the full model, we examined the correlograms of standardized residuals and their squares and found no evidence of autocorrelation. Therefore, the estimated models can be considered well specified. [20]

As shown in Table 3, the estimation results for the USA are quite similar in all the cases considered. First, the *ARMA(1,1)* representation for the growth process seems adequate. Also, the GARCH-in-mean parameter ϕ is not statistically significant in all cases, implying that growth volatility does not affect the growth rate of output. This result is consistent with the view

[20] Also, in both cases, we carried out LM tests to make sure that the residuals of the proposed growth equation did not exhibit any significant (at the 5% or better) autocorrelation patterns and, at the same time, they showed ARCH effects. The results are shown in Table A.3 in the Appendix.

Table 2

GRANGER NON-CAUSALITY TESTS

Granger non-causality		*Rank equal to 2*		*Rank equal to 1*		*Rank equal to 0*	
from:	*to:*	*T, L*	*W test*	*T, L*	*W test*	*T, L*	*W test*
				USA (1957Q01-2016Q02)			
DCRGDP	REALGDP	235.2	4.99 (0.0825)	235.1	4.19[a] (0.0406)	235.1	12.47[a] (0.0004)
REALGDP	DCRGDP	235.2	3.46 (0.1774)	235.1	1.66 (0.1972)	235.1	1.16 (0.2813)
BSCGDP	REALGDP	235.2	6.57[a] (0.0374)	235.1	3.29 (0.0697)	235.1	10.64[a] (0.0011)
REALGDP	BSCGDP	235.2	2.46 (0.2923)	235.1	0.61 (0.4332)	235.1	0.17 (0.6807)
M2GDP	REALGDP	227.2	4.79 (0.0914)	227.1	2.43 (0.1188)	227.1	10.38[a] (0.0013)
REALGDP	M2GDP	227.2	2.23 (0.3281)	227.1	0.78 (0.3775)	227.1	0.04 (0.8331)
M3GDP	REALGDP	222.2	8.04[a] (0.0180)	222.1	4.13[a] (0.0422)	222.1	13.06[a] (0.0003)
REALGDP	M3GDP	222.2	3.19 (0.2028)	222.1	2.76 (0.0967)	222.1	0.32 (0.5707)

Mexico (1981Q01-2016Q01)							
DCRGDP	REALGDP	74.3	4.36 (0.2252)	74.2	3.49 (0.1748)	74.2	1.45 (0.4845)
REALGDP	DCRGDP	74.3	24.73[a] (0.0000)	74.2	15.11[a] (0.0005)	74.2	16.64[a] (0.0002)
BSCGDP	REALGDP	74.3	5.31 (0.1507)	74.2	1.22 (0.5436)	74.2	2.55 (0.2798)
REALGDP	BSCGDP	74.3	15.66[a] (0.0087)	74.2	5.29 (0.0709)	74.2	11.29[a] (0.0035)
M2GDP	REALGDP	115.7	14.63[a] (0.0410)	115.6	8.41 (0.2097)	115.6	9.76 (0.1353)
REALGDP	M2GDP	115.7	12.32 (0.0906)	115.6	5.75 (0.4521)	115.6	15.23[a] (0.0186)
M3GDP	REALGDP	117.5	15.58[a] (0.0082)	117.4	7.06 (0.1327)	117.4	4.77 (0.3114)
REALGDP	M3GDP	117.5	18.11[a] (0.0028)	117.4	5.30 (0.2581)	117.4	12.81[a] (0.0122)

Note: The tests for the case of rank 2 use estimation results from a VAR in levels while the tests for the case of rank 0 are based on estimation results of the VAR in first differences. In the case of rank 1, the tests are based on a VEC model. T and L indicate, respectively, the number of observations and lag order in each case. The Wald test for Granger non-causality is denoted by W-test. In all cases, the W-test has L degrees of freedom.

[a] The W-test is significant at the 5% or better. For the case of Mexico, seasonal dummies were included.

Table 3

GARCH-M ESTIMATION RESULTS FOR UNITED STATES

	Case 1		*Case 2*		*Case 3*		*Case 4*	
	GREALGDP and GDCRGDP		*GREALGDP and GBSCGDP*		*GREALGDP and GM2GDP*		*GREALGDP and GM3GDP*	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
				Conditional mean				
Cons.	1.02[b] (0.01)	0.30 (0.60)	1.06[b] (0.01)	1.04 (0.12)	0.95[b] (0.02)	0.87 (0.18)	1.03[b] (0.02)	1.08 (0.12)
AR(1)	0.65[c] (0.00)	0.65[c] (0.00)	0.65[c] (0.00)	0.65[c] (0.00)	0.67[c] (0.00)	0.67[c] (0.00)	0.66[c] (0.00)	0.66[c] (0.00)
MA(1)	–0.37[b] (0.02)	–0.36[b] (0.03)	–0.37[b] (0.03)	–0.37[b] (0.03)	–0.40[b] (0.01)	–0.40[b] (0.01)	–0.39[b] (0.02)	–0.39[b] (0.02)
ϕ	n. a.	0.24 (0.14)	n. a.	–0.00 (0.98)	n. a.	0.03 (0.86)	n. a.	–0.02 (0.93)
				Conditional variance				
Cons.	0.90 (0.21)	0.57 (0.30)	1.05 (0.17)	1.04 (0.17)	0.97 (0.21)	0.93 (0.22)	1.16 (0.18)	1.18 (0.18)

ARCH (1)	0.20[b] (0.02)	0.17[b] (0.02)	0.18[b] (0.03)	0.18[b] (0.03)	0.21[b] (0.02)	0.20[b] (0.02)	0.21[b] (0.02)	0.21[b] (0.02)
GARCH (1)	0.73[c] (0.00)	0.78[c] (0.00)	0.74[c] (0.00)	0.74[c] (0.00)	0.72[c] (0.00)	0.73[c] (0.00)	0.71[c] (0.00)	0.71[c] (0.00)
ψ	–0.06 (0.78)	–0.06 (0.74)	–0.03 (0.87)	–0.03 (0.87)	–0.07 (0.73)	–0.06 (0.76)	–0.10 (0.65)	–0.10 (0.63)
φ	–0.01 (0.92)	0.06 (0.44)	–0.07 (0.46)	–0.07 (0.47)	0.00 (0.98)	0.00 (0.99)	0.00 (0.98)	0.00 (0.99)
Adj-R^2	0.12	0.11	0.12	0.11	0.10	0.10	0.10	0.10
Log L	–590.25	–589.79	–589.90	–589.90	–562.99	–562.98	–553.99	–553.98
Observations	236	236	236	236	228	228	223	223

All models were estimated by maximum likelihood using the numerical optimization algorithm Marquardt, with the software Eviews 9. For each model, columns *a* and *b* refer to estimation results of the models without and with GARCH-in-mean effects respectively. Numbers in parenthesis are *p*-values. The conditional mean equation was specified as an *ARMA (1,1)*. [a], [b], [c] indicate significance levels at the 10%, 5% and 1% levels, respectively.

that the likely effects of growth volatility on risk-adjusted investment returns and precautionary savings cancel out. Alternatively, Black's (1987) hypothesis that higher volatility may be positively related to the average growth rates of the economy is not confirmed by these data.

For the conditional variance process, the results show significant ARCH and GARCH coefficients. Growth volatility in USA is a highly persistent process but stationary, since the sum of the ARCH and GARCH parameters is close to unity (about 0.93 on average). We also find that $\psi < 0$. This may imply that more rapid growth in the US economy tends to reduce its volatility, although this result is not statistically significant.

As for the effect of finance on growth volatility, in the case of USA we find some positive and negative values for the parameter φ, but in all the estimated models they are not statistically significant. Thus, we may conclude that finance and growth volatility are unrelated in this country.

The results for Mexico are shown in Table 4. For the conditional mean process, we find that Mexico's output growth is well approximated by an *ARMA* (1,1) and that seasonal effects are present in the data. More importantly, output growth is positively related to the growth rate of the US economy; the result that $\omega > 0$ is significant and quite robust. It reflects the well-known fact that Mexico's growth is highly dependent on US growth. In addition, we find that $\phi < 0$ and that it is significant in three out of the four estimations.

Thus, in the case of Mexico, greater growth volatility is detrimental for the growth process, in contrast with the USA, where we found no effect. A plausible interpretation of this result is that the negative effect of greater growth volatility on investment–through the need for higher risk-adjusted returns–dominates its positive effect on the accumulation of precautionary savings, particularly in view of the large role that the Mexican government has played as insurer of last resort, thereby discouraging deposit mobilization.

Although growth volatility in Mexico seems to be less persistent than in the USA, the growth process in Mexico is by far

more volatile than in the USA. This result is implied by the very high and statistically significant constant parameter in the conditional variance process for Mexico. This may reflect, in part, the smaller size and lesser opportunities for diversification of the Mexican economy, compared to the USA.

In a couple cases, we find that the parameter ψ is statistically significant at the 10% significance level. This implies that changes in growth rates of real GDP may affect the predictability of this process, though this effect is neither strong nor robust; in other words, there is some weak evidence on feedback effects from output growth to the volatility of growth.

As far as the effect of financial development on the volatility of growth, captured by the parameter φ, in the cases related to the money deepening measures, M2 and M3, we find that this parameter is negative and statistically significant. This suggests that financial development may reduce Mexico's growth volatility.

Interestingly, the findings of $\varphi < 0$ and $\phi < 0$ taken together imply a positive effect from financial development to economic growth through the volatility channel: That is, greater financial development–measured as money deepening–reduces the volatility of growth which, in turn, leads to higher output growth.

Finally, we find that the growth rate of the USA may affect Mexico's growth through the volatility channel, since we find the result $\zeta < 0$ to be significant in some cases. This result suggests that the volatility of growth in Mexico may depend on the economic performance of the USA. Thus, we find some evidence that higher growth rates in the USA reduce Mexico's growth volatility and, given the negative relation between growth volatility and growth rates, this would lead to more rapid growth in Mexico.

Table 4

GARCH-M ESTIMATION RESULTS FOR MEXICO

	Case 1		*Case 2*		*Case 3*		*Case 4*	
	GREALGDP and GDCRGDP		*GREALGDP and GBSCGDP*		*GREALGDP and GM2GDP*		*GREALGDP and GM3GDP*	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
				Conditional mean				
Cons.	−10.4[c] (0.00)	−6.3[b] (0.03)	−11.9[c] (0.00)	−9.8[c] (0.00)	−14.2[c] (0.00)	−8.1[b] (0.02)	−14.6[c] (0.00)	−6.0 (0.11)
MA(1)	−0.67[c] (0.00)	−0.58[c] (0.00)	−0.66[c] (0.00)	−0.62[c] (0.00)	−0.58[c] (0.00)	−0.60[c] (0.00)	−0.58[c] (0.00)	−0.58[c] (0.00)
SD(2)	16.5[c] (0.00)	21.7[c] (0.00)	20.6[c] (0.00)	22.2[c] (0.00)	24.8[c] (0.00)	26.0[c] (0.00)	25.4[c] (0.00)	26.6[c] (0.00)
SD(4)	24.7[c] (0.00)	28.1[c] (0.00)	27.7[c] (0.00)	29.4[c] (0.00)	32.8[c] (0.00)	34.2[c] (0.00)	33.2[c] (0.00)	33.8[c] (0.00)
ϕ	n. a.	−0.73[c] (0.00)	n. a.	−0.34 (0.13)	n. a.	−0.67[b] (0.05)	n. a.	−0.96[b] (0.01)
ω	1.18[c] (0.00)	0.76[c] (0.00)	1.07[c] (0.00)	0.95[c] (0.00)	0.92[c] (0.00)	0.85[c] (0.00)	0.93 (0.00)	0.75[c] (0.00)
				Conditional variance				
Cons.	20.2 (0.20)	41.4[c] (0.00)	39.5 (0.14)	46.9[b] (0.02)	96.2[b] (0.02)	63.6[b] (0.03)	104.8[b] (0.02)	47.2[c] (0.00)

	Case 1		*Case 2*		*Case 3*		*Case 4*	
	GREALGDP and GDCRGDP		*GREALGDP and GBSCGDP*		*GREALGDP and GM2GDP*		*GREALGDP and GM3GDP*	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
ARCH (1)	0.03 (0.86)	−0.12[b] (0.03)	−0.14 (0.17)	−0.17[c] (0.00)	0.03 (0.78)	0.03 (0.68)	0.02 (0.88)	−0.01 (0.82)
GARCH (1)	0.73[b] (0.01)	0.68[c] (0.00)	0.66[b] (0.05)	0.65[c] (0.00)	0.19 (0.57)	0.43 (0.11)	0.14 (0.70)	0.61[c] (0.00)
ψ	1.53 (0.14)	0.28 (0.77)	0.92 (0.55)	0.29 (0.83)	−1.31 (0.16)	−1.63[a] (0.06)	−1.19 (0.20)	−1.16[a] (0.05)
φ	0.15 (0.76)	−0.28 (0.52)	0.32 (0.71)	0.08 (0.93)	−1.95[a] (0.06)	−1.76[b] (0.04)	−2.01[a] (0.10)	−1.49[c] (0.00)
ζ	−5.05[b] (0.01)	−7.63[c] (0.00)	−6.64 (0.06)	−7.45[a] (0.05)	−9.14 (0.11)	−4.63 (0.2691)	−9.53 (0.12)	−3.96 (0.16)
Adj-R^2	0.68	0.66	0.67	0.66	0.70	0.70	0.70	0.68
Log L	−251.2	−249.9	−252.9	−250.3	−426.7	−424.1	−426.8	−423.8
Obs.	75	75	75	75	120	120	120	120

All models were estimated by maximum likelihood using the numerical optimization algorithm Marquardt, with the software Eviews 9. For each model, columns *a* and *b* refer to estimation results of the models without and with GARCH-in-mean effects respectively. Numbers in parenthesis are *p*-values. The mean equation was specified, originally, as an *ARMA (1, 1)* but the *AR* parameter resulted not significant and, therefore, it was excluded. In all cases, based on a preliminary estimation, seasonal dummies (*SD*) for the quarters 2 and 4 were included and they kept highly significant. [a], [b], [c] indicate significance levels at the 10%, 5% and 1% respectively.

5. CONCLUSIONS

Using time series methods, in this paper we empirically investigate the effects of financial development on the growth of real GDP and on its volatility, in the cases of Mexico and the USA. The paper also explores the possible effect of output growth in the USA on the volatility of the Mexican output growth, a channel that is worth investigating, given the enormous influence of the US economy on Mexico's economic performance.

The Granger-causality tests suggest that, in the case of the USA, financial development positively influences economic growth, but we find no evidence that this relation occurs in the opposite direction. The results for Mexico, however, provide some support for bidirectional causality; that is, there is a relation from economic growth to finance as well as from finance to economic growth, although the former is stronger than the later, at least for the shorter period examined.

Results from the time series model relating growth and volatility suggest that, in the case of the USA, financial development (money and credit deepening) does not affect the volatility of growth and that such volatility is unrelated as well to output growth. In the case of Mexico, however, the growth of the financial sector–particularly money deepening–seems to have a positive influence on economic growth, by reducing the volatility of output growth. Finally, more rapid growth in USA not only positively influences Mexico's growth directly, a fact that is well known, but also indirectly, by reducing growth volatility in Mexico. Thus, the performance of the US economy continues to be, through several channels, critical for the pace and stability of growth in Mexico.

Overall, these results suggest that Mexico is far from achieving its potential for more rapid and more stable output growth, unless–among other determinants–it fosters the development of a financial sector capable of promoting growth more widely and deeply. Further investigation, both theoretical and empirical, will be necessary to identify the specific channels and mechanisms through which these impacts may occur and the appropriate policies to encourage financial deepening.

APPENDIX

Table A.1

UNIT ROOT TESTS

Test	*REALGDP*	*DCRGDP*	*BSCGDP*	*M2GDP*	*M3GDP*
			United States (1957Q01-2016Q02)		
ADF	−1.060	−1.297	−0.406	−1.117	−0.984
	−7.655[a]	−16.454[a]	−15.587[a]	−5.323[a]	−10.151[a]
DF-GLS	3.910	2.176	2.247	−1.284	−1.113
	−5.238[a]	−1.262	−2.067[b]	−3.229[a]	−5.268[a]
PP	−0.974	−1.313	−0.401	−0.670	−0.987
	−10.936[a]	−16.425[a]	−15.596[a]	−13.114[a]	−10.185[a]
MZT	4.547	2.234	2.297	−1.485	−1.139
	−4.693[a]	−0.996	−1.505	−2.493[b]	−4.713[a]
KPSS	2.074[a]	1.988[a]	1.988[a]	0.481[b]	0.604[b]
	0.410[c]	0.148	0.087	0.313	0.278
			Mexico (1981Q01-2016Q01)		
ADF	1.527	−0.460	0.281	0.152	0.044
	−3.417[b]	−2.415	−3.297[b]	−6.966[a]	−4.580[a]
DF-GLS	2.061	−0.701	0.064	1.109	1.290
	−0.549	−1.510	−2.223[b]	−2.130[b]	−2.175[b]
PP	−0.010	0.440	0.490	−0.652	−0.227
	−22.577[a]	−8.201[a]	−10.415[a]	−13.536[a]	−12.845[a]
MZT	3.425	−1.171	−0.140	1.244	1.529
	1.306	−0.627	−0.967	−1.527	−1.602
KPSS	1.416[a]	0.698[b]	0.846[a]	1.299[a]	1.229[a]
	0.045	0.436[c]	0.389[c]	0.040	0.074

Note: For each test two entries are displayed. The first shows results for the level of the variables (in logarithms) and the second entry shows the results for the growth rates. The null hypothesis for the ADF, DF-GLS, PP and MZt tests is that the series has a unit root, while the null for the KPSS test is that the series is stationary. In all cases the test equation includes an intercept. For the first four tests the number of lags was determined using the Schwarz information criterion. The symbols [a], [b] and [c] indicate significance levels at the 1%, 5% and 10% respectively.

Table A.2

VAR LAG ORDER AND COINTEGRATION RANK

			Lag order		*Cointegration rank*	
Variables in VAR	*No. of obs.*	*Seasonal dummies*	*SC*	*HQ*	*Tr*	*Max λ*
United States (1957Q01-2016Q02)						
REALGDP,DCRGDP	225	Yes	2	2	(0,0)	(0,0)
REALGDP,BSCGDP	225	Yes	2	2	(1,1)	(1,1)
REALGDP, M2GDP	217	Yes	2	2	(0,0)	(0,0)
REALGDP,M3GDP	212	No	2	2	(1,1)	(1,1)
Mexico (1981Q01-2016Q01)						
REALGDP,DCRGDP	65	Yes	1	3	(1,1)	(1,1)
REALGDP,BSCGDP	65	Yes	1	3	(1,1)	(1,1)
REALGDP,M2GDP	110	Yes	1	7	(1,0)	(1,0)
REALGDP,M3GDP	110	Yes	1	5	(1,1)	(1,1)

The lag orders correspond to the Schwarz criterion (SC) and Hannan-Quinn criterion (HQ), which are both consistent in this setting. The cointegration rank is determined using Johansen´s trace (Tr) and maximum eigenvalue (Max λ) tests. In all cases, the VEC model allows for an intercept in the cointegration relation and no trends in the variables. Two values are displayed for each test and they are obtained using the number of lags given by the SC and HQ criteria respectively.

Table A.3

LM TESTS FOR RESIDUAL AUTOCORRELATION (AR) AND ARCH EFFECTS

	United States		*Mexico*	
Lag	*AR*	*ARCH*	*AR*	*ARCH*
1	0.03 (0.87)	3.74 (0.05)[b]	0.06 (0.80)	14.46 (0.00)[a]
2	0.66 (0.72)	12.54 (0.00)[a]	0.18 (0.91)	14.38 (0.00)[a]
4	1.56 (0.82)	17.22 (0.00)[a]	2.38 (0.67)	17.13 (0.00)[a]
8	7.63 (0.47)	22.26 (0.00)[a]	6.38 (0.60)	92.91 (0.00)[a]
12	13.70 (0.32)	26.84 (0.01)[a]	11.09 (0.52)	19.66 (0.07)[c]

The growth process was modeled as *ARMA (1,1)* solely, without GARCH effects. Specifically Equations 3 and 3a were fitted to output growth of the USA and Mexico, respectively. In the case of Mexico the *AR* term was excluded since it resulted not significant; also, seasonal dummy variables for quarters 2 and 4 were included in this case. As usual, [a], [b], [c] indicate significance levels at the 10%, 5% and 1%, respectively. In both cases, the errors of the growth equation are free of auto-correlation even at lag 12th and yet there is overwhelming evidence on ARCH effects.

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What Is the Role of Size in Latin American Banks' Performance in Response to External Shocks?

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Abstract

Are there differences in the performance of Latin American banks when facing external financial shocks? Could larger size be associated with a better performance? The main results of this empirical study reveal that an adverse external shock allows larger sized banks to avoid reductions in deposits and improve their profitability. The increase in profitability takes place despite a temporary loss in operating efficiency and a generalized reduction in lending, meaning that it is attributable to non-intermediation activities. Such gains seem to partly occur in response to a better leveraging of local currency depreciations in investment strategies. Nevertheless, the improved profitability of large banks does not translate into greater stability. The external shock also induces greater accumulation of liquid assets and a reallocation of resources toward mortgage credit for large banks. One possible interpretation of results points to the need of refocusing the policy debate on the role of bank intermediation and the arrangements for encouraging it.

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1. INTRODUCTION

In the wake of the subprime mortgage crisis, one topic of interest in the debate has been the vulnerability of advanced and emerging financial markets to external shocks. Significant falls in credit, leverage, and profitability have been identified as some of the triggers of systemic financial instability in those markets (Demirgüc-Kunt et al., 2006; Adrian and Shin, 2010; Duttagupta and Cashin, 2011). Moreover, the assumption that large banks are subject to problems of moral hazard that distort their adherence to market discipline have highlighted the importance of analyzing how bank size might determine their performance during crises. Although this discussion is not new, the theoretical and empirical results of the related research have not been fully conclusive.

There is a substantial amount of literature linking financial stability to bank size. Some papers review how high bank concentration, possibly generated by the appearance of large banks, encourages greater risk taking by borrowers given the high-interest rates that tend to prevail in less competitive markets (Boyd and De Nicoló, 2005). It has also been argued that lower competition in banking markets leads to more bank defaults as a result of the reduced diversification in their portfolios, making those banks more vulnerable to market shocks (Anginer et al., 2014). In other cases, given the incentives that large banks face in regulatory and bailout frameworks due to the moral hazard issues, it is assumed that these banks make riskier investing decisions (Siegert and Willinson, 2015).[1]

[1] However, the literature does not completely dismiss the potential advantages associated with the coexistence of a few banks with large participations. It is possible to mention the arguments of Beck (2008) in favor of improved supervision and more diversified portfolios in markets where such entities predominate.

Another important part of the analysis has focused on the link between size and efficiency. A large proportion of the empirical evidence in this regard mentions the presence of economies of scale in large banks that reduce operating costs as the size of the business increases (Carvallo and Kasman, 2005; Wheelock and Wilson, 2012; Laeven et al., 2014). For Latin America, the recent work of Tabak et al. (2013) also establishes that size is important in explaining the efficiency and profitability of local banks. This viewpoint generally implies that large banks, by displaying greater operating efficiency, can therefore exhibit improved profitability (Berger et al., 1993) and lower credit risk by having better technologies available to monitor and control lending activities (Berger and DeYoung, 1997; Fiordelisi et al., 2011).

In Latin America, since the financial liberalization of the 1990s and the resulting appearance of larger and more complex entities (IMF, 2001), the debate on bank size has become particularly relevant. Our qualitative analysis of banks in the region shows how, in the last decade, large banks have on average been more efficient (with lower operating costs and intermediation margins), but have paradoxically allocated fewer resources to traditional intermediation, i. e., the proportion of assets allocated to loans is significantly lower in large banks then in midsize and small ones.[2]

More recent literature has studied banks' business models, paying particular attention to the type of revenues they receive or the type of funding they use. Demirgüc-Kunt and Huizinga (2010) assert that banks whose earnings rely on activities other than intermediation or on non-deposit funding exhibit greater instability. For Köhler (2015), specialization in non-traditional activities is also important for explaining instability, suggesting that investment banks' operations (such as brokerage and securitization activities that do not generate interest

[2] Details of the qualitative analysis can be found in the following section.

income) are the ones that make financial institutions become insolvent. Moreover, DeYoung and Torna (2013) proved that banks whose income mainly came from securities trading or handling high-risk assets had a higher probability of default during the mortgage crisis. Nevertheless, after the financial deregulation of the 1990s, these transactions have precisely been the ones that have allowed diversification in large banks with a broad customer portfolio (DeYoung and Rice, 2004). In this regard, Laeven et al. (2014) state that large banks tend to have less capital, less stable sources of funding and more market-based income. Those authors and Brunnermeier et al. (2012) add that the presence of large-sized banks can unleash greater systemic risk because their earnings are more exposed to financial asset price fluctuations.

Although the latter discussion has revolved around the debate on the role of large banks in explaining instability or systemic risk, little is known about how such banks respond in times of stress. That is, up to now there has been a fundamentally static view of how size is directly or indirectly related to certain variables of interest such as concentration or competition, efficiency, default probability and stability. This paper aims to fill this gap in the literature by asking, firstly in general terms, whether bank size differentiates bank performance during sudden changes in the external environment. In particular, we attempt to determine if larger size generates advantages in the dynamic performance of banks that allow for establishing macroprudential policy implications. Although the current state of the discussion appears to be still deliberating the pros and cons of the different findings associated with size, the presentation of empirical evidence on the dynamic dimension of adjustments to shocks offers another important perspective.

To properly answer the questions set forth, the empirical strategy consists of assessing different facets of bank performance in the region, among them stability, during common external shocks. In this way, we not only seek to define the adverse financial conditions that are important in the regional

environment, but also to obtain financial responses that have a common trigger and that are, therefore, not related to countries' conditions. Methodologically this allows us to focus on the analysis of the responses of financial entities according to size.

The most outstanding findings of the paper are that larger institutions manage to maintain their deposits and even increase their profitability, over a horizon of one year after the shock. Moreover, larger size does not prevent contractions in lending, as stylized facts on crisis describe. Given this increased profitability, the reduction in operating efficiency and the low sensitivity of interest margins to the external shock, large banks' higher earnings after the crisis do not seem to stem from intermediation. However, these larger profits do not translate into greater stability. In terms of their assets, the adverse external shock encourages large banks to increase their positions in liquid assets and mortgage loans.

The paper estimates a factor-augmented vector autoregression (FAVAR) model that combines US economic performance with macroeconomic and micro financial data from a significant part of Latin America. Based on said data, financial performance indicators were also constructed by banks' groups: *large*, *midsize* and *small banks*. Identification of the external shock captures the fact that during the mortgage crisis two related events were produced simultaneously: an increase in financial uncertainty and a generalized fall in commodities prices. The shock was identified using the sign restrictions approach developed by Canova and De Nicoló (2002) and Uhlig (2005). The model is structured in two blocks: the first is associated with the US macroeconomic dynamics; and the second relates to the evolution of regional financial systems. Both blocks are estimated simultaneously and attempt to reflect the strong endogeneity between the US economy, the variables defining the shock and Latin American variables.

The rest of the paper is structured as follows: Section 2 presents some descriptive considerations about regional banks according to their size. Section 3 justifies the definition of the

external shock and describes the model estimated. The data employed and some details of the estimation are outlined in Section 4. Section 5 analyzes the results obtained through impulse responses. A panel data estimation is performed in Section 6 to establish the impact of size on bank profitability. Finally, conclusions and some policy considerations are given in Section 7.

2. QUALITATIVE ANALYSIS OF THE REGION'S BANKS

This regional study considers a total of 72 banks belonging to different countries with available monthly data: Argentina, Colombia, Ecuador, Mexico, Peru and Venezuela.[3] On average, selected banks accounted for around 90% of national assets at year-end 2012 and privately owned banks, operating under the figure of commercial banks or multipurpose/universal banks, predominate (only three institutions are publicly owned).[4] The analyzed variables were constructed based on the balance sheet and financial statements published by said institutions, trying as far as possible to homogenize the definitions or items employed.

Selected banks are categorized according to size, based on the share each institution's average assets represent (in millions of United States dollars) of the region's total assets (given by the sum of average assets of all the banks included in the sample). The accumulated frequency distribution of the

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[3] Two important countries of the region, Brazil and Chile, were not included in the sample because their bank data is only available as of 2008 and 2009, respectively. Inclusion of these countries would mean reducing the time span of all the variables and leave 2005-2008 out of the sample. This is because calculation of principal components is carried out with complete time series. Moreover, given that the external shock is defined in line with what happened in 2008, reducing the sample size to include more countries does not seem appropriate.

[4] These banks, besides intermediation, offer other types of services that can include capital market activities, broking services, currency operations, among others.

Table 1

LATIN AMERICA: BANK SAMPLE CLASSIFICATION BY COUNTRY, 2005-2012

Number of entities and percentages

	Size			
Country	*Small*	*Midsize*	*Large*	*Total*
Argentina	7 (18)	6 (26)	1 (9)	14
Colombia	6 (16)	5 (22)	2 (18)	13
Ecuador	12 (32)	1 (4)	–	13
Mexico	1 (3)	4 (17)	7 (64)	12
Peru	4 (11)	3 (13)	1 (9)	8
Venezuela	8 (21)	4 (17)	–	12
Total	38 (100)	23 (100)	11 (100)	72

Note: Figures in parentheses correspond to percentage participation.

size variable was used to qualitatively establish the inflection points that determined the reference sizes for creating the three groups. Thus, a bank was classified as large if its assets account for above 2% of regional assets, midsize if equal to or above 0.55% and below 2%, and small if below 0.55 percent.[5]

A brief review of the sample (Table 1) shows that most selected countries add a very similar number of banks to the regional sample (between 12 and 14 banks), but the classification by size reveals an unequal structure across countries. Within large banks, which account for 67% of the region's assets, Mexico has 7 out of 11 institutions (64% of regional assets). Furthermore, within the 38 small banks, which account for 10% of

[5] The use of other grouping techniques, such as cluster analysis, provided unsatisfactory segmentations that only distinguished between the four largest banks and the other banks. Thus, the methodology used allowed for greater distinctions among smaller banks and for one category grouping the 11 largest banks .

regional assets, 20 are in Ecuador and Venezuela.[6] As for the origin of capital, 65% of the sample (47 out of 72 banks) are domestically owned.

What are the values of the main performance indicators by group? Did the 2008 crisis affect those indicators? The first approach to this information, summarized in Table 2, is that large banks in Latin America have exhibited significant differences from the rest of the institutions, both before and after the crisis, in terms of most of the selected variables. In particular, on average, large banks clearly have a lower interest margin than smaller ones, particularly after the crisis. The operating costs of large banks are also below those of other banks during both periods (approximately 3.5% of their assets). According to some authors, low costs and interest margins can be interpreted as indirect evidence for the advantages large banks possess for intermediation. That is, the combination of greater operating efficiency with a lower rate of return (margin) per intermediated unit allows them to be potentially more competitive in intermediation.[7] In terms of net income (ROA), no significant differences are observed compared to the other institutions.

Regarding the composition of assets, large banks tend to allocate less resources to intermediation through credit, while they allocate a significant portion to purchasing securities, especially before the crisis. Even after the crisis when this allocation became statistically more diffuse, these banks maintained a qualitatively similar asset structure. After the crisis, the marginal increase in the share of assets allocated to credit in detriment of securities, seems to have taken place through greater mortgage funding, which is statistically higher. Contrarily, although large banks seem to have increased their capitalization in years following the crisis (from 10.7% to 12.3%),

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[6] Although the composition of groups is not homogenous across countries, the model controls for the responses associated with specific countries and banks by using regional factors. In this way, the response of groups to external shocks is exclusively related to comovements among regional variables.

[7] Demirgüc-Kunt and Huizinga (1999).

Table 2

LATIN AMERICA: MAIN INDICATORS FOR AVERAGE BANK PERFORMANCE BY SIZE[1]

Period	*Stratum*	*Capital*	*Credit*	*Securities*	*Mortgage credit*[2]	*Net result*	*Financial margin*[3]	*Operating costs*
2005-2008	Small (%)	10.9	52.6	19.7	11.3	2.9	6.1	5.7
	Midsize (%)	9.4	51.1	22.3	9.3	2.0	6.1	5.5
	Large (%)	10.7	43.6	28.6	15.5	2.2	4.6	3.5
2009-2012	Small (%)	10.9	52.6	17.8	11.0	2.4	6.1	5.5
	Midsize (%)	10.0	55.0	18.5	13.1	2.8	7.6	5.7
	Large (%)	12.3	49.0	24.5	18.1	2.0	4.5	3.4
Comparison of means[4]	2005-2008	0.45	0.11[c]	0.11[c]	0.25	0.26	0.25	0.04[a]
	2009-2012	0.36	0.40	0.22	0.09[b]	0.47	0.05[a]	0.13[c]

[1] All indicators are calculated as a proportion of banks' assets, except for mortgage credit. [2] As a proportion of total credit. [3] The difference between financial income and disbursements. [4] Bonferroni corrected *p* values (H_0: no difference in means across groups). [a] 5%; [b] 10%; [c] 15 percent.

this difference is not confirmed statistically, which might indicate greater dispersion among sample results. Finally, in bank stability and liquidity terms, results for large banks are not statistically different from the averages exhibited by other banks before or after the crisis (Table A.1, Annex 1).

It is possible to extract two interpretations from the above characterization. On the one hand, smaller financial margins and lower costs in large banks could reflect greater efficiency and the presence of economies of scale in the intermediation of local banks, even during the years after the crisis. These economies of scale can be produced even though large banks tend to hold a major part of their assets in items other than credit. On the other hand, given that profitability is similar for all banks, higher intermediation margins attributable to midsize and small banks seem to be channeled to funding their higher operating costs. This characterization is in line with the recent work of Tabak et al. (2013), who establish that large banks have greater operating efficiency. However, this possible advantage for intermediation does not translate into higher average levels of profitability.

One important question is whether the differences that emerge in large banks could be associated with the origin of capital. Of the 11 large banks in the sample, 5 (45%) are foreign owned, while out of the 38 small banks, 12 (32%) are foreign owned, i. e., the share of foreign banks is higher among large ones, but the distribution between domestic and foreign tends to be equal among large banks. When distinguishing for domestic and foreign banks in the total sample, it is not possible to identify any significant statistical or qualitative differences between the averages of the different performance indicators analyzed above (see Table A.2, Annex 1). Nevertheless, when the same classification is used (domestic compared to foreign) for large and small banks some characteristics do stand out. This information is shown in Table 3.

Table 3

LATIN AMERICA: MAIN PERFORMANCE VARIABLES OF LARGE AND SMALL BANKS BY ORIGIN OF CAPITAL
Averages 2005-2012, in terms of assets

Stratum	*Origen*	*Capital*	*Credit*	*Securities*	*Mortgages*[1]	*Net income*	*Financial margin*	*Operating costs*	*Liquidity*[3]	*Stability*[4]
Large (%)	Domestic	12.5	50.8	23.8	13.0	2.1	4.5	3.7	6.1	38.9
	Foreign	10.4	40.8	29.9	19.1	2.1	4.6	3.2	3.1	37.0
Small (%)	Domestic	10.7	52.0	17.9	11.7	2.8	5.8	5.8	6.8	38.3
	Foreign	11.3	53.9	20.6	9.8	2.3	6.5	5.3	5.8	36.4
Comparison of means[2]	Large	0.41	0.19	0.36	0.43	0.92	0.92	0.51	0.36	0.84
	Small	0.75	0.66	0.53	0.62	0.53	0.31	0.58	0.70	0.75

[1] As a proportion of total credit. [2] Bonferroni corrected *p* values (H_0: no difference in means across groups). [3] Liquid reserves/deposits.
[4] Distance to default measured based on the Z-score.

Statistically, it continues to be true that none of the differences between group averages are significant, i. e., these indicators do not distinguish domestic from foreign banks or large banks from small banks. This result is probably influenced by the small sample size. However, there are greater qualitative differences between the two large bank groups than between the two small bank groups. In particular, it can be seen that among large banks foreign ones tend to have lower capitalization, allocate a smaller portion of assets to credit, a larger portion of assets to securities and a higher portion of lending to the real estate market. Such differences are compatible with the assertion that foreign banks' business management is different from that of domestic banks, just as suggested by Arena et al. (2007) and Claessens and Van Horen (2014). Furthermore, as these foreign banks are mostly represented in the stratum of large banks, it is possible that some of the latter's behavior is influenced by the presence of foreign banks. Nevertheless, this is a hypothesis for which we do not seek additional evidence.

The statistical measures described in this section are simple averages across banks and do not allow for distinguishing the causes of the adjustments observed in the indicators or their temporality. Below we perform the analysis based on a dynamic structural model. This model allow us to disentangle the temporary adjustment of banking indicators by size in response to common external shocks and to properly define the characteristics of the structural shock.

3. STRATEGY FOR IDENTIFYING THE EXTERNAL FINANCIAL SHOCK AND MODEL SPECIFICATION

To assess the different aspects of the performance of regional banks in response to common external shocks (not related to the local conditions in each country), it is necessary to start by defining the characteristics of such shock in the context of the model.

The definition of the external financial shock is based on two factors: one, the movements observed in variables associated

with the subprime crisis and, two, the findings in Pagliacci (2014). During the mortgage crisis, there was a sudden increase in the Chicago Board Options Exchange Market Volatility Index (VIX), widely considered in the literature as an appropriate proxy variable for financial uncertainty, that affected financial decisions worldwide (Bloom, 2009; Hakkio and Keeton, 2009; Jurado et al., 2015; Bekaert et al., 2013). Adler and Tovar (2014) suggest that the rise in financial uncertainty is associated with the sharp fall in commodities prices that affected the external trade of countries in the region. In more general terms, Pagliacci (2014) shows that US contractionary financial shocks, defined as a simultaneous increase in the VIX and a reduction in share prices, explain a significant part of long-lasting commodities price movements. Moreover, idiosyncratic commodities prices movements significantly affect regional (net) capital flows that can potentially have important repercussions on financial systems. These results point to considerable endogeneity (or double causality) between US stock market volatility and commodities prices and open the possibility for characterizing the external financial shock to the region as a simultaneous movement in those variables. This paper defines a contractionary external shock as the simultaneous occurrence of an increase in US financial volatility and a fall in commodities prices. Theoretically, the explanations for this endogeneity are found in the growing financialization of commodity future markets, as pointed out in Fatttouh, Kilian and Mahadeva (2013), which probably also ends up affecting the behavior of the spot market.

The above contractionary shock is defined within the context of a factor-augmented vector autoregression (FAVAR) model and is identified by imposing sign restrictions. The model is composed of two blocks that are estimated simultaneously using seemingly unrelated regressions (SUR). The first block can be characterized as a structural vector autoregressive (SVAR) model that describes US macroeconomic performance. The second block refers to a dynamic factor model (DFM) that allows for

describing the behavior of Latin American financial systems using a broad set of financial and macroeconomic variables. The shock is identified within the first block and is transmitted to the emerging block through the correlation of residuals and the specification of the model itself, which is explained below.

The variables describing the path over time of the US economy are represented by Z^{US} through a *VAR(q)*, rewritten as a *VAR(1)*:

$$Z_t^{US} = A^{US} Z_{t-1}^{US} + B^{US} Y_{t-1}^{RW} + e_t^{US}, \quad (1)$$

where $Z^{US} = \left[Y^{US} \quad P^{US} \quad MP^{US} \quad STK^{US} \quad VIX \quad PCM \right]'$ contains the variables for US real economic activity growth, US inflation, monetary stance indicator, S&P500 index growth, stock market volatility, and commodity prices growth (*PCM*).[8] The system includes economic activity from the rest of the world (Y^{RW}) as a control. A^{US} represents the coefficients of the system, and e^{US} the reduced form residuals, distributed normal and correlated. The second block describes a similar (approximated) factor model to that proposed by Forni et al. (2009), and Forni and Gambetti (2010) for characterizing a data vector X^{LA}, which is an $N \to \infty$ dimensional vector corresponding to macroeconomic and financial variables for the region. For each $t = 1, 2..., T$, variables contained in X^{LA} are expressed as a function of g latent factors F ($N >> g$) as follows:

$$X_t^{LA} = \Lambda F_t + \zeta_t, \quad (2)$$

$$F_t = A^{LA} F_{t-1} + C Z_{t-1}^{US} + B^{LA} Y_{t-1}^{RW} + e_t^{LA}, \quad (3)$$

being Λ the loading matrix ($N \times g$) that relates X^{LA} with F, and ζ are the idiosyncratic errors orthogonal to common components ΛF, which are weakly correlated. The dynamic process of factors in 3 is represented by a *VAR(1)*, incorporating two groups

[8] As Pagliacci (2014) states, the importance of US performance in the global economy justifies the endogeneity between commodities prices and the variables in Z^{US}.

of lagged variables: one proxy variable of economic activity from the rest of the world (Y^{RW}), and vector Z^{US}. The residuals from this block are represented in vector e^{LA}, which are distributed normal and are correlated. Both blocks are rewritten as one FAVAR type system:

$$Z_t = AZ_{t-1} + BY_{t-1}^{RW} + e_t, \quad (4)$$

where $Z = [(Z^{US} \quad F)]'$, A is a matrix that combines information A^{US}, A^{LA}, C, and several zero-restrictions;[9] B combines B^{US} and B^{LA}, and $e = [e^{US} e^{LA}]'$ is the vector of all reduced form residuals, distributed normally with variance Σ. Thus, all system residuals are potentially correlated.

This reduced form system can be associated with the structural model:

$$\Psi^{-1} Z_t = \Gamma Z_{t-1} + DY_{t-1}^{RW} + u_t, \quad (5)$$

where u refers to structural shocks of the system $A = \Psi\Gamma$, $B = \Psi D$ and $e = \Psi u$. Estimation of 4 is carried out in two steps. First, we estimate factors F through principal components of X^{LA}, according to the model in 2. Then we estimate system 4, assuming that factors are observable. Given the presence of zero restrictions in coefficients matrix A, we apply generalized least squares. Identification of structural shocks u is carried out using the sign restrictions technique proposed in Canova and De Nicoló (2002), and Uhlig (2005). Details on how to perform this identification are provided in Annex 2.

[9] The structure of matrix A considers that US variables only respond to their own behavior and not to that of regional variables, being $A = \begin{bmatrix} A^{US} & 0 \\ C & A^{LA} \end{bmatrix}$.

4. DATA AND ESTIMATION

Data for the US block were obtained using statistics from the Federal Reserve, while commodities prices come from the statistical compendium of the IMF. As in Pagliacci (2014), a synthetic measure of the stance of US monetary policy was included and obtained from the first principal component between the federal fund rate (conventional measure), assets purchased by the Federal Reserve as a proportion of the quantity of money in the economy (M2) (heterodox measure) and real liquidity growth (M2).[10] Similarly, the proxy variable for activity linked to the rest of the world was computed as the first principal component of the annual growth rate of industrial production indexes for a group of 31 advanced and emerging countries, excluding the US and members of the region.

The sample employed includes data for the period 2005-2012, a time frame chosen in terms of the availability of the series (T= 96). The matrix of regional data (X^{LA}) was constructed by including macroeconomic and micro financial variables. The combination of macroeconomic and financial data for calculating the factors is justified by the strong endogeneity between both types of variables. Moreover, the fact that these factors capture the comovement of both types of variables at regional level means that the common external shock can be methodologically interpreted as part of the explanation for such comovement. The use of regional factors tends to control for country specific and bank specific effects because they capture the total variance of the region's variables. In contrast, the idiosyncratic errors of Equation 2 tend to capture all the movements in variables associated with the specific conditions of a

[10] Although there are other ways to measure the US monetary policy stance, the composite variable used is not crucial for identifying the external shock. It is employed in an attempt to include important data on the US economy regarding its monetary policy to avoid the appearance of estimation bias due to the omission of important information.

country or a bank. Once the comovement of the region's variables (financial and macroeconomic) has been found through factors, we can determine what part of this comovement depends on the defined (common) external shock.

Macroeconomic variables include information from each country in the sample: real activity index, consumer price index, imports, exports, exchange rate, international reserves, interest rates, monetary aggregates and fiscal variables, obtained from central bank publications and expressed in annual log differences. With respect to financial information, data from 20 indicators commonly employed in bank analysis were considered for each bank in the sample (72 banks). This data includes: growth rates of main balance sheet items (total assets, liquid assets, credit and its components, securities, deposits, and capital); ratios of main variables in the income statement (implicit interest rates of the assets and liabilities, operating costs, global profitability); and the stability indicator (z-score) by bank. These variables were calculated for each bank included in the sample, making use of data from their financial statements, provided by the application SAIF. Moreover, in order to include measures that typify the behavior of institutions in the region by size, bank data is broadened with: *1)* the means of each variable for all banks, and *2)* the means by variable for each group of banks (large, midsize and small). As a result, matrix X^{LA} had column dimension N = 1,583.

Based on the structure of matrix X^{LA}, since $N > T$, the common factors in the Latin American block (F) were approximated as the g first principal components of the matrix, as stated in Bai and Ng (2002). The number of factors g was qualitatively chosen to ensure a selection of components that would produce stable impulse responses and reduce the volatility associated with the addition of new factors. Under these criteria, $g = 10$ was selected as the most appropriate dimension for the common components, which explain around 83% of the variance

in X^{LA}.[11] Once these factors had been selected, estimation of 4 was carried out using generalized least squares.

Sign restrictions for identifying the external shock were imposed for six consecutive months in order to guarantee that the identified shock had a sufficiently persistent impact on variables.

5. STRUCTURAL FAVAR RESULTS AND ANALYSIS

In this section, we show the main results of the paper. Impulse responses were generated using Equation 6 of Annex 2 for relevant financial variables (means by banks' groups). The rotation matrices that satisfy the restrictions imposed on the external shock (117 matrices out of the 2,000,000 *Qs* evaluated) were used to calculate the median path and upper and lower bands of impulse responses (50, 16 and 84 percentiles of accumulated responses).[12] These functions were computed for a 24-month horizon.

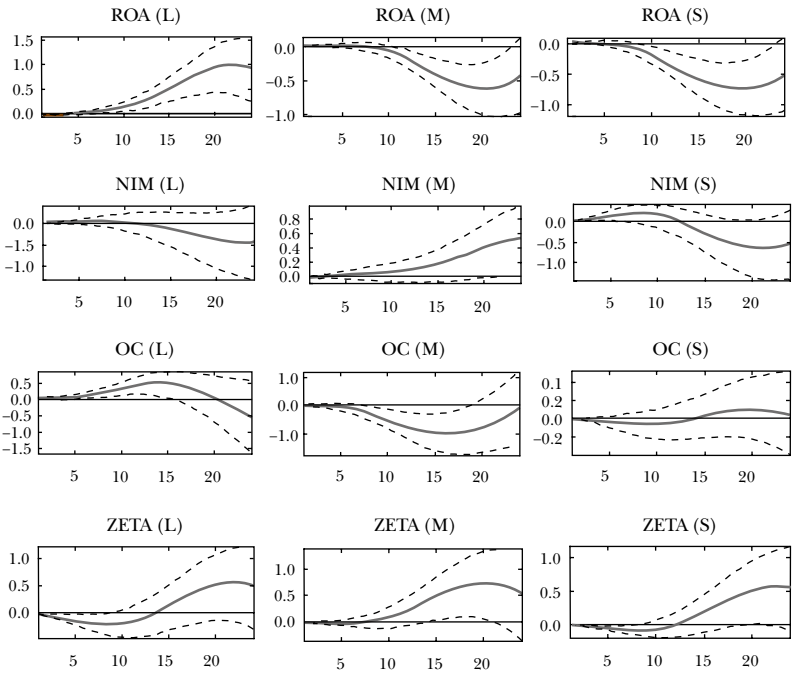
When evaluating results by size (Figure 1), it stands out that for several months after the contractionary external shock, the profitability (ROA) of large banks increases, while that of other banks declines. However, there are no significant increases

[11] A total of 7 to 12 X^{LA} factors were evaluated (between 77% and 85% of data variance). Considering a number less than 10 significantly altered the findings obtained, showing that a reduction in the components would lead to a substantial loss of information. Choosing 12 factors added negligible information that generated qualitatively similar responses with greater variance and, thereby, less significance.

[12] These bands capture uncertainty on different possible structural parameterizations that are consistent with reduced-form estimates of the model and that satisfy sign restrictions in the structural impulse responses. Following Bernanke et al. (2005), this uncertainty surrounding estimated factors is considered insignificant (given that $N > T$), and it is not included in these intervals. The size of the bands is also in line with available empirical works that identify shocks with sign restrictions.

Figure 1

BANKING IN LATIN AMERICA: CUMULATIVE IMPULSE RESPONSES TO A CONTRACTIVE EXTERNAL SHOCK BY SIZE (PROFITABILITY AND STABILITY)[1]



[1] The size of the shock corresponds to a standard deviation. The responses are expressed in the standardized units, where the dotted lines represent the lower and upper bands. Large banks: (L); medium banks: (M); small banks: (S). ROA: net result / asset; NIM = interest margin, defined as the difference between income and financial outlays as a proportion of assets; OC: operating expenses / assets; ZETA: z-score stability indicator, defined as the sum of ROA and capitalization, standardized by the changing volatility of ROA.

in the interest margin (NIM) of large banks, or reductions in their operating costs, which, on the contrary, temporarily increase. By construction, the growth in profitability can be broken down as follows: $\Delta ROA = \Delta NIM - \Delta OC + \Delta OtherNetIncome$, meaning that the increase in profitability of large banks seems to stem from an increase in other net inflows. That is, the higher revenues of large banks seem to have been obtained from activities not directly related to intermediation such as, for

instance, charging higher commissions for services or earnings associated with the purchase and sale of different types of assets. Due to limitations in the data, it is not possible to distinguish the source of these earnings. Nevertheless, it is clear that their importance becomes apparent after the episode of external stress.

For the other banks, profitability tends to decline during the year following the contractionary external shock. In the case of midsize banks, this reduction in profitability takes place despite marginally improved profits from intermediation (NIM) and lower operating costs (OC). That is, despite the efforts of these banks to increase their unitary profits and become more efficient, the decrease in profitability could not be prevented. This also implies that other net incomes of midsize banks must have fallen significantly, the opposite to what happened to large banks. For small banks, net income from intermediation (margin) seems to have risen slightly during several months after the shock, while operating costs do not appear to have changed. Thus, just like midsize banks, small banks also experienced lower profits in activities different from intermediation.

In terms of financial stability (ZETA), it can be seen that different patterns of profitability responses (ROA) do not have a direct influence on the behavior of stability. For large banks, the increase in ROA does not generate stability gains, while for the other banks the decrease does not have a negative impact on stability. In contrast, midsize and small banks can marginally increase their stability in periods of lower profitability. This implies that stability is highly determined by capitalization strategies, which will be assessed later in this section.

Figure 2 presents the overall results for banks' balance sheets. The first outstanding result is that, in the presence of the adverse external shock, credit (LOAN) granted by all banks' groups decreases considerably. This is in line with the idea that the external shock during the subprime mortgage crisis led to a substantial fall in lending, possibly as a result of the decline

in aggregate demand that took place in several countries of the region. However, this reduction in lending only translates into a decrease in assets (ASSET) in midsize and small banks. The counterpart to the reduction in assets is the decrease in deposits, particularly for small banks. Large banks, on the other hand, seem to increase their assets and deposits at the margin. This probably indicates that, after the crisis, rather than a reduction in countries' aggregate deposits, a reallocation of deposits from small banks to large ones could have occurred.

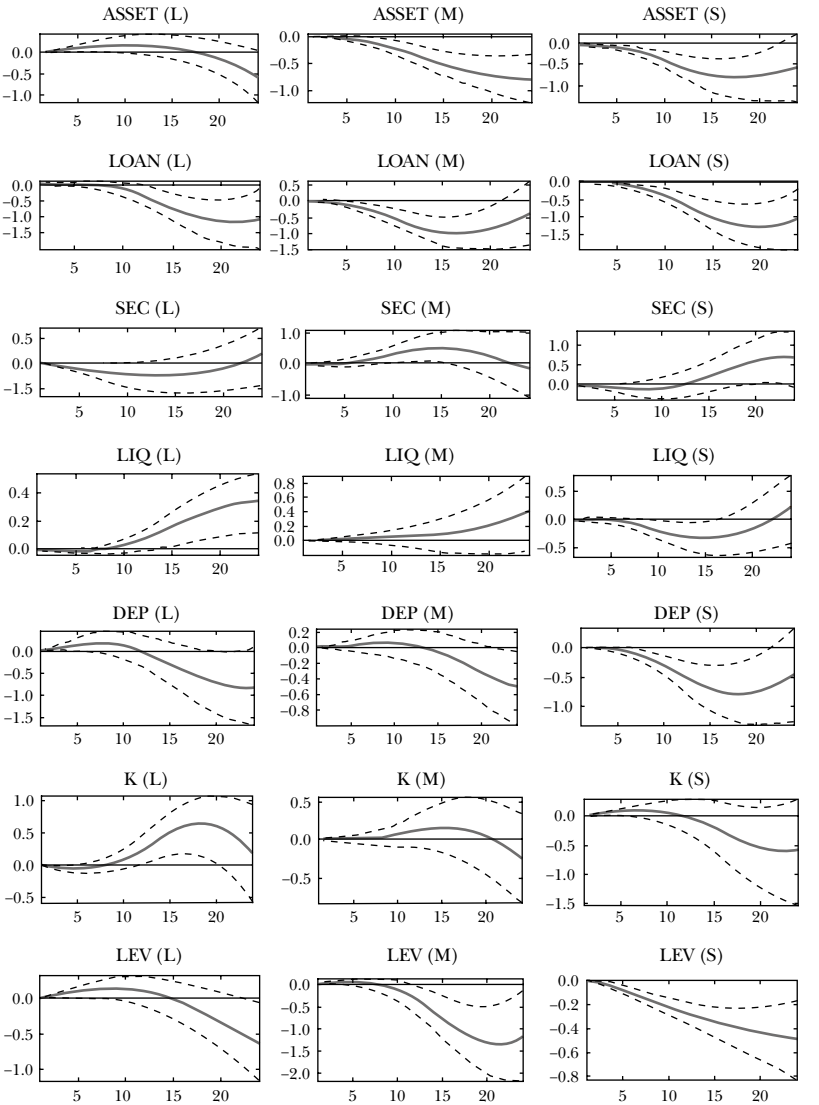
Comparing the behavior of credit with that of total assets, the reduction in midsize and small banks' lending is partly offset only by an increase in the holding of securities (SEC). However, in larger banks, the fall in lending is accompanied by a reduction in the holding of securities (SEC) and a significant accumulation of liquid assets (growth of LIQ).

The descriptive analysis in the previous section showed that before 2008 large banks tended to hold a greater portion of their assets in securities, approximately 10% more than the other banks. This difference declines after the crisis, even though large banks continue to hold a substantial part of their assets in securities. One possible hypothesis regarding the generation of earnings different from intermediation is assuming that large banks' profits were associated with a partial settlement of the securities portfolio, which is also observed in the reduction of SEC (Figure 2). These profits could have originated from two types of price movements: sovereign bond prices and relative prices of local currencies. On the one hand, after the initial fall of commodities prices in August 2008, starting in March 2009, government bond prices probably recovered sharply and along with them regional governments' funding conditions.[13]

[13] This statement is related to research that has found that terms of trade are negatively related to sovereign spreads, indicating that potential gains in countries' export tend to be coupled with increases in sovereign bond prices and consequently, spreads' reductions. Examples of this literature are Hilsher and Nosbusch (2010), and Acosta et al. (2015).

Figure 2

CUMULATIVE IMPULSE RESPONSES TO A CONTRACTIVE EXTERNAL SHOCK (BALANCE SHEET)[1]



[1] The size of the shock corresponds to a standard deviation. The responses are expressed in the standardized units, where the dotted lines represent the lower and upper bands. Large banks: (L); medium banks: (M); small banks: (S). ASSET: annual change in assets; LOAN: annual variation of credit; SEC: annual variation of securities; LIQ: reserves/deposits; DEP: annual variations of deposits; K: annual variation of capital; LEV: assets/capital.

Thus, the sale of securities in advantageous conditions could have contributed to the generation of these other net earnings. On the other hand, the depreciation of local currencies in the region, also after the external shock, could have encouraged the settlement of assets denominated in foreign currency to make profits in domestic currency. In this case, the explanation of earnings not related to intermediation would require assuming that large banks possess a greater amount of foreign currency denominated securities in their portfolios than the other banks. This is a hypothesis we cannot directly test due to a lack of information on the composition of assets according to their denomination. Nevertheless, Section 6 attempts to perform an indirect test of this hypothesis.

In both cases, the distribution of large banks' assets previous to the shock (less inclined towards credit and more dependent on securities) might have led to earnings not associated with intermediation.

As for the behavior of large banks' liquidity, this clearly differs from the performance of liquidity in other banks. Its growth is in line with the liquidity hoarding that tends to occur during periods of crisis or financial uncertainty, just as it is generally pointed out in banking literature. However, given that large banks potentially have a greater impact on domestic interbank markets, it can be assumed that this accumulation of liquidity could have explained redistributive tensions among banks during the external shock.[14] Attributing large banks' liquidity accumulation to the growth in deposits observed after the crisis it is another way to rationalize this phenomenon.

For the region, the general reduction in interest rates that took place after the external shock probably prevented the excessive liquidity accumulation of large banks from generating systemic repercussions. Nevertheless, it is possible that

[14] Acharya and Merrouche (2012) find that there were significant increases in interbank rates in the UK during the initial periods of the subprime crisis.

smaller banks' access to liquidity could have been compromised to some extent, although we do not have statistical data to prove this suspicion.

With respect to bank leverage (LEV), midsize and small banks are the ones that mostly reduce it after the contractionary external shock. This deleveraging is mainly explained by the reduction in assets that, in the case of small banks, seems to be caused by the fall in their deposits. This behavior of leverage, when accompanied by slower economic growth, is compatible with the financial procyclicality described by Adrian and Shin (2010). In the case of large banks, on the other hand, leverage initially rises slightly in response to the increase in their assets. Only after two years does a modest deleveraging take place, explained in this case by a significant expansion of capital.

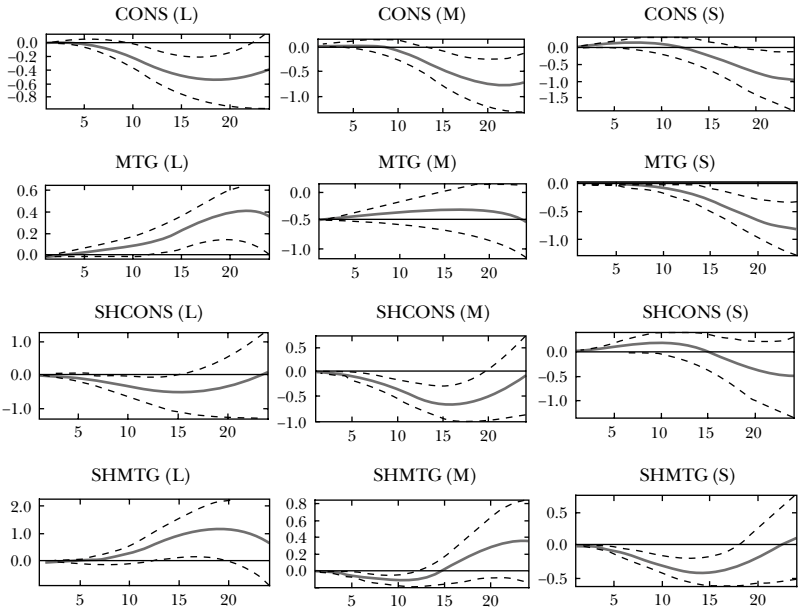
Large banks' capital accumulation one year after the shock can be understood in the context of the higher profits they obtain from activities other than intermediation.[15] Nevertheless, the fact that large banks tend to accumulate more capital than other banks can also be interpreted as indirect evidence for large banks' low capital holdings during normal times, as stated in Laeven et al. (2014) and Kasman et al. (2015). These low capitalization levels, which could be understood as capital levels very close to regulatory limits or as minimum buffers, must be compensated for at times of financial stress, making greater accumulation necessary during recessionary phases of the economic cycle.

As for the role of capitalization (the opposite of LEV) in the behavior of stability (ZETA), it would seem that higher capitalization ratios explain increased stability for midsize and small banks after two years. This rise in capitalization appears to originate from a reduction in balance sheet assets (ASSET) and not from a direct capital growth (K). For large banks, the decrease

[15] Cohen and Scatigna (2016) show that banks in emerging economies have used large portions of their higher earnings to build capital during periods following the crisis.

Figure 3

CUMULATIVE IMPULSE RESPONSES TO CONTRACTIVE EXTERNAL SHOCK (CREDIT COMPOSITION)[1]



[1] The size of the shock corresponds to a standard deviation.The responses are expressed in the standardized units, where the dotted lines represent the lower and upper bands. Large banks: (L); medium banks: (M); small banks: (S). CONS: annual variation of consumer credit; MTG: annual variation of mortgages; HSCONS: consumer credit/total credit; SHMTG: mortgages/total credit.

in capitalization during several months after the shock might also explain the decline in stability. Such behavior of stability could also originate from the increased volatility of bank earnings implied by higher ROA. The later recovery of stability in large banks appears to be associated with the capital accumulation in line with their higher profit margins.

Although we have pointed out that the fall in credit occurs for all three types of banks, its composition appears to differ according to size (Figure 3). While large banks raise their

mortgage credit position (MTG) and decrease their consumer loans (CONS), small banks show the opposite behavior. Considering that the macroeconomic environment in the region during 2009 and 2010 was characterized by slump in real activity, depreciations in domestic currencies and slack monetary policy, just as described by Pagliacci (2014), the increase in large banks' mortgage loans (MTG) can be understood as a result of these changes. In particular, loose monetary conditions, caused by reductions in policy rates, could have contributed to rising house prices. Moreover, adverse external conditions, such as the depreciation of domestic currencies, might have favored the increase in property prices, especially in dollarized market segments, as pointed out by Carvallo and Pagliacci (2016) for Venezuela. Such upward adjustments in regional house prices, clearly in the opposite direction to the change that took place in USA, could have foster a reallocation of resources towards the property market. In empirical terms, this phenomenon would be compatible with the increase in mortgage loans as a proportion of total lending (SHMTG), for large banks.

In sum, the above results allow us to deduce two lessons from the response of large banks to the contractionary external shock.

On the one hand, considering the adjustments in profitability, financial margin and operating costs, it can be concluded that the external shock induced higher profits from non-intermediation activities for large banks. This suggests that those banks have a business model oriented towards other activities rather than intermediation, just as suggested by recent literature. This potential specialization also helps explain why, in an environment of generalized credit contraction, only large institutions were able to turn changes in asset prices into profits.

However, the literature tends to point out that a nonconventional model for obtaining profits may encourage the appearance of additional risk factors during episodes of systemic instability. Thus, DeYoung and Rice (2004) state that banks

depending to a great extent on nontraditional income (such as investment or brokerage activities) increase the volatility of their earnings. Laeven et al. (2014) and Brunnermeier et al., (2012) show that greater exposure to fluctuations in the market value of the assets of these institutions possibly increase their default probabilities during the crisis, which would lead to greater systemic risk. For Latin America, we find that this potential specialization could have explained the use of strategies for generating profits after 2008 external crisis but, in fact, it also led to a slight decline in stability, measured with ZETA.

The other piece of empirical evidence this paper provides are the differences observed in the leverage and distribution of large banks' assets. After the crisis, only large banks did not clearly deleverage. This is partly connected with the reallocation of deposits towards those banks. Moreover, large banks tended to reduce security holdings, increase liquidity and reallocate lending towards the mortgage market, probably as part of a differentiated asset management strategy. There are no comparable studies on the distribution of different types of assets. However, some conjectures and their potential consequences could be extracted. On the one hand, the reallocation towards mortgage credit implies a greater exposure of large banks to fluctuations in real estate market prices. It is, therefore, reasonable to say that the latent risk associated with this market increases as the losses that could materialize during sudden falls in prices grow. This reallocation could also trigger more recessive macroeconomic conditions and more unstable financial systems, as shown in Jordá et al. (2016) in its historical understanding of the crisis and the role of mortgage credit. On the other hand, the accumulation of liquidity during times of stress can also lead to additional risks in domestic interbank markets, through interest rate premiums or frictions in the distribution of liquidity among agents.

6. A PANEL MODEL: HOW DOES SIZE AFFECT PROFITABILITY?

The previous section shows that a key variable in the performance of banks is profitability (ROA). Another way to compare the differentiated impact (according to bank size) of certain variables on profitability is by using a panel data regression. The model to be estimated is as follows:

$$ROA_{it} = \rho \sum_{k=1}^{3} ROA_{it-k} + \alpha \sum_{k=1}^{3} X_{it-k} + \beta M_{jt-l} + (\delta + \gamma * size) Z_{jt-l} + \varphi_i + \varepsilon_{it}, \quad (6)$$

where the level of current profitability is affected by past profitability. X represents the variables for bank i in period $t-k$ that affect profitability: the net interest margin (NIM) and operating costs (OC). The inclusion of these two variables aims to take into account the main components of profitability whose behavior was described in the previous section. Note that the part of profitability that is not explained by past ROA, NIM or OC attempts to register the part of profitability not related with intermediation activities. Some estimations consider the possibility that X also includes securities as a share of total assets (SHSEC) held by bank i in period $t-k$. M refers to j country variables that can influence profitability such as the real annual growth of economic activity (GDP) or inflation (PI), as stated by Albertazzi and Gambacorta (2009). Terms φ_i refer to banks' fixed effects and ε_{it} are regression errors related to different banks at each time-period. Z contains variables that are assumed to behave differently by bank type, i. e., Z coefficients allow for a nonlinear behavior with respect to size (SIZE). In particular, Z contains external variables, such as the level of volatility of the S&P500 index (VIX) and the annual growth rate of commodities prices (PCM), as well as the annual depreciation (DEP) of countries' currencies. The inclusion of depreciation rates tries to identify to what extent the behavior of non-interest earnings could be related to foreign currency assets' portfolio management for the largest banks.

Given that variables in *X*, *M* and DEP can be considered endogenous with respect to ROA, all these variables are included with lags. Moreover, a two-step estimation that uses instruments in the first step is carried out.[16] PCM and VIX variables are also used with lags, but serve as instruments for the other variables. Given that sufficient lags are included for bank variables, it is assumed that regression residuals can be correlated across banks, but do not exhibit serial correlation (cross section SUR). This implies that in the second step of the estimation we use generalized least squares to include the structure of residuals in the estimation of parameter values. This is equivalent to carrying out estimations using generalized method of moments. A total of three variations of model 6 are estimated. Results from estimations are shown in Annex 3.

Main results of the estimations of regression model 6 can be summarized as follows:

- There are differentiated effects of size on the portion of profitability that is not related to intermediation. These effects are summarized in Table 4.
- Higher real economic growth in countries tends to generate greater profitability, while higher inflation tends to produce a lower profitability.
- An increase in interest margin tends to raise profitability, while an increase in operating costs tends to reduce it. A settlement of securities that leads to a decrease in their proportion of total assets generates an increase in profitability.

As for non-linear effects (by size) on profitability, Table 4 shows intervals that reflect the variability (according to the three models estimated in Annex 3) of average effects different variables have on profitability. This Table illustrates that large banks are see their profitability reduced in response to an increasing volatility in the US stock market. A contraction in commodities prices also implies larger losses in profitability for

[16] The use of instruments also attempts to deal with the potential endogeneity of the lagged dependent variable that emerges in panel structured data. However, this problem is more obvious in panels with many individuals and few temporary observations.

Table 4

AVERAGE PROFITABILITY RESPONSES TO VARIATIONS IN VARIABLES BY BANK TYPE

	Large banks	*Midsize banks*	*Small banks*
Increase of one VIX unit	(–9.1E–05; –1.8E–04)	(2.1E–05; 3.4E–05)	(3.7E–05; 6.7E–05)
Annual growth of 100% of the PCM	(0.023; 0.053)	(0.003; 0.005)	(–0.0004; 0.0005)
Annual depreciation of 100%	(0.09; 0.17)	(0; 0.02)	(–0.02; 0.01)

larger banks. The greater sensitivity of large banks to changes in external variables (VIX and PCM) could be associated with the larger connections such banks typically have with international markets.[17] Viewed separately, these two results suggest that changes in the external environment would affect large banks more adversely than other banks.

However, large banks' potential losses, which are directly attributable to the international environment, are offset by earnings associated with domestic currency depreciations. Thus, although all banks might earn income from depreciations, large banks obtain much more earnings per percentage point of depreciation than their domestic peers. With this evidence, the hypothesis that large banks' earnings not related to intermediation could be linked to the sale of foreign currency assets becomes more relevant. In this case, the origin of earnings would be specifically connected to initial greater availability of foreign currency securities or to a greater leverage of domestic currency depreciation rates. However, in general terms, this description might also suggest a possible advantage or specialization of large banks in investment strategies.

[17] These connections can also originate from a greater share of foreign capital in large banks, as highlighted in Section 2.

7. CONCLUSIONS AND POLICY CONSIDERATIONS

Two important results are obtained from the construction of an econometric model that assesses the response of the region's banks to a negative external shock. First, large banks exhibit higher profitability after the external shock, possibly as a result of greater specialization in activities other than intermediation. In particular, such activities appear to be related to the application of better investment strategies that take advantage of domestic currency depreciations . These profitability gains did not, however, translate into stability gains. Second, the shock and the resulting macroeconomic conditions led to a reallocation of large banks' assets towards liquid assets and mortgage credit.

The potential consequences of such asset reallocation appear to be contingent, depending on the future occurrence of significant falls in domestic housing markets or interbank liquidity shortages. Nevertheless, the ability shown by large banks to obtain higher earnings that are not strictly related to intermediation could be interpreted in two ways.

On the one hand, the generation of greater profits in times of external stress could be interpreted as evidence for a greater adaptability of large banks. Nevertheless, we do not strictly know if the results obtained are tied to the particular mix of asset price changes resulting from the external shock or if they can be extrapolated to other situations of external stress. On the other hand, the fact that large banks have not translated higher profitability into greater stability shows that higher profitability could be the expression of increased volatility in earnings, which works against financial stability over the long term, as suggested by DeYoung and Rice (2004).

Thus, strictly based on the evidence above, it is very difficult to reach a definitive conclusion about the contribution of large banks to systemic financial risk. It is also hard to justify the need for imposing macroprudential regulations explicitly aimed at limiting the size of institutions.

One aspect, however, that is implicit in the considerations about the empirical evidence is the possible specialization of large banks in other activities rather than intermediation. Moreover, the qualitative evidence described at the beginning of the paper appears to suggest that credit intermediation is relatively smaller in larger banks. Thus, as suggested by Stiglitz (2015), one possible policy consideration would revolve around discussing the importance of credit for the real economy and the guidelines required to encourage it.

In contrast to this idea, the discussion and application of financial markets regulatory frameworks in the US and Europe have been carried out in terms of limiting the scope of securities trading inside traditional banks.[18] These arrangements have mainly been based on controlling activities exposed to market risk (such as the Vicken proposal), avoiding bank overspecialization in investment activities or preventing their migration to unregulated market segments (such as the cross-subsidization of Liikanen).[19] Nevertheless, application of this type of regulation in Latin America is not necessarily appropriate, especially if the considerable heterogeneity of the region in financial development and complexity is taken into account.

It is therefore important to continue seeking more specific answers for the region with respect to the precise nature of the operations large banks carry out, and which institutional or domestic factors ultimately discourage the development of more vigorous intermediation. Although the business of intermediation depends on the booms and busts of the economic cycle, it is also possible to think about arrangements that make it more resilient to these ups and downs, and thereby transform intermediation into a true buffer that minimizes short-term fluctuations in real economic activity.

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[18] In particular, the benchmarks of the regulation are summarized in the US Financial Systems Modernization Act 2010 (the Volcker rule); the proposals of the UK Independent Commission on Banking 2013 (Vickers report); and the 2012 Liikanen proposal for the European Union.

[19] A comparison of such regulatory reforms can be found in Gambacorta and Van Rixtel (2013).

Annex 1

Table A.1

LATIN AMERICA: PERFORMANCE VARIABLES FOR BANKS BY SIZE
Averages, in terms of assets

Period	Stratum	Liquidity[1]	Stability[2]
2005-2008	Small	6.9%	29.1
	Medium	7.3%	33.0
	Large	4.4%	30.9
2009-2012	Small	6.1%	46.4
	Medium	9.2%	43.9
	Large	5.0%	45.2
Comparison of means[3]	2005-2008	0.62	0.59
	2009-2012	0.22	0.93

[1] Liquid reserves/deposits in percent. [2] Measured by Z-score. [3] Bonferroni corrected *p* values (H_0: no difference in means across groups).

Table A.2

LATIN AMERICA: PERFORMANCE VARIABLES FOR BANKS BY ORIGIN OF CAPITAL
Average in terms of assets

Period	*Stratum*	*Capital*	*Credit*	*Securities*	*Mortgages*[1]	*Net income*	*Interest margin*	*Operating costs*	*Liquidity*[3]	*Stability*[4]
2005-2008	National (%)	10.3	49.9	21.9	11.0	2.7	5.9	5.5	6.4	31.8
	Foreign (%)	10.6	52.3	21.8	13.0	2.1	5.7	4.8	7.0	28.3
2009-2012	National (%)	10.8	52.9	18.7	11.7	2.4	6.4	5.5	6.2	44.8
	Foreign (%)	10.9	52.5	19.8	15.6	2.6	6.2	4.9	8.4	46.5
Comparison of means[2]	2005-2008	0.81	0.46	0.97	0.47	0.20	0.67	0.25	0.77	0.33
	2009-2012	0.89	0.89	0.70	0.15	0.74	0.83	0.46	0.25	0.78

[1]As a proportion of total loans. [2] Bonferroni corrected *p* values (H_0: i no difference in means across groups). [3] Liquid reserves / deposits.
[4]Measured by Z-score.

Annex 2

Identification of Shocks Using Sign Restrictions

The process of identifying shocks using the specification in 4 starts with the orthogonalization of residuals e_t, which involves finding a matrix $\hat{V}$ that decomposes its covariance matrix (Σ) such that $\hat{\Sigma} = \hat{V}\hat{V}'$. This matrix is obtained using the Cholesky decomposition of Σ. With this information, it possible to find orthogonal errors through $\hat{\varepsilon}_t = \hat{V}^{-1} e_t$, being ε a vector of non-structural orthogonal residuals, without interpretation. If it is also assumed that these orthogonal residuals are linked to structural errors by the rotation matrix Q (that satisfies $QQ' = I$ and $Q'Q = I$) and $\varepsilon_t = Q u_t$, the responses of variables Z to shocks u for horizon h is given by:

A1
$$I\hat{R}Z(h) = \hat{A}^{h-1}\hat{V}Q\,.$$

Producing equivalents $e_t = \hat{V}Q\,u_t$ and $\Psi = \hat{V}Q$. This representation A1 allows orthogonal shocks to be identified based on the expected effects on observable variables in Z, in particular PCM and VIX. Thus, sign restriction identification involves selecting the matrices Q that satisfy the expected signs in the IR of Z variables for structural shocks.[20] Since Z contains factors, the reactions of Latin American financial variables are given by:

A2
$$I\hat{R}X^{LA}(h) = \Lambda IRF(h)\,,$$

where Λ is the matrix of loads, which transmit movements of the *g principal* components F to X^{LA}.

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[20] According to Rubio, Waggoner and Zha (2001), the Q matrices can be obtained from applying the QR decomposition to a uniform random matrix. Moreover, to ensure that the identification of the external shock only employs information coming from the first block of the model, we impose that rotation matrices comply to the form $Q = \begin{bmatrix} Q_1 & 0 \\ 0 & Q_2 \end{bmatrix}$, where Q_1 and Q_2 are square matrices with dimension equal to the rank of Z^{US} and F respectively, that satisfy $Q_1'Q_1 = I$, $Q_2'Q_2 = I$.

Annex 3

Data Panel Regressions for Profitability (ROA)

Dependent variable Variable: ROA.

Representative samples: 72
Periods: 92
Total observations: 6,624

Representative sample SUR (PCSE) standard errors and covariance (corrected d.f.)

	Model 1		*Model 2*		*Model 3*	
Instruments	d(X) size VIX PCM		d(X) size VIX PCM		d(X) size VIX PCM	
	Coefficient		Coefficient		Coefficient	
C	0.000		0.003	*	0.008	*
ROA(–1)	0.700	*	0.735	*	0.734	*
ROA(–2)	0.060	*	0.060	*	0.046	*
ROA(–3)	0.004		0.005		–0.003	
MRG(–1)	–0.050	*	–0.063	*	–0.003	
MRG(–2)	0.050	*	0.044	*	0.052	*
MRG(–3)	0.053	*	0.048	*	0.060	*
Oc(–1)	0.032	*	0.028	*	0.004	
OC(–2)	–0.005		0.004		0.004	
OC(–3)	–0.036	*	–0.042	*	–0.059	*
SHSEC(–1)			–0.007	*	–0.012	*
SHSEC(–2)			0.006	*	0.005	*
SHSEC(–3)			–0.008	*	–0.007	*
VIX(–2)	0.000	*	0.000	*	0.000	*
SIZE*VIX(–2)	–0.002	*	–0.002	*	–0.004	*
PCOM(–3)	–0.001		–0.001		–0.007	*
SIZE*PCOM(–3)	0.563	*	0.448	*	1.021	*
DEP(–3)	0.006	*	0.008	*	–0.029	*
SIZE*DEP(–3)	1.782	*	1.395	*	3.295	*
GDP(–3)	0.021	*	0.027	*		
PI(–3)					–0.051	*

Fixed effects by bank (fictitious variables)

	Weighted statistical measures		
R squared	0.991725	0.988643	0.987208
Adjusted R squared	0.991615	0.988486	0.987032
Standard error of the regression	1.0491	1.020035	1.009836
Durbin-Watson statistic	1.757717	1.888866	1.931095
Instrument range	89	92	92
J statistic	0.028785	0.053543	0.069769
Prob (statistical measure of J)	0.865276	0.817009	0.791674
	Unweighted statistical measures		
R squared	0.889838	0.893083	0.865687
Durbin-Watson statistic	1.660277	1.759149	1.472502

* Coefficients with *p* values below 0.05.

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The Effects of US Unconventional Monetary Policies in Latin America

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Abstract

This paper offers an empirical analysis of how US unconventional monetary policy has affected Latin American countries. First, we estimate the effects of US monetary policy announcements on sovereign bond interest rates, exchange rates, and stock market indices for a set of emerging countries, including five Latin American economies. We found that QE announcements in 2008/2009 and the tapering talk in 2013 generated sizable sovereign yield and exchange rate fluctuations. We further find, just in a few cases, some excessive response of asset prices in Latin American countries. In the second part of the paper, we estimate a simple model that measures the influence of country-specific macroeconomic fundamentals on the transmission of US financial

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disturbances. An estimated model including the inflation rate, the CDS spread, the ratio of official reserves and market capitalization explains some of the observed cross-country heterogeneity of spillovers from US monetary policy announcements. Under this model, a greater impact from the normalization of US monetary policy can be expected in Latin America relative to other emerging economies.

Keywords: unconventional monetary policy, spillovers, emerging economies, event study.

JEL classification: E52, F32, G11.

1. INTRODUCTION

After the 2007-2008 global financial crisis, once central banks in the major advanced economies had used up conventional instruments, these central banks resorted to new, unconventional monetary policy tools to help improve the weak economy. This unprecedented monetary policy reaction–and, perhaps more importantly, the perception that major central banks were firmly committed to adopting any measure needed to preserve an orderly financial intermediation–helped to calm financial markets. Against this background, from late 2009 until the beginning of the tapering tantrum in the spring of 2013, emerging market economies (EME) received a high volume of capital flows that ran in parallel with asset appreciation and the reduction of interest rates.

The opposite movement occurred after the Federal Reserve's announcement in May 2013 that anticipated the end of expansionary monetary policy in the United States. There were sudden reversals of capital inflows in several episodes between May 2013 and early 2014, as market perceptions of the Federal Reserve's intention to gradually withdraw its asset purchase program. Capital outflows from emerging markets during these episodes led to exchange rate depreciations of emerging market currencies, increases in the risk premia on their financial assets and falls in their equity markets.

In this paper, we analyze the effects of US unconventional monetary policy announcements on sovereign bond yields,

exchange rates, and stock market indices for 20 EMEs, including five from Latin America, and we also explore how the transmission of such monetary impulses is influenced by country-specific variables, such as macroeconomic variables, market conditions, and the external position, reflecting the countries' fundamentals. Thus, we analyze spillover effects by focusing on the reaction of the prices of financial assets. But, admittedly, we disregard other dimensions of the international transmission of monetary policy, namely changes in quantities (gross capital flows) and policy reactions.

This paper contributes to an already extensive literature which has explored the effects of the new unconventional instruments, mainly asset purchase programs in the United States. A number of papers have focused on the impact of these programs on US economy. Although results differ across studies depending on their methodology, sample periods, and variables analyzed, a number of general conclusions can be drawn. First, quantitative easing programs have been successful in improving financial conditions, sustaining activity and mitigating deflation risks (IMF, 2013). There is an ample literature that quantifies the effects of balance sheet policies on asset pricing (Neely, 2010; Gagnon et al., 2011; Meaning and Zhu, 2011; Krishnamurthy and Vissing-Jorgenson, 2011; among many others) and there is also some evidence, although admittedly scarcer, documenting the fact that asset purchases provided significant stimulus to activity and counteracted disinflationary pressures (Chen et al., 2014, for US LSAP, and Joyce et al., 2011, or Kapetanios et al., 2012, for UK APF programs). Second, the effects of the subsequent programs have been documented as being progressively smaller (Krishnamurthy and Vissing-Jorgensen, 2011, and Bauer, 2012). Third, three main transmission channels of unconventional monetary policy (UMP) measures are identified: the *portfolio-balance channel* (increase in the demand for other riskier assets, reducing financing costs), the *signaling channel* (reinforcement of the perception that the monetary policy stance will remain loose for

a prolonged period), and the *confidence channel* (increasing investors' risk appetite) (Woodford, 2012; IMF, 2013).

With regards to the analysis of cross-border spillovers (especially to EMEs) of unconventional monetary policy measures, the recent literature also offers some robust results. The overall picture provided by this literature is that asset purchase programs (especially those of the Federal Reserve) encouraged capital flows to EMEs, leading to appreciations of their exchange rates, increases in their stock market indices and contractions in their credit spreads. A number of papers have focused on more specific features. Fratzscher et al. (2013) document that LSAP1 policies induced a portfolio rebalancing from the rest of the world to US, in particular to US bonds lowering their yields. In contrast, LSAP2 policies triggered a rebalancing from US funds to foreign funds, in particular, EME equities. Bowman et al. (2015) found that the effects of US unconventional monetary policy on EMEs' financial assets prices depend on country-specific time-varying characteristics. Comparing the impact of conventional and unconventional measures, Chen et al. (2014) found that unconventional monetary policies had larger spillovers than conventional policies and they argue that this result is explained by structural issues–related to the instruments used during the UMP period–and, to a lesser extent, to weaker EME growth prospects. Gilchrist et al. (2014) also found a substantial pass-through of unconventional US monetary policy to EME bond yields but with larger heterogeneity than that observed in the transmission to advanced economies.

Finally, more recent papers have focused specifically on the cross-border impact of the *tapering talk*. Market reaction to talk of tapering was initially indiscriminate during the bout of volatility in May-June 2013, although later some differential effects relating to fundamentals were observed (Sahay et al., 2014). In particular, Eichengreen and Gupta (2013) and Aizenman et al. (2014) found that the impact was greater in countries that had accumulated external vulnerabilities in

terms of currency appreciation and a deteriorating current account during the previous expansionary period, although liquidity, market depth, and the size of investors' holdings also influenced the magnitude of the spillover effects. Mishra et al. (2014), in keeping with Bowman et al. (2015), showed that countries with stronger fundamentals, deeper financial markets, and a tighter macroprudential policy stance in the run-up to the tapering announcements experienced smaller currency depreciations and smaller increases in government bond yields. Sahay et al. (2014), reviewing the evidence of the cross-border impact of the tapering period, conclude that those countries that responded earlier and decisively to the initial tapering announcements fared better in later episodes of volatility in international financial markets.

This paper adds to this literature in two respects. Its first contribution is to analyze whether the impact of the US nonstandard monetary policies on Latin American economies differs from the impact on other EMEs. In this connection, there are reasons to expect that Latin American economies might be more vulnerable to increases in US interest rates. First, although many Latin American economies have reduced their reliance on dollar-denominated debt, this is still higher than in other EME economies. Second, financial interdependencies with the United States are particularly high within this region. Third, the main export products for most of these economies are commodities whose prices on international markets are set in US dollars. All these factors support the large and significant responses of Latin American macroeconomic variables to US monetary disturbances found in the literature in *normal times* (Canova, 2005) and the higher estimated sensitivity of sovereign bond yields in Latin America to US yields during the taper tantrum episode (IMF, 2014). Nevertheless, if the normalization of US monetary policy mirrors a better US growth performance, for those economies that are close trading partners (for example, Mexico) the positive impulse from stronger US growth is likely to counteract the impact of the rise in US interest rates.

The second contribution of this paper is to explore whether the role of fundamentals in conditioning the responses in EME economies to US unconventional monetary policy shocks differs across different episodes. More precisely, we explore whether country characteristics were more decisive in explaining differences in the reaction to QE announcements than they were in response to the news on the tapering process.

Taking together these two contributions, we want to test whether the impact of US nonstandard monetary policies on Latin American economies differs from the impact on other EMEs and, secondly, whether these differences remain once we control for fundamentals.

The remainder of the paper is organized as follows. In Section 2, using a daily panel data sample for the period from October 2008 to April 2015, we first analyze the effects of US monetary policy announcements on sovereign bond yields, exchange rates, and stock market indices for 20 countries, including five from Latin America. In Section 3, we explore whether the reaction of EME asset prices to US monetary policy differs depending on country-specific characteristics and whether the impact on Latin American asset prices differs from that found for other EMEs. Section 4 summarizes the main results of the paper and identifies some remaining issues.

2. EVENT STUDIES

This section presents an event study to show the effect of US policy changes on emerging markets. We report the results for 2-day changes (from the day before to the day after) in foreign markets after monetary policy announcements, assuming that economic news does not affect the policy choice in that short period of time. The daily data run from October 1, 2008, to April 24, 2015.

In the literature of event studies, there are different methods to identify monetary policy surprises. And in the case of nonstandard monetary policies, the identification tries to

extract information of the signaling channel, the portfolio rebalancing channel and the confidence channel out of the movements in the long-term interest rates, the yield curve, and other asset prices.[1]

Our analysis is much simpler since we do not try to identify monetary policy shocks. As explained below we follow Fratzscher et al. (2013) and measure the impact of the Federal Reserve announcements controlling for market developments. The strong assumption is that within the 2-day window we are able to measure all the policy effect on asset prices (thus, there has not been an anticipation effect by the investors and all the revision of the asset price expectation is taking place within that period). Moreover, around the Federal Reserve announcement, there is no other information affecting asset prices in that window length and the Federal Reserve is not responding to the state of the economy.[2]

Our analysis covers three types of financial assets: 10-year sovereign bonds in local currency, bilateral exchange rates relative to US dollar, and headline stock market indices. Appendix 1 describes the data sources and defines the variables and Appendix 2 presents a summary of statistics. The sample includes the following 20 emerging economies: Brazil, Chile, China, Colombia, the Czech Republic, Hong Kong, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Singapore, South Africa, Taiwan, Thailand, and Turkey. This country sample is similar to others considered recently in the literature but we will also present some robustness analysis.

Table 1 describes the selected set of official announcements and speeches by the Federal Reserve considered since the

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[1] Wright (2012) and Gertler and Karadi (2015), among others, provide alternative VAR identifications of monetary policy shocks during the recent period of unconditional monetary policy in the US.

[2] The results for 1-day and 7-day windows around events do not differ much from those reported in the next section. And similarly when we consider for Asian asset prices opening times in *t+1*.

establishment of unconventional policies in November 2008. The set of events includes announcements relating to the first two large-scale asset purchases (LSAP1 and LSAP2) in 2008-2009 and in 2010, the maturity extension program in 2011 (MEP), the third LSAP (LSAP3) in 2012, the so-called *tapering tantrum* in May-October 2013 and the official tapering period of asset purchases from December 2013 to October 2014. Besides these QE events, we also consider statements on forwarding guidance policy and some speeches by Bernanke that could prompt potential market reactions.

Table 1

LIST OF RELEVANT FOMC MEETINGS AND EVENTS: NOVEMBER 2008 TO OCTOBER 2014

	First Large Scale Asset Purchase (LSAP)	
Nov 25, 2008	Announcement	The Federal Reserve announces the purchases of MBS backed by government agencies, and the creation of TALF.
Dec 1, 2008	Speech (Austin)	Bernanke hints future Treasury purchases.
Dec 16, 2008	FOMC statement	The Federal Reserve cuts the target Federal Funds rate to zero.
Jan 28, 2009	FOMC statement	The Federal Reserve announces the PDCF, the TLSF and the AMFL.
Mar 18, 2009	FOMC statement	The Federal Reserve extends its purchases of MBS and announces that it will start to purchase Treasury securities.
	Second LSAP	
Aug 10, 2010	FOMC statement	The Federal Reserve announces it is willing to buy long-term Treasury securities through reinvestment of payments of its MBS.
Aug 27, 2010	Speech (Jackson Hole)	Bernanke's speech at Jackson Hole.
Sep 21, 2010	FOMC statement	According to the FOMC, the short-term interest rate will stay at low levels for a long period of time.
Oct 15, 2010	Speech (Indiana)	According to Bernanke, new measures might be necessary.
Nov 2, 2010	FOMC statement	The Federal Reserve decides to purchase additional 600 billions of dollars of long-term Treasury securities.

	Maturity Extension Program (MEP)	
Aug 09, 2011	FOMC statement	According to the FOMC, the short-term interest rate will stay at low levels for a long period of time and will take new measures if necessary.
Aug 26, 2011	Speech	Bernanke's speech at Jackson Hole.
Sep 21, 2011	FOMC statement	The Federal Reserve announces its Maturity Expansion Program.
	Third LSAP	
Aug 22, 2012	FOMC minutes	The Federal Reserve will take new measures if necessary.
Aug 31, 2012	Speech (Jackson Hole)	Bernanke suggests new QE.
Sep 13, 2012	FOMC statement	The Federal Reserve announces new quantitative easing.
	Events in 2013	
Mar 20, 2013	FOMC statement	The Federal Reserve will continue its accommodative monetary policy until certain goals of unemployment and inflation are reached.
May 01, 2013	FOMC statement	FOMC: accommodative monetary policy will be held for a long period of time.
	Taper Talk Period	
May 22, 2013	FOMC minutes and testimony	Bernanke suggests the end of expansive monetary policy.
Jun 19, 2013	FOMC statement	The Federal Reserve suggests that *tapering* could begin next year.
Jul 11, 2013	FOMC minutes and speech (NBER)	Bernanke says that the central bank's easing of monetary policy would continue for the foreseeable future.
Oct 30, 2013	FOMC statement	The Federal Reserve decides to continue its accommodative monetary policy.
Dec 18, 2013	FOMC statement	*Tapering* is officially announced.
	Events in 2014	
Sep 17, 2014	FOMC statement	Announcement of policy normalization principles and plans.
Oct 29, 2014	FOMC statement	Concluded tapering period. Starts *indefinite* forward guidance.

Figure 1 shows the time series for the aggregate index for EMEs, Latin American and US sovereign yields (panel A) and the aggregate index for EMEs and Latin American exchange rates with respect to the US dollar (panel B) along with the stock market indices (panel C). This figure provides some insight into the relation between US unconventional monetary policy phases and EME financial asset prices. First, a comovement between US sovereign yields and EME (and Latin American) yields is observed, and it is clearer in the case of the LSAP1 and tapering periods. Second, the relation between US unconventional monetary policy measures and EME stock market prices and exchange rates is less clear. Third, the series of Latin American financial asset prices display wider fluctuations than the corresponding aggregate EME series.

Figure 2 shows the time series for the aggregate capital inflows for different regions. In the aftermath of the global financial crisis, capital flows displayed a steep upward trend in most emerging market regions and particularly in Latin America, while the increase in advanced economies was less marked.

2.1 Emerging (and Latin American) Market Reactions

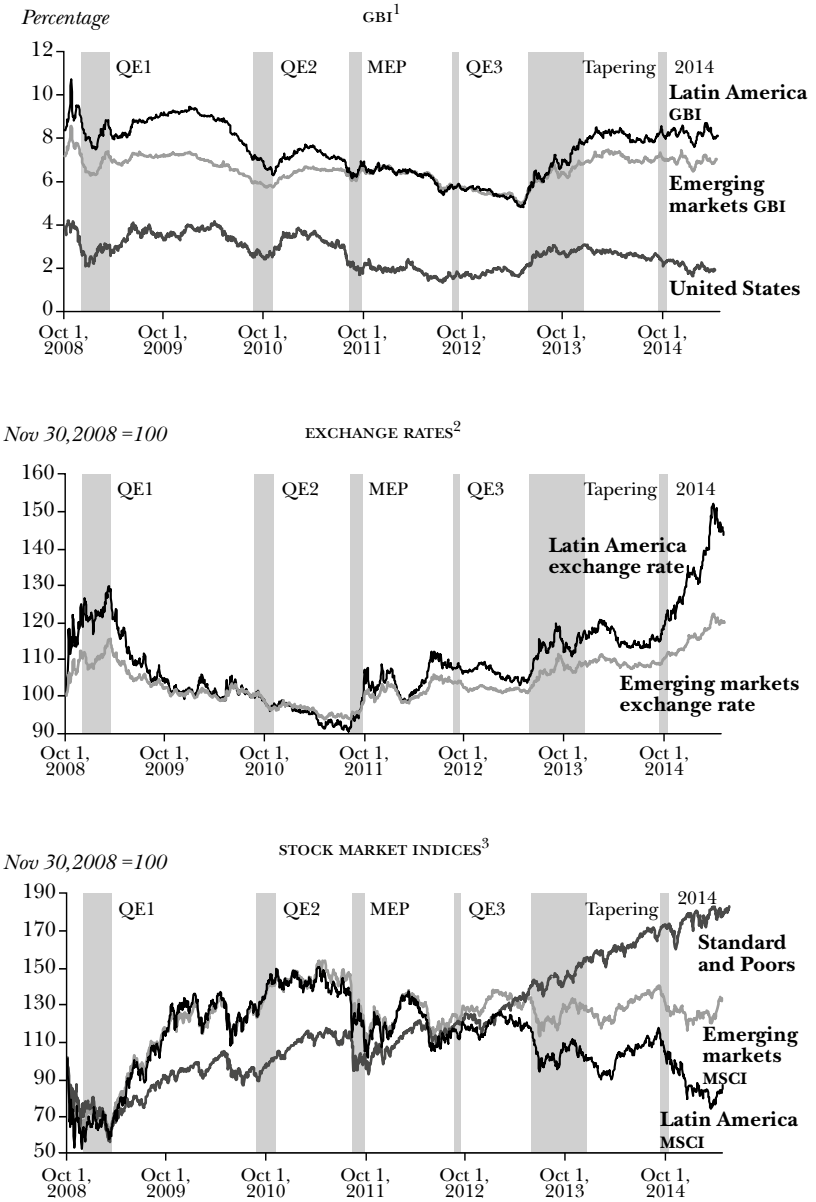
The standard event-study specification to test the impact of unconventional monetary measures would be:

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it}\right] + \sum_{j=1}^{25} \beta_j * D_j + \varepsilon_{it}, \quad (1)$$

where Δy_{it} is the change in the financial variable of interest, $E_{it-1}\left[\Delta y_{it}\right]$ denotes the expected change in this variable in absence of shocks, and β_j is the coefficient associated with the dummy of each unconventional policy announcements (D_j).

Tables 2, 3 and 4 report the 2-day changes in sovereign yields, exchange rates, and stock prices, respectively, around the 25 selected dates of the announcements. As a reference, in each table, we include a first column that reports the estimated

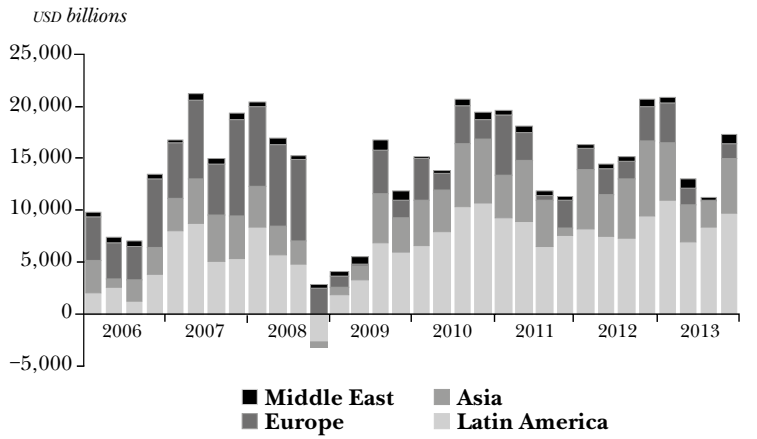
EMERGING MARKET ASSET PRICES AND US FINANCIAL VARIABLES



Sources: [1] JP Morgan and Federal Reserve Board. [2] National sources and own calculations. [3] Standard and Poors, and Morgan Stanley.

Figure 2

EMERGING ECONOMIES: CAPITAL INFLOWS CHANGING DISTRIBUTION (2004-2013)



Source: IFS, International Monetary Fund.

changes in the US variable,[3] a second column with the changes in the corresponding aggregate EME index and a third column with the responses in a similar aggregate LATAM index. The fourth and fifth columns report the coefficients for a regression that considers as dependent variables each of the assets not only with time variation but also with a country variation:

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it}\right] + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}, \quad (2)$$

where β_j is the coefficient associated with the dummy of each event (D_j) and γ_j refers to the interaction coefficient of the event dummy with a Latin American dummy (Lat). Thus, the coefficients reported in column 4 (β_j) represent the average change of the dependent variable at date j for a non-Latin American

[3] This first column is not included in the case of the changes in the exchange rate (Table 3).

country, while the sum of the coefficients reported in columns 4 and 5 ($\beta_j + \gamma_j$) represent the average change of the dependent variable at date j for a Latin American country.[4]

We followed Fratzscher et al. (2013) and included a set of financial variables that approximate the expected component of the variable of interest: the lagged dependent variable, the change in the VIX, the change in the US 10 years sovereign bond yield, a liquidity spread (US 3-months OIS minus US T-bill 3-months), the change in the S&P500 index and the change in the local equity index (all dated in $t-1$). We also considered country fixed effects. The high frequency of the regression (daily data) limited the inclusion of real variables as additional controls.

US yields (first column in Table 2) dropped significantly around the first LSAP announcements, except for the January 28, 2009, event, at which time the yield rose. Fluctuations in US yields are smaller and less significant around the second and third LSAP, and they are again significant around two of the MEP announcements. Finally, the only significant reversal event with respect to yields is on June 19, 2013, when the FOMC suggested that tapering could begin in 2014. Other US assets such as the stock market index (reported in Table 4) show more mixed results. The number of significant events is lower and in some cases a fall is observed after the expansionary QE announcements.

Looking now at foreign assets, the changes in the EME aggregate yield index (GBI-EM in column 2, Table 2) are less uniform and of a lower magnitude. As in the case of the United States, the most significant events are those around the LSAP1 and the tapering. The changes in EME exchange rates and the stock market indices are relevant around the same dates although in general with a lower significance. The results for the LATAM

[4] It is worth mentioning that the sample includes only five Latin American countries (the five largest inflation targeters in the region). For this reason, the results should not be extrapolated to other economies of the region, that in many cases have very different characteristics.

Table 2

EVENT STUDY FOR CHANGES IN SOVEREIGN YIELDS: DAILY DATA
(November 30, 2008 to April 24, 2015)

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it}\right] + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$$

Dates	*US yields*	*EME GBI index*	*LATAM GBI index*	*Event effect* (β)	*LATAM effect* (γ)
			First LSAP		
Nov 25, 2008	−33.84[c]	−21.46[c]	−22.24[b]	−4.80[a]	12.12[b]
Dec 1, 2008	−26.46[c]	−2.86	−25.04[b]	−1.54	−40.16[c]
Dec 16, 2008	−33.23[c]	−16.86[b]	12.74	−2.26[c]	4.08
Jan 28, 2009	29.88[c]	9.24	10.46	3.73	3.75
Mar 18, 2009	−40.31[c]	−5.86	9.84	−0.78	−1.44
			Second LSAP		
Aug 10, 2010	−14.59[a]	−2.96	−6.84	−1.31	−3.53
Aug 27, 2010	5.28	4.14	7.36	−0.00	0.04
Sep 21, 2010	−14.25[a]	−3.26	−2.84	2.28	−4.26
Oct 15, 2010	0.64	1.34	3.66	2.40	4.80
Nov 3, 2010	−12.58	−2.06	0.00	1.73	0.83
			MEP		
Aug 9, 2011	−19.87[b]	−8.06	−13.14	−2.61	6.62
Aug 26, 2011	5.33	−5.56	−10.44	1.13	−6.04
Sep 21, 2011	−22.57[c]	17.24[b]	21.36[b]	2.82	14.16[b]

			Third LSAP		
Aug 22, 2012	−13.87[a]	−7.36	−11.94	−1.71	−0.14
Aug 31, 2012	−6.47	−3.87	−1.94	−1.39	3.55
Sep 13, 2012	10.63	4.04	4.36	0.63	4.70
			Events in 2013		
Mar 20, 2013	2.19	2.01	3.06	0.02	3.45
May 1, 2013	−4.49	−3.89	−1.84	−0.53	−0.66
May 22, 2013	8.03	9.84	12.86	3.23	6.56
Jun 19, 2013	23.84[c]	36.64[c]	46.76[c]	16.61[c]	7.77
Jul 11, 2013	−7.56	−5.26	−9.54	−2.42	−1.06
Oct 30, 2013	3.76	18.04[b]	35.06[c]	4.15	4.05
Dec 18, 2013	8.37	1.84	−0.24	3.64	4.95
			Events in 2014		
Sep 17, 2014	4.15	1.54	0.02	1.94	3.03
Oct 29, 2014	2.44	5.24	0.12	1.07	−0.75

Note: Column 2 reports the changes in US 10-year sovereign yields. Columns 3 and 4 report the changes in two aggregate indices. Columns 5 and 6 report the average country changes and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence level. $E_{it-1}\left[\Delta y_{it}\right]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1*): the lagged dependent variable, the change in the VIX, the change in US 10 years sovereign bond yield, a liquidity spread (US 3-months OIS minus US T-bill 3-months), the change in the S&P500 index, the change in the local equity index, and country fixed effects.

Table 3

EVENT STUDY FOR CHANGES IN EXCHANGE RATES (DEPRECIATION DATA): DAILY DATA

September 30, 2008 to April 24, 2015

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it}\right] + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$$

Dates	*EME index*	*LATAM index*	*Event effect* (β)	*LATAM effect* (γ)
		First LSAP		
Nov 25, 2008	−0.76[a]	−1.46	0.01	0.20
Dec 1, 2008	0.89[b]	0.81	−0.16	−0.40
Dec 16, 2008	−0.96[b]	−1.11	−1.00[c]	0.14
Jan 28, 2009	0.05	−0.69	1.13[c]	−0.49
Mar 18, 2009	−0.74[a]	−0.39	−0.53[b]	2.07[c]
		Second LSAP		
Aug 10, 2010	0.55	0.56	0.96[c]	−0.57
Aug 27, 2010	0.01	0.07	0.07	−0.12
Sep 21, 2010	−0.36	−0.44	−0.39	0.56
Oct 15, 2010	0.19	0.07	0.80[c]	−0.73
Nov 3, 2010	−0.62	−0.99	−0.47[b]	0.23
		MEP		
Aug 9, 2011	0.19	0.42	−0.21	0.02
Aug 26, 2011	−0.35	−0.55	−0.42[a]	0.07
Sep 21, 2011	1.67[c]	5.12[c]	1.07[c]	1.50[c]

		Third LSAP		
Aug 22, 2012	−0.19	0.17	−0.14	0.10
Aug 31, 2012	−0.33	−0.95	−0.29	−0.15
Sep 13, 2012	−0.62	−1.00	−0.54[b]	0.23
		Events in 2013		
Mar 20, 2013	0.08	0.11	0.13	−0.07
May 1, 2013	−0.21	0.27	−0.20	0.29
May 22, 2013	0.51	0.66	0.30	0.05
Jun 19, 2013	1.46[c]	3.43[c]	1.08[c]	0.87[a]
Jul 11, 2013	−0.34	−0.42	−0.17	0.02
Oct 30, 2013	0.32	0.83	0.33	0.19
Dec 18, 2013	0.51	0.82	0.64[c]	−0.04
		Events in 2014		
Sep 17, 2014	0.27	0.65	0.44[a]	−0.19
Oct 29, 2014	−0.02	−1.80[a]	0.37	−0.98[b]

Note: Columns 2 and 3 report the changes in two aggregate indices. Columns 3 and 4 report the average country changes and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels. $E_{it-1}\left[\Delta y_{it}\right]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1):* the lagged dependent variable, the change in the VIX, the change in US 10 years sovereign bond yield, a liquidity spread (US 3-months OIS minus US T-bill 3-months), the change in the S&P500 index, the change in the local equity index, and country fixed effects.

Table 4

EVENT STUDY FOR CHANGES IN STOCK MARKET INDEX: DAILY DATA
November 30, 2008 to April 24, 2015

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it}\right] + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$$

Dates	*US S&P 500*	*MSCI EME index*	*MSCI LATAM index*	*Event effect* (β)	*LATAM effect* (γ)
			First LSAP		
Nov 25, 2008	4.12[b]	5.66[c]	6.23[b]	0.19	−1.28
Dec 1, 2008	−5.38[c]	−4.94[b]	−7.99[c]	−0.58	1.34
Dec 16, 2008	4.04[b]	4.12[a]	6.25[b]	0.65	1.93[b]
Jan 28, 2009	−0.15	2.50	2.49	−0.75[a]	−0.49
Mar 18, 2009	0.67	2.81	3.10	0.44	−0.28
			Second LSAP		
Aug 10, 2010	−3.49[a]	−3.38	−3.80	−1.67[c]	−0.37
Aug 27, 2010	0.08	0.59	0.66	0.18	−0.07
Sep 21, 2010	−0.82	0.31	−0.22	−0.54	−0.02
Oct 15, 2010	0.84	−1.37	−0.18	−0.52	0.00
Nov 3, 2010	2.22	2.34	3.07	1.03[b]	−0.24
			MEP		
Aug 9, 2011	0.03	−1.01	3.79	0.18	5.15[c]
Aug 26, 2011	4.30[b]	3.19	4.12	1.34[c]	1.57[a]
Sep 21, 2011	−6.12[c]	−7.47[c]	−9.57[c]	−3.55[c]	−0.32

			Third LSAP		
Aug 22, 2012	−0.87	−0.20	−0.80	−0.10	−0.23
Aug 31, 2012	0.42	0.84	0.92	0.96[b]	−0.78
Sep 13, 2012	1.95	3.58[a]	3.58	1.10	−0.09
			Events in 2013		
Mar 20, 2013	−0.25	−0.30	−0.22	−0.03	0.34
May 1, 2013	−0.09	−0.26	−1.07	0.07	−0.01
May 22, 2013	−1.20	−2.17	−1.43	−1.11[c]	1.19
Jun 19, 2013	−3.94[b]	−4.78[b]	−6.57[b]	−3.03[c]	−0.23
Jul 11, 2013	1.58	3.19	1.84	1.34[c]	−0.73
Oct 30, 2013	−0.96	−0.28	−1.05	−0.56	0.22
Dec 18, 2013	1.52	−0.04	0.72	−0.54	0.54
			Events in 2014		
Sep 17, 2014	0.53	0.16	−1.16	0.44	−0.94
Oct 29, 2014	0.40	1.46	2.27	0.18	−0.32

Note: Column 2 reports the changes in the S&P500 returns. Columns 2 and 3 report the changes in two aggregate return indices. Columns 4 and 5 report the average country change and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels. $E_{it-1}[\Delta y_{it}]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1):* the lagged dependent variable, the change in the VIX, the change in US 10 years sovereign bond yield, a liquidity spread (US 3-months OIS minus US T-bill 3 months), the change in the S&P500 index, and country fixed effects.

aggregate yield index (column 3 in Table 2) are similar and, in a number of cases, of a larger size. The different response of assets has already been reported by, among others, Bowman et al. (2015). More generally, the decreasing effect of the different QE programs has been documented in the US economy (for example, Krishnamurthy and Vissing-Jorgensen, 2011) and internationally (for example, Fratzscher et al., 2013).

The last two columns in Table 2 allow us to see whether the movements in sovereign yields around the relevant events are significant once we control for the proxies of the expected component of the yield and allow for country variability and whether these responses differ in the Latin American countries with respect to other emerging market economies. EME yields decreased on average two basis points within the LSAP1 period and the fall was more significant after the December 16, 2008, announcement when the Federal Reserve cut the federal funds rate to zero. We do not find that the Latin American countries have a systematic differential response.

The decreasing effect of subsequent QE programs in EME economies is clear since the movements in yields are not significant between 2010 and 2012. Nevertheless, when Operation Twist was launched in September 2011, there was a significant interest rate increase for Latin America. Finally, during the tapering period, yield increases were found around June 2013. The size of the yield change was larger than the one during the LSAP1 period and the reaction for Latin American countries was not significantly different.

A monetary shock that lowers US yields also generates an appreciation of the EME currencies (Table 3) and an increase in the stock market indices of the EME economies (Table 4). Contrary to Fratzscher et al. (2013) results, we do not find evidence of a significant US dollar appreciation during the LSAP1 period and that would support a portfolio rebalancing out of EME assets into US assets.

Interestingly, the EME movements in exchange rates and stock markets are more significant when we control for the expected component in the changes of these variables and the

cross-country dimension of the data is taken into account than when looking to aggregate indices. And we found more significant events for the EME coefficient with these two assets than with the yields. The LSAP1 caused a dollar depreciation of 1% on December 16, 2008, and an increase of stock market of 2% just for Latin American indices.[5] Nevertheless, other events did not have the expected sign coefficient. In the case of exchange rate fluctuations, the depreciation after the June 2013 FOMC announcement of tapering was significantly greater in Latin America. This same pattern was also observed around the March 2009 LSAP1 announcement, but in this case Latin America and aggregate EME moved in opposite directions. The MEP announcement in September 2011 had a significant negative impact on equity markets internationally and induced a cross-country rebalancing on bonds, especially out of Latin American yields and into US bonds that appreciated the dollar significantly, particularly against Latin American currencies. After the October 2014 FOMC meeting, when the tapering process concluded and an indefinite forward guidance policy was announced, the aggregate Latin American exchange rate against the US dollar appreciated. Thus, it seems that Latin American exchange rates were more sensitive in a few cases to some of the US monetary shocks. Similarly, there is evidence of a significantly higher stock market response for the Latin American countries in three events: the announcement on December 16, 2008; August 9, 2011, when the FOMC assured that interest rates would remain exceptionally low over the period to mid-2013; and Bernanke's speech at Jackason Hole on August 26, 2011.

In sum, a simple time series analysis of US unconventional monetary policies shows that they have had a more significant effect across EME asset prices after the LSAP1 (2008-2009) and the tapering (2013) periods with some excess response

[5] When the regression analysis was repeated eliminating the five countries with higher per capita income the significant events and their coefficients remain very much the same.

by Latin American assets. Comparing the three asset prices, the exchange rate is the variable which has more significant events, consistently with the relevance of the exchange rate channel in the transmission of monetary shocks to EME economies (Taylor, 2013).

3. TRANSMISSION OF US MONETARY POLICY

This section examines the role played by country characteristics in financial market reactions to the Federal Reserve's policy actions. We first make use of the previous event study framework and analyze differences in transmission between the previously identified positive and negative events. In the second part, we study country heterogeneity in a monthly panel data set-up modeling a specific transmission channel. In both cases, we test whether or not Latin American countries follow different patterns in response to the exogenous policy announcements relative to the sample of emerging market economies (EMEs).

The country characteristics are detailed in Appendix I. They can be classified in four categories: *1)* macro fundamentals: GDP growth, inflation, and public debt/GDP; *2)* financial market conditions: CDS spread and the policy interest rate; *3)* external conditions: reserves/GDP, current account/GDP, external debt/GDP, short-term external debt/GDP, net banking position/GDP, portfolio flows/GDP, nominal exchange rate deviation, and the accumulated change in the real exchange rate; and *4)* structural characteristics: an index of financial openness; exports to the United States/GDP and stock market capitalization (relative to GDP). Note that among the external conditions, we have included two exchange rate indicators that measure the competitiveness gains in the most recent period, and that among the structural variables we have included stock market capitalization as a proxy of financial market size.

Some of these characteristics may represent country vulnerabilities in the sense that the market reaction of those country assets could be stronger in response to an exogenous shock. Others represent country strengths and the market reaction to the US monetary policy announcement might be negatively

correlated with them. However, for variables that measure the level of financial and real integration as well as the change in competitiveness, the effect may be more uncertain.

3.1 Market Reaction and Country Characteristics: Sample of UMP Events

We initially estimate a set of regressions by pooling the identified 25 policy events across the 20 EMEs. The dependent variable Δy_{ij} is the 2-day change for one of three financial asset prices considered in country i and event date j. The explanatory variables, besides the country fixed effect, include each of the country characteristics (CC_{it-1}), a dummy variable (D_j^s) for the selected events that were significant (positively or negatively) in the previous time-series regression, and the interaction between the significant event dummies and the country characteristics. The specification is:

$$\Delta y_{ij} = E_{it-1}\left[\Delta y_{ijt}\right] + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}. \quad (3)$$

The regression with a positive event considers the December 12, 2008 LSAP1 date that became significant across EME or Latin American economies in regression 2. And the regression with the negative event considers the June 19, 2013, significant date during the tapering talk by the Federal Reserve. We use the same set of controls than in the event study and all the characteristics are lagged one month to avoid correlation with the error term.

Table 5 presents the regression results for changes in sovereign bond yields. For each of the country characteristics, the left-hand side of the table reports the estimated coefficients for the regression with the dummy variable under the significant LSAP1 event and the interaction of the dummy with the characteristics. The right-hand side of the table reports the regression results under the significant tapering event.[6]

[6] We do not report the general vulnerability coefficients since we are only interested in the effects around the significant policy events.

Table 5

EFFECT OF THE LSAP1 AND THE TAPERING TALK PERIODS ON EMERGING MARKET YIELDS AND THEIR RELATION TO COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = E_{it-1}\left[\Delta y_{it}\right] + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}$$

	LSAP1 period		*Tapering talk period*	
	Dummy (β)	Dummy*CC (δ)	Dummy (β)	Dummy*CC (δ)
	Macroeconomic variables			
GDP	−0.096	−0.007	0.155[c]	−0.000
Inflation	0.245[c]	−0.059[c]	0.109[a]	0.013
Debt	−0.060	−0.001	0.230[c]	−0.002
	Market conditions			
Policy rate	0.068	−0.027[c]	0.222[b]	−0.012
CDS	0.578[c]	−0.002[c]	0.164	0.000
	External variables			
Current account to GDP	−0.139[c]	0.010[a]	0.151[c]	−0.012[a]
Reserves to GDP	−0.272[c]	0.005[c]	0.189[c]	−0.001
External debt to GDP	−0.140	0.000	0.166[b]	−0.000
Portfolio flows to GDP	−0.136[b]	0.004	0.108	0.020
Net banking position to GDP	−0.138[b]	0.002	0.149[c]	−0.003
Exchange rate deviation	−0.120[a]	−0.001	0.178[c]	−0.002
Real exchange rate	−0.121[b]	0.002	0.153[c]	−0.000
	Structural variables			
Market size (capitalization to GDP)	−0.145[c]	0.000	0.152[c]	−0.000
Real integration (exports to US to GDP)	−0.141[b]	0.006	0.140[c]	0.001
Financial integration (Chinn Ito index)	−0.145[b]	0.016	0.153[c]	0.019

Notes: this table reports the set of regressions pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period, the date considered is December 16, 2008. In the tapering talk period, the date is June 19, 2013. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels. $E_{it-1}\left[\Delta y_{it}\right]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1):* the lagged dependent variable, the change in the VIX, the change in the US 10 years sovereign bond yield, a liquidity spread (US 3-months OIS minus US T-bill 3-months), the change in the S&P500 index, and country fixed effects.

First, the dummy variable for most of the country characteristics is significant and has a negative effect for the LSAP1 events (reducing yields) and a positive effect for the tapering events (increasing yields). By contrast the inflation rate and the CDS correlate positively with the first UMP event. In general, the significance around these events, their sign, and magnitude is consistent with the average event estimates in Table 2.

A second result is that a number of the interaction coefficients (five) are significant under the LSAP1 whereas they are not so under the tapering events. Thus, we can say that on impact, the tapering had a more indiscriminate effect across EMEs whereas the LSAP1 had a differential effect across countries depending on the country characteristics. During the LSAP1 period countries with a higher inflation rate, higher CDS spread, and higher policy rate yields responded more to the US monetary shock whereas countries with higher current account surpluses or higher reserves yields responded less. The size of these effects is nonnegligible: A one standard deviation increase in CDS (92.4 bp), the inflation rate (2.9%) and the policy rate (2.8%) implies an additional reduction in sovereign yields after LSAP1 announcement of 20 bp, 17 bp and 8 pb, respectively, while a one standard deviation increase in the reserves to GDP ratio (28%) and the current account to GDP ratio (6.28) implies an increase in sovereign yields after LSAP1 announcement of 14 bp, and 6 pb, respectively.

The results are less relevant when the dependent variable is the change in exchange rates during the LSAP1 event (see Table 6). Only in some regressions, the dummy for that event is significant and there is only one country characteristic that interact significantly with the first set of unconventional Federal Reserve policies, which was also significant in the yields regression–the domestic policy rate. By contrast, some of the country characteristics become significant when interacting with the tapering period: Countries with higher output growth and higher reserves experimented lower depreciations of their currencies.

Table 6

EFFECT OF THE LSAP1 AND THE TAPERING TALK PERIODS ON EMERGING MARKET EXCHANGE RATES AND THEIR RELATION TO COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = E_{it-1}\left[\Delta y_{it}\right] + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}$$

	LASP1 period		*Tapering talk period*	
	Dummy (β)	Dummy*CC (δ)	Dummy (β)	Dummy*CC (δ)
	Macroeconomic variables			
GDP	−1.124[b]	0.097	1.828[c]	−0.295[c]
Inflation	−0.446	−0.062	0.897[b]	0.012
Debt	−0.590	−0.006	−0.026	0.021[b]
	Market conditions			
Policy rate	0.157	−0.125[a]	0.679	0.104
CDS	0.567	−0.003	−0.075	0.007
	External variables			
Current account to GDP	−0.917[c]	0.054	0.949[c]	−0.058
Reserves to GDP	−1.186[c]	0.013	1.500[c]	−0.016[b]
External debt to GDP	0.124	−0.033[b]	0.284	0.023[b]
Portfolio flows to GDP	−0.999[b]	0.031	1.160[b]	0.012
Net banking position to GDP	−1.018[b]	0.011	1.175[c]	−0.004
Exchange rate deviation	−0.424	−0.024	1.316[c]	0.007
Real exchange rate	−0.669[a]	−0.019	1.086[c]	0.016
	Structural variables			
Market size (capitalization to GDP)	−0.879[b]	0.001	1.145[c]	−0.002[a]
Real integration (exports to US to GDP)	−0.772[a]	0.012	0.759[b]	0.026
Financial integration (Chinn-Ito index)	−0.547	−0.302	0.866[c]	0.269

Notes: this table reports the set of regressions pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period, the date considered is December 16, 2008. In the tapering talk period, the date is June 19, 2013. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels. $E_{it-1}\left[\Delta y_{it}\right]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1):* the lagged dependent variable, the change in the VIX, the change in the US 10 years sovereign bond yield, the change in the S&P500 index, and country fixed effects.

Therefore, there are differential effects of the sovereign interest rates during the LSAP1 period depending on variables proxying vulnerabilities and strengths of these economies. However, the bond yield responses around the first two months of the tapering process are consistent with the indiscriminate impact of the earlier events in this process, although market differentiation was gradually becoming more relevant later on (Sahay et al., 2014). Moreover, when the analysis is carried out with the exchange rates we found that the impact of the taper talk was significantly related to some macroeconomic fundamentals. Thus, the results with this asset are more in line with the ones found by Mishra et al. (2014).

Next, we examine whether there are additional specific Latin American effects besides those captured by the country characteristics. To that end, we repeat the estimation of Equation 3, adding an interaction effect with a Latin American dummy (*Lat*) for each of the previous variables considered. The specification is as follows:

$$\Delta y_{ij} = E_{it-1}\left[\Delta y_{it}\right] + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \eta Lat D_j^s + \\ + \lambda Lat\, CC_{it-1} + \rho Lat D_j^s CC_{it-1} + \varepsilon_{it}. \quad (4)$$

The estimation results for Equation 4 with sovereign yields as the dependent variable and under the relevant LSAP1 events are presented in Table 7.[7] As in the previous regression, we find a negative and significant dummy interactions with the country characteristics that remain significant and with the expected sign for the same variables: inflation, CDS spreads, policy rates, reserves and the current account. But the interaction of the LSAP1 event and the *Lat* dummy is weakly significant for a few cases. And a similar result holds for the regression with the dummy for the tapering talk events and the interaction with the *Lat* dummy.

[7] The magnitude of the effects is similar to that of the results reported in Table 5.

Table 7

EFFECT OF THE LSAP1 ON EMERGING AND LATIN AMERICAN ECONOMIES YIELDS DEPENDING ON THEIR COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = E_{it-1}\left[\Delta y_{it}\right] + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \eta LatD_j^s + \lambda LatCC_{it-1} + \rho LatD_j^s CC_{it-1} + \varepsilon_{it}$$

	Dummy (β)	*Dummy*CC* (δ)	*Dummy*Lat* (η)	*Dummy*Lat*CC* (ρ)
	Macroeconomic variables			
GDP	−0.092	−0.015	−0.034	0.026
Inflation	0.253[c]	−0.066[c]	−0.458	0.086[a]
Debt	−0.207[b]	0.001	0.419[b]	−0.009[b]
	Market conditions			
Policy rate	−0.007	−0.025[b]	0.378[a]	−0.023
CDS	0.546[c]	−0.002[c]	−0.494	0.002
	External variables			
Current account to GDP	−0.186[c]	0.014[b]	−0.360	−0.271[b]
Reserves to GDP	−0.355[c]	0.006[c]	−0.052	0.014
External debt to GDP	−0.171	−0.000	−0.226	0.014[b]
Portfolio flows to GDP	−0.190[b]	0.005	0.114	0.009
Net banking position to GDP	−0.192[b]	0.002	0.149	0.000
Exchange rate deviation	−0.179[b]	0.003	0.147[a]	−0.008
Real exchange rate	−0.147[b]	0.002	0.099	0.002
	Structural variables			
Market size (capitalization to GDP)	−0.177[c]	0.000	−0.090	0.005
Real integration (exports to US to GDP)	−0.217[c]	0.017	0.209[a]	−0.022
Financial integration (Chinn-Ito index)	−0.154[b]	−0.011	−0.069	0.137

Notes: this table reports the set of regressions pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period, the date considered is December 16, 2008. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels. $E_{it-1}\left[\Delta y_{it}\right]$ represents the expected change in the dependent variable in the absence of shocks. This expected component is captured by including the following controls (all dated in *t−1):* the lagged dependent variable, the change in the VIX, the change in US 10 years sovereign bond yield, the change in the S&P500 index, and country fixed effects.

We consider the above regression results as weak evidence of an independent effect coming out of the Latin American economies, once the country characteristics are taken into account to explain the EME country heterogeneity when facing US monetary policy shocks. That spillover result is in line with the weak evidence found for the excess response on Latin American asset prices in the event study section.

3.2 Channels of Transmission

This section estimates a simple model for the transmission of unconventional US monetary policy. The objective is to analyze whether the observed asset price responses for EME economies found in the event study (Section 2) correspond to the implied model response.

We adopt the specification of Bowman et al. (2015), which distinguishes the monetary policy effect through US 10-year sovereign yields $\left(\Delta Y_{sovt}^{US}\right)$ and high-yield corporate bond spreads $\left(\Delta Y_{hyt}^{US}\right)$:

$$\Delta y_{it} = \alpha_i + \delta \Delta y_{it-1} \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y_{sovt}^{US} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y_{hyt}^{US} + \delta Z_t + \varepsilon_{it}. \quad (5)$$

Thus, we characterize for the transmission of US monetary shocks through the interest rate channel $\left(\Delta Y_{sovt}^{US}\right)$ and the risk channel $\left(\Delta Y_{hyt}^{US}\right)$ that has been found for the US economy at the zero lower bound.[8] The specification considers how international spillover differences may depend on the country characteristics (CC_{it-1}), consistent with the evidence presented in the previous section around policy events. The specification 5 also includes a set of control variables (Z_t) to explain the changes in EME asset prices: the VIX index, the change in commodity price index, and the change in the return on the S&P500 index. We include them contemporaneously because we think they are not affected by changes in the countries' financial variables. Moreover, the lagged dependent variable is included to

[8] More precisely, following Bowman et al. (2015) relies on the findings in Wright (2012), Rogers et al. (2014) and Bowman et al. (2015) that US monetary policy shocks have a significant effect on the yields US sovereign and corporate bonds.

control for the serial correlation component. The model is estimated with monthly data for the period from October 2008 to December 2014.

The estimation results, including one country characteristic at a time, for yields, exchange rates, and the stock market index are reported in Tables 8, 9 and 10, respectively. The standard deviations of the estimated coefficients are computed using the SUR method in order to correct for the potential cross-section and time correlation of the residuals. We report the coefficients of the interactions of the country characteristics with the changes in both US sovereign yields and high-yield corporate bonds (β_2 and γ_2) and their significant value. Later on (Table 11), we report the joint estimation results for the sovereign yields including a set of country characteristics with the highest explanatory power.

In the panel regression of EME sovereign yields (Table 8), inflation is the only macroeconomic variable with significant interactions. Countries with higher inflation are experiencing a higher response to fluctuations in US sovereign yields and in high-yield bond spreads. But we do not find a similar result for the public debt ratio or GDP growth. Agents seem to be more concerned with the real return of their investments what may explain the significance of inflation. The market conditions measured by a high CDS spread or a high policy rate also positively affect the response to US fluctuations since they may be proxies for financial risk. Most of the eight external variables considered are significant. The current account, reserves, portfolio flows, and the net lending banking position, all measure the strengthening of the external position of the country and consequently reduce the variability of yields to US shocks. The external debt to GDP does not prove to be significant[9] and the outstanding international debt appears with the sign opposed to the expected one. Similarly, the last year's cumulative real appreciation reflect vulnerability but it causes a reduction of interest rates instead of an increase when facing an external shock.

[9] Non-financial corporations' external debt has raised after the global financial crisis in many EMEs. The interaction of that variable in regression 4 was significant but with the sign opposed to the expected one.

Table 8

REACTION OF EMERGING MARKET YIELDS TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \delta \Delta y_{it-1} + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

	US sovereign yield (β_2)	*US high yield spread* (γ_2)	R^2 *gains*
Macroeconomic variables			
GDP	−0.011	−0.003	0.07
Inflation	0.126[c]	0.020[c]	4.65
Debt to GDP	0.001	0.001[b]	0.12
Market conditions			
Policy rate	0.151[c]	0.028[c]	6.27
CDS	0.004[c]	0.001[c]	6.32
External variables			
Current account to GDP	−0.034[c]	−0.010[c]	1.64
Reserves to GDP	−0.008[c]	−0.003[c]	1.67
External debt to GDP	−0.001	0.001	0.53
Portfolio flows to GDP	−0.038[b]	−0.009[b]	0.44
Net banking position to GDP	−0.006[c]	−0.002[c]	0.23
Exchange rate deviation	0.001	−0.001	0.15
Real exchange rate increase	−0.021[c]	−0.005[c]	0.83
Outstanding international debt	−0.016[a]	−0.011[c]	0.73
Structural variables			
Market size (capitalization to GDP)	−0.033[c]	−0.022[c]	0.68
Real integration (exports to US to GDP)	−0.015[a]	−0.001	0.16
Financial integration (Chinn-Ito index)	−0.039	−0.013	0.10

Note: Δy_{it} is the one-month change in each EME sovereign bond yield. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations are computed using the SUR (PCSE) method in order to control for the potential cross-section and time correlation of the residuals.

As for the three structural variables considered, we find that market size is significant: a bigger market size and thus a more liquid financial system reduces the response of yields to a financial shock. We also find that the real integration variable is marginally significant.

Table 9 presents the estimation results for the panel data model with the EME exchange rates. An increase in the bilateral rate against the dollar represents a depreciation of the EME currency. Interestingly, a similar group of country characteristics to the yields equation affect the exchange rate fluctuations in a significant way. Higher inflation, higher policy rates, higher CDS spreads, lower reserves, a lower current account, lower portfolio flows, lower net lending banking position and a lower market capitalization depreciate the exchange rate more after an increase in US sovereign yields or in high-yield spreads. Table 10 shows the estimation results for the EME stock market returns. The number of significant country characteristics is smaller and the risk channel plays a more important role in this case.

We conducted some robustness exercises controlling for domestic variables besides global ones in regression 5. For example, when the Z_{it} vector includes the countries' policy rate, inflation rate, and output growth, the same country characteristics became significant with the exception of the market size.

Moreover, once each of these characteristics is introduced into the panel regression, there is not a significant common Latin American dummy to explain any of the three asset price movements.[10] That reinforces the previous specific event analysis (QE1 and tapering) where there was no a strong evidence of excess sensitivity for Latin American economies to US monetary disturbances once country-specific fundamentals are taken into account.

[10] These results are not reported to save space.

Table 9

REACTION OF EMERGING MARKET EXCHANGE RATES TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \delta \Delta y_{it-1} + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

Country variables	*US sovereign yield* (β_2)	*US high yield spread* (γ_2)	R^2 *gains*
	Macroeconomic variables		
GDP	−0.051	−0.036[a]	0.17
Inflation	0.278[c]	0.134[c]	1.74
Debt to GDP	−0.007	0.008[c]	0.38
	Market conditions		
Policy rate	0.218[a]	0.140[c]	1.80
CDS	0.006[a]	0.005[c]	2.19
	External variables		
Current account to GDP	−0.148[c]	−0.103[c]	3.70
Reserves to GDP	−0.043[c]	−0.031[c]	4.53
External debt to GDP	0.027	0.016[c]	1.50
Portfolio flows to GDP	−0.185[b]	−0.055[c]	0.59
Net banking position to GDP	−0.025[b]	−0.013[c]	0.50
Exchange rate deviation	−0.005	0.001	−0.08
Real exchange rate increase	−0.022	−0.022[b]	0.31
Outstanding international debt	−0.163[c]	−0.105[c]	1.87
	Structural variables		
Market size (capitalization to GDP)	−0.341[c]	−0.251[c]	2.13
Real integration (exports to US to GDP)	−0.126[c]	−0.054[c]	0.54
Financial integration (Chinn-Ito index)	0.252	−0.032	0.13

Note: Δy_{it} is the one-month depreciation rate of each EME currency with respect to the US dollar. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations are computed using the SUR(PCSE) method in order to control for the potential cross-section and time correlation of the residuals.

Table 10

REACTION OF EMERGING MARKET STOCK INDICES TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \delta \Delta y_{it-1} + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

Country variables	*US sovereign yield* (β_2)	*US high yield spread* (γ_2)	R^2 *gains*
Macroeconomic variables			
GDP	−0.312	0.044	0.54
Inflation	−0.293	−0.048	0.16
Debt to GDP	0.006	−0.017[c]	0.46
Market conditions			
Policy rate	−0.088	−0.020	0.02
CDS	−0.006	−0.001	0.07
External variables			
Current account to GDP	0.091	0.013	0.05
Reserves to GDP	0.025	−0.003	0.15
External debt to GDP	−0.005	−0.022[c]	2.52
Portfolio flows to GDP	0.193	−0.006	1.82
Net banking position to GDP	0.001	−0.005	0.04
Exchange rate deviation	−0.013	−0.002	0.87
Real exchange rate increase	−0.060	−0.005	0.04
Outstanding international debt	0.046	−0.001	0.01
Structural variables			
Market size (capitalization to GDP)	0.000	−0.000	0.03
Real integration (exports to US to GDP)	0.080	0.096[c]	0.56
Financial integration (Chinn-Ito index)	−0.391	−0.337[c]	0.49

Note: Δy_{it} is the one-month return of each EME country stock market index. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations are computed using the SUR (PCSE) method in order to control for the potential cross-section and time correlation of the residuals.

Table 11 presents a joint estimation of the specific country variables for the EME sovereign yields.[11] Based on the R^2 gains of the variable by variable estimation in Table 8, the multivariate specification considers the following characteristics: CDS spread for market conditions, inflation for macroeconomic conditions, the official reserves ratio for external conditions, and market capitalization for structural conditions. The three first estimates are consistent with previous univariate estimations: An increase in CDS spread and inflation or a decrease in reserves is related to a country's higher vulnerability. By contrast, the coefficient of the stock market capitalization is estimated with a positive sign, implying that relatively large markets display larger responses to US monetary policy announcements.[12] This result is consistent with the more specific evidence around the tapering period where investors found it easier to rebalance their portfolios in larger EME economies and therefore experienced higher asset price responses (Eichengreen and Gupta, 2013). When experimenting with an alternative set of relevant country characteristics such as the current account or the policy rate, the results did not change much but the explanatory power decreased.

This multivariate estimation is similar to one by Bowman et al. (2015) although they consider a vulnerability index estimating a principal component of a set of macro variables and control for the currency regime. Nevertheless, our estimates present two important differences: First, both channels of transmission, sovereign yields, and high-yield bond spreads, are relevant for explaining the heterogeneity of EME yields; and second, the explanatory power of the country characteristics considered in our multivariate estimation is much higher than their vulnerability index.

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[11] Data availability makes the set of countries considered in the joint regression (Table 11) different from the ones considered with the individual characteristics regressions (Tables 8-10).

[12] The estimates of the joint specification for the two other asset prices (not reported) go in the same direction, although the coefficients present a lower significance level.

Table 11

MULTIVARIATE ANALYSIS OF THE REACTION OF EMERGING MARKET YIELDS TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \delta \Delta y_{it-1} + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

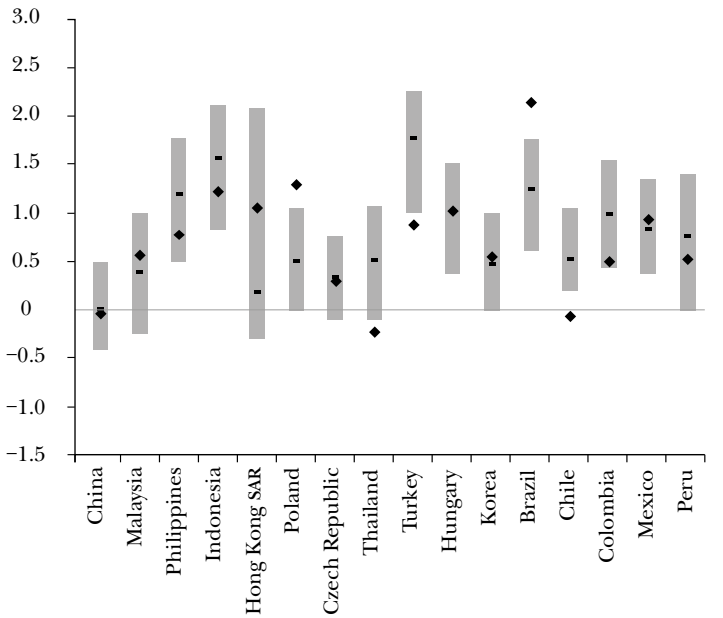
	Specifications			
	1	*2*	*3*	*4*
	Inflation			
US sovereign yield	0.182[c]	0.135[c]	0.135[c]	0.118[c]
High yield spread	0.028[c]	0.012[b]	0.011[b]	0.010[a]
R^2 gains	7.39			
	CDS			
US sovereign yield		0.002[c]	0.002[c]	0.002[c]
High yield spread		0.001[c]	0.001[c]	0.001[c]
R^2 gains		9.08		
	Reserves			
US sovereign yield			0.001	−0.007
High yield spread			−0.001	−0.001
R^2 gains			9.26	
	Capitalization to GDP			
US sovereign yield				0.073[b]
High yield spread				0.001
R^2 gains				9.52

Note: Δy_{it} is the 1-month change in each EME sovereign bond yield [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations are computed using the SUR (PCSE) method in order to control for the potential cross-section and time correlation of residuals.

From the estimation results in Table 11, we can now compare the observed country response to US monetary policy announcements with the implied response by the estimated model. Figure 3 shows the average and one standard deviation of the model's response to a change in US Treasury

Figure 3

AVERAGE RESPONSE OF THE EME YIELDS TO CHANGES IN US SOVEREIGN YIELDS



Note: the diamonds indicate the average observed response (2-day change). The squares and the gray area represents the average and the confidence intervals (one-standard deviation) of each country's model response for the multivariate panel-data model (Table 11, specification 3).

yields.[13] Thus, taking the multivariate version of Equation 5, we calculate the average response ($\beta_1 + \beta_2 ECC_{it-1}$) of the three country characteristics for each of the countries for which we have data and their standard deviation from the parameters' uncertainty. Similarly, Figure 3 draws the average country response (also relative to the US) using the 2-day changes in the event study (Table 2).

[13] An event study around the effect of US monetary policy announcements on the high-yield bond spread gave few significant events. That is the reason to focus on the response through the Treasury yields.

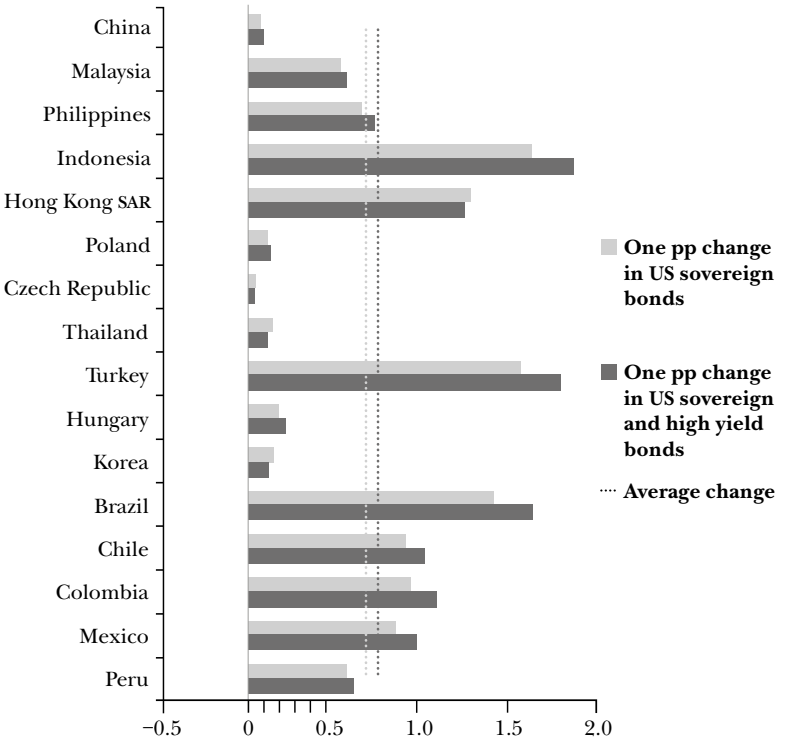
We find a large variability across countries. Nevertheless, for most of the countries in the sample, the responses to the US policy have not outsized the expected price response of the model once the parameter uncertainty has been considered. The only two countries with an observed response above the upper limit of the confidence band are Poland and Brazil. Interestingly, Brazil is an example of a large EME with a relatively open capital account and a flexible exchange rate regime where carry trade operations and thus capital flows have responded very significantly to external QE policies. Other Latin American countries' responses are within the model bands or have had a nil response, as seen in the case of Chile. Thus, the observed EME heterogeneity of sovereign yields spillovers of unconventional US monetary policy, including that of the Latin American economies, can be explained to a large extent by the model setup above.

Finally, we used the estimated model 5 to obtain some inference relative to the current normalization of US monetary policy. Figure 4 simulates a monetary shock that increases US sovereign bonds by 100 bp versus a shock that simultaneously increases sovereign bonds and high-yield spreads by 100 bp. We take the estimated model as the true one and fix the parameter values abstracting any model uncertainty. The simulation exercise considers the observed country characteristics on December 2014. There are two significant results. First, the interest rate channel, represented by changes in the Treasury bond, is more relevant than the risk channel represented by the high-yield spreads. The average EME yield response is 64 bp through the interest rate channel and 72 bp when adding the risk channel. The size of the impact of the country characteristics on these responses is non-negligible: A one standard deviation increase in CDS (92.4 bp), the inflation rate (2.9%) and the stock capitalization (258%) implies an increase in the average EME yield response of 28 bp, 37 bp and 19 pb, respectively, while a one standard deviation increase in the reserves to GDP ratio (28%) implies a 22 bp reduction in the average EME yield response. Second, the countries with weaker economic fundamentals (Indonesia, Brazil or Turkey) respond more than the average country, and thus experience a higher vulnerability to changes in US monetary conditions.

Another group of countries combines better fundamentals with lower sensitivity to US shocks like the Eastern European economies that are more linked to the euro area (Poland, Hungary or the Czech Republic). Moreover, the remaining Latin American countries are above the EMEs average showing also a higher vulnerability. That is a consequence of the relative deterioration of their financial and macroeconomic fundamentals at the end of the sample period as a result of a number of shocks (slowdown of the Chinese economy, reduction of commodities' prices, and tightening of global financial conditions) that affected Latin American economies more severely.

Figure 4

MODEL RESPONSE TO AN INCREASE IN THE US SOVEREIGN YIELD AND THE US HIGH YIELD SPREAD, DECEMBER 2014



Note: average response of countries to 100 basis points in US sovereign yields (light gray bar) and 100 basis points increase in US sovereign yields and high-yield spread (dark gray bar). It uses the multivariate panel-data model (Table 11, specification 3).

4. CONCLUSIONS

The empirical literature has shown that Latin American economies are very sensitive to US monetary policy shocks. Higher dollarization of assets and liabilities, closer financial and commercial links with the United States, and dependency on the commodities cycle could account for this historically. Moreover, after the financial crisis and the launching of unconventional monetary policies in advanced economies, Latin America was one of the regions that received massive capital flows. Now that the US monetary cycle is starting to turn, it is important to anticipate the asset price response considering country specificities, as this may be relevant for designing the proper policy response.

First, we analyzed whether there was a significant impact of US nonstandard monetary policies on financial asset prices for a set of emerging economies, including five Latin American countries. The analysis of policy events showed a more significant effect across EME asset prices after the first set of quantitative easing announcements in 2008-2009 and the tapering talk in 2013, consistent with previous results in the literature. We also found for some events an excessive response by Latin American yields and exchange rates.

Second, we explored whether the role of fundamentals in conditioning the responses in EME economies to US unconventional monetary policy shocks differed across different episodes. We found that depending on the asset price there are some country characteristics relevant in explaining the first set of unconventional measures in 2008-2009 or the tapering talk in 2013. And in both cases, we found weak evidence of an independent effect coming out of the Latin American economies.

Finally, we estimated a simple model of the international transmission of US financial conditions that incorporated the domestic country characteristics to explain the observed cross-country differences. The inflation rate, the CDS spread, the official reserves ratio, and the market capitalization are the

most significant variables for measuring the vulnerability of the EME economies, and Treasury yield changes are a relevant channel to measure the spillover effects of US financial shocks. On average, the observed event responses to US unconventional monetary policies were within the estimated model bands, including those Latin American countries in our sample with the exception of Brazil.

Overall, we showed that the intensity of the reaction of a number of financial asset prices in emerging economies to US monetary policy announcements depends on macroeconomic fundamentals. In particular, we found that a parsimonious model including CDS spreads, the ratio of official reserves to GDP, the inflation rate, and the market capitalization explains, to a large extent, the cross-country heterogeneity in the spillovers of US monetary policy. In addition, although we found some excessive response of Latin American asset prices to recent US monetary policy announcements, this differential response disappears once we take into account country-specific characteristics. In light of our results, the current deterioration of macroeconomic fundamentals in the Latin American region suggests that they are particularly vulnerable to the foreseeable normalization of the US monetary policy.

The evidence provided by the effect of US monetary policies on EME asset prices did not consider the policy responses and the exchange rate framework of the domestic economies. These are relevant aspects to be considered in future work. Moreover, this future work should also consider the response of other financial market variables (dollar-denominated sovereign bonds, corporate bonds, capital flows, to name a few) to US monetary policy measures, in order to assess the robustness of our spillover results.

Appendix 1

Definitions of the Variables

Dependent variables	*Description*	*Source*	*Unavailability*
Sovereign yields	In local currency	Bloomberg[1]	
Exchange rates	Bilateral exchange rate with US dollar	Datastream	
Stock market prices	Aggregate index	Reuters	

Country characteristics	*Description*	*Source*	*Unavailability*
GDP	Year to year GDP growth	National statistics, IFS, OECD	
Inflation	Year to year consumer price index growth	National statistics, IFS	
Debt to GDP	Public debt to GDP (%)	Oxford Economics	Chile
Policy rate	Official interest rate, set by the central bank	National central banks, IFS	China, Singapore, Taiwan
CDS	Credit default spread	Datastream	South Africa, Singapore, Taiwan, India
Current account	Current account balance respect to GDP (%) (+): surplus, (−): deficit	National statistics, IFS, OECD, Oxford Economics	
Reserves	Reserves assets to GDP (%)	National statistics, Datastream, IFS	
External debt	External debt to GDP (%)	National statistics, Oxford Economics	Singapore, Malaysia, Philippines, Hong Kong, Taiwan, Korea

Portfolio flow	Net inflows of capital to GDP (%)	National statistics, IFS, OECD, Datastream	Singapore, Malaysia, Philippines, Hong Kong, Taiwan
Net banking position	Foreign assets minus foreign liabilities to GDP (%)	National statistics, IFS	Singapore, Malaysia, Philippines, Hong Kong, Taiwan, Poland, Korea
Exchange rate deviation	Deviation from equilibrium exchange rate (proxied as a deviation from the historical average). A positive value indicates that the national currency is overpriced	JP Morgan	Singapore, Malaysia, Philippines, Hong Kong, Taiwan
Real exchange rate growth	Last year real exchange rate growth. An increase is an appreciation of the national currency	JP Morgan	-
Capitalization	Stock market capitalization to GDP	Bloomberg	-
Chinn-Ito index	Chinn and Ito index. An increase in the value implies a greater degree of openness of the financial account	Chinn and Ito web	Taiwan
Exports	US exports to GDP (%)	National statistics, FRED	

[1] For Chile, the source is the Central Bank of Chile; and for Brazil, the source is De Pooter, M., P. Robitaille, I. Walker and M. Zdinak, *Are Long-term Inflation Expectations Well-anchored in Brazil, Chile and Mexico?*, International Finance Discussion Papers, No. 1098, Board of Governors of the Federal Reserve System, 2014.

Appendix 2

Summary Statistics

Variable	*Obs.*	*Mean*	*Standard deviation*	*Min*	*Max*
Yields (one month change)	1,500	−0.04	0.50	−4.39	4.30
Exchange rates (one month change)	1,500	0.12	4.42	−14.02	26.69
Stock indices (one month change)	1,500	0.77	6.39	−37.28	38.46
GDP growth	1,500	3.61	3.86	−14.74	18.86
Inflation	1,500	3.67	2.94	−9.48	16.22
Current account to GDP	1,500	1.36	6.28	−9.55	24.18
Chinn-Ito index	969	0.53	1.39	−1.18	2.42
Exports to GDP	1,500	4.73	4.69	0.42	25.67
CDS	1,200	178.97	92.36	51.00	725.00
Policy rate	1,275	4.41	2.76	0.05	16.75
Capitalization	1,500	1.35	2.58	0.99	14.94
Debt to GDP	1,500	44.11	22.00	3.79	106.65
Net banking position	1,022	−0.33	21.25	−27.66	90.39
External debt	1,035	37.12	30.20	3.31	148.15
Portfolio flow	1,023	2.19	3.27	−6.46	16.85
Exchange rate deviation	1,080	7.78	18.86	−35.70	72.74
Reserves	1,500	33.32	27.70	8.78	122.13
Real exchange rate growth	1,500	−0.39	7.14	−30.00	30.90

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XX Meeting of the Central Bank
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In the 2014 Meeting of CEMLA's Research Network, CEMLA's Central Banks decided that starting in 2015 they would conduct joint research on international spillovers of monetary policy. The Associate Directorate General International Affairs of Banco de España, with technical assistance from CEMLA, coordinated this joint research. Researchers from the Central Banks of Brazil, Chile, Colombia, Costa Rica, Dominican Republic, England, Europe (European Central Bank), Guatemala, Jamaica, Mexico, Peru, Spain and Uruguay participated in the activities of this joint research. Research work was supported by webinars of academic specialists, virtual meetings where research progress was presented, a workshop at CEMLA, presentations and discussions at the 2015 CEMLA Research Network Meeting hosted by the Banco Central de República Dominicana and an internal blind review process. The documents that integrate this book represent a memoir of the work done by this group of researchers and it gives a comprehensive analysis of the spillover effects of US monetary policy in Latin America and the Caribbean.

Ángel Estrada García
Alberto Ortíz Bolaños

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European Central Bank
Federal Reserve System (United States of America)
Sveriges Riksbank (Sweden)
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