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**Stress Testing Liquidity Risk:
the case of the Brazilian Banking System**

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Stress Testing Liquidity Risk: the case of the Brazilian Banking System

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Abstract

The Working Papers should not be reported as representing the views of the Banco Central do Brasil. The views expressed in the papers are those of the author(s) and do not necessarily reflect those of the Banco Central do Brasil.

This paper discusses the effects of the recent financial crisis on the Brazilian banking system. It discusses how liquidity risks have risen during the crisis and preventive measures that were taken in order to cope with these risks. It presents the liquidity stress testing approach that is under use in the Central Bank of Brazil and results from a survey on liquidity stress testing that has been applied to banks that operate in the Brazilian banking system.

Keywords: Stress test; liquidity risk; emerging markets; banking system.

JEL Classification: G01; G21; G28; G33.

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1. Introduction

Stress tests are already a widely used tool for risk management of financial institutions. Central banks and individual banks run these tests for determining potential risk sources that they might encounter in scenarios of severe change in the macroeconomic settings and assessing their resilience to such events. By testing themselves or the financial system as a whole beyond normal operational capacity, vulnerabilities can be quantified and the stability of the given system or entity may be studied and pursued more easily.

To design and apply a stress test, many important assumptions should be taken. The first step must be identifying the specific risk and vulnerability of concern. In the literature about stress testing of banking risks, the most common type of risks considered are credit, market and liquidity. The majority of papers have focused in assessing credit risks since this is the bank's most important risk component. However, in recent years, liquidity stress testing is getting more visibility and importance.

Although liquidity crises are not so frequent, their impacts are high (low frequency-high impact events), especially due to their contagious effects and to the consequences of the interaction between the banking risk factors. After the recent global financial crisis there is an increasing interest in studying the vulnerabilities provided by liquidity risk. From this important event many lessons can be taken. De Larosière (2009) points out as the key lesson that regulators paid little attention to the system as a whole, while too much focus were given on micro-prudential supervision of individual institutions.

The crisis served to show weakness in the stress testing exercises performed on financial institutions and systems around the world (Ong and Čihák, 2010). It also showed how the vicious dynamics of liquidity risk can undermine the stability of the financial system (Van den End 2010). To Aikman et al. (2009) the crisis illustrates the importance of modeling the closure of funding markets to financial institutions and accounting for liquidity feedbacks within any model of systemic risk. In sum, the ongoing crisis serves as an alert to the importance of managing liquidity risk and therefore, it underscores the need to explicitly take into account liquidity risk in stress-testing frameworks (Van den End, 2009).

Once understood the importance of stress testing liquidity risk, researchers working for different financial institutions around the world started to develop methods to endogenize liquidity risk in a stress testing framework. This task is quite complex since one has to develop a method that has the ability to quantify dependences and interactions between the various types of risk. Wong and Hui (2009) suggest that for banking stability it is important to assess the extent to which a banking system is exposed to the interaction of risks. In their paper the stress testing framework explicitly captures the link between default risk and deposit outflows. Not only the interaction of the risks are incorporated but also their contagious effects. The framework presented by Aikman et al. (2009) also attempts to fully integrate funding risks and solvency risk.

In a framework of stress testing for liquidity risk two components are important: funding liquidity risk (concerning the bank's balance sheet liability side: there may be a bank run by depositors or the bank may be unable to rollover liabilities) and market liquidity risk (asset side: illiquidity in the market for the bank's assets, when the bank needs to sell them). An example of a stress-test model which involves both components is the one presented by Van den End (2009). By considering the first and second-round (feedback) of shocks, the model presented endogenizes market and funding liquidity risks and captures, as second round effects, the collective response of heterogeneous banks and reputational effects. The IMF originally centered their liquidity tests on the paper of Čihák (2007) using bank balance sheet data to perform bank-run type stress tests on a bank-by-bank level. Aikman et al. (2009) on the other hand, focused on the role of asset-side (market liquidity) feedbacks.

Some papers innovate with their stress-testing models. One topic that motivated some interesting works is the establishments of minimum standards for liquidity risk (Liquidity Coverage Ratio-LCR) and (Net Stable Funding Ratio-NFSR) by Basel III (BCBS, 2010). To study the effects of these new minimum standards, Van den End (2010) developed a stress study that linked funding cost liquidity to regulation and central bank operations. The conclusions from its model outcomes support policy initiatives such as the ones proposed by the Basel Committee (BCBS, 2010). By testing scenarios of stress, the paper finds that banks that adjust to the Basel III establishments (such as by holding a higher stock of liquid assets) have substantially lower second round effects and tail risks. These findings highlight the importance of defining sufficient high quality level of liquid assets to limit the idiosyncratic risks to a bank. The outcomes of the tests also evidence the important role of stronger liquidity profiles in reducing the risk of collective reactions by banks and therefore in preventing second round effects and instability of the financial system as a whole.

Van den End and Kruidhof (2012) simulate the systemic implications of the LCR using a liquidity stress-testing model. The authors model the LCR as a macro prudential instrument that can be used to moderate the adverse side-effects that arise due to interactions of bank behavior with the regulatory liquidity constraint. The authors applied tests with different switching rules and banking sector structures. By testing the reduction of the minimum LCR requirements, the paper finds that a flexible approach of the LCR in stress times reduces the number of bank reactions and associated negative side-effects. Another rule tested was the widening of the buffer definition and the measure was found effective in limiting the interaction between the minimum requirement and bank reactions. At extreme stress levels the paper finds that the LCR becomes ineffective as macroprudential instrument and in order to maintain the stability of the system, a lender of last resort is requested.

The development of the framework that endogenizes liquidity risk into stress-tests is an essential stage to the stress testing exercise. Maybe just as important are the stages of data collecting, information processing and numerical analysis. The top-down and bottom-up are the two strategies of information processing that can be applied to

stress testing bank risks. The advantages of running a test with the bottom-up approach are the use of more detailed data and less complexity in modeling liquidity shocks. The disadvantage is that unlike the top-down approach, these tests are less consistent. The advantages of the top-down approach include more consistent results and more flexibility to simulate different scenarios of shocks. According to Čihák (2007), the majority of stress tests presented in financial stability reports are based on bank-by-bank data. Central banks that are not involved in microprudential supervision and do not have access to more detailed data rely on top-down approaches.

The BCBS (2011) published a document on the progress in implementing macroprudential policy frameworks, gathering information on the subject. Although the document discussed macroprudential policy and systemic risk, much of its considerations can be readily applied to liquidity risks, given their systemic nature. According to it, risk measures should be able to capture the time and cross-sectional dimensions of risk, which define requirements for metrics to be created and monitored. The main measurement approaches which apply, extracted from a survey conducted by the IMF (2011), includes the following: indicators of imbalances (e.g., of bank credit, liquidity and maturity mismatch, and currency risk), indicators of liquidity market conditions, metrics of concentration of risk within the system, which could be used to determine the systemically important institutions (metrics related to the cross-sectional dimension of risk, focusing on the channels of contagion and amplification), and stress testing, to evaluate the resilience of individual banks and of the banking system as a whole.

Stress tests for liquidity are not so developed as stress tests for credit and market risks. However, important works have been done by central banks researchers, as the already mentioned Van den End (2010), Wong and Hui (2009), and Aikmen et al (2009). These models usually are integrated with credit or market risk. This feature is the main difference between these models and the approach for liquidity stress test of Central Bank of Brazil.

Despite the importance of liquidity risk stress testing most central banks do not publish results from liquidity stress tests. This reflects the liquidity modeling complexity and the need of more detailed and high frequency data. Central Bank of Brazil publishes liquidity stress test results since 2009. From the side of banks, a survey with Brazilian banks indicates that their risk management policies have been improved to account for possible liquidity problems. Many banks have started run liquidity stress test after the recent financial crisis. However, it is not usual to disclose the results.

Given the importance of developing liquidity stress test models we focus on the Brazilian banking system case. We present the Brazilian banking system and how it has been impacted by the recent financial crisis focusing on liquidity issues. Section 2 presents the Brazilian banking system. Section 3 discusses the impacts of the crisis on the Brazilian banking system and employs contagion tests to show that banks may have heterogeneous responses to liquidity shocks. Section 4 presents a discussion on liquidity

stress testing performed by the Central Bank of Brazil and also results from a survey of banks that operate in the Brazilian banking system. Finally, section 5 concludes the paper.

2. The Brazilian Banking System (BBS)

Banks are financial institutions with a major role in a capitalist economy. Their importance is a consequence of their roles as money creators, as managers of the payments system and as financiers of economic activities. At the same time, as rational agents, banks take actions to maximize their profits. Restrictions can come from the macroeconomic environment and from the banking system micro structure. This condition gives a hint on the risks involving the banking system and why they are potentially dangerous. Fragility in banks' individual accounting and management combined with macroeconomic shocks can lead to crises in the system. When such crises happen, the consequences can reach great dimensions and will include impacts on the economies' credit situation, interest rates, investments plus negative changes in the levels of economic activities. To maintain a solid and healthy banking system, it is essential to establish bank regulations supplemented by constant supervision.

The Brazilian's banking system began its trajectory at the 19th century when the bank "Banco do Brasil" was first founded and later, was partially considered a monetary authority (da Costa, 2012). However, it was only between 1930 and 1945 that the most important banks were founded and the Brazilian's banking system effectively begun to grow, reaching the total of 644 banks in 1944. Since its rudimentary start, Brazil's banking system went through various transformations processes, mainly adaptations to the also various changes in the national and international politics and economic scenarios. These transformations led to a system with solid regulations, supervised by the Central Bank of Brazil (created in 1964). Based on the Federal Constitution of 1988, some of the Central Bank functions as a monetary authority are: the issue of money, the determination of the reserves requirements of banks and controlling liquidity with open market operations.

The current banking system condition was shaped by important structural transformations occurred in the early 90's. These transformations were consequences of the implementation of measures of monetary policy in 1994 and 1995. The 1994's is known as "Plano Real", in which the exchange rate between the Brazilian currency (real) and the American dollar was initially set as 1 to 1. This measure was used by the government to stabilize the economy that had been passing through a long period of high inflation rates initiated in 1964, during the military regime (1964-1985). The impact provoked by this plan on the banking system was deep. One of the major changes faced by banks was on their profits' sources. During the high inflation period, banks took advantage of the condition to profit from floating; however, after the currency stabilization, this kind of revenues vanished. Banks found an alternative source of profit by charging their customers fees for services provided. The demand for credit also increased, given the increase of the predictability horizons allowed by the

stabilization of the economy and the more optimistic expectations associated. The banks' profit with services, that only represented 8% of the GDP in 1990, reached 10.5% in 1993 and 21.5% in 1995.

Important policies were also implemented in 1995. Programs were created to restructure and fortify the financial system preventing liquidity crisis and stabilizing the system. Another relevant measure taken this year were the incentives given to the opening of the Brazilian's financial system to foreign capital and banks. The objective of this action was to attract foreign banks to the national system and expand the credit supply. This would increase banks competition, forcing them to reduce costs by improving their management to become more efficient. To the population and firms, the benefits would be a greater variety of banks and lower interest rates. The measure was indeed effective in attracting more foreign banks, but the concentration increased. This happened because mergers and acquisitions involved not only the new entrant foreign banks, but also were performed by domestic institutions among themselves. During the first four years after the "Plano Real", 104 financial institutions suffered some kind of adjustment. The number of domestic private banks and state-owned banks reduced while the number of foreign controlled banks was increased less than the mentioned reduction of domestic banks. In 1993, foreign controlled banks owned 7.28% of the total financial system, reaching 25.91% by 1999.

From 1999, Brazilian banks began an innovation process. They developed techniques of fund raising and asset management, increasing their loans over reserves ratios. The efficient use of the interbank market can be considered the key innovation (da Costa, 2012). The period between 2003 and 2006 was marked by an increasing access by the population to banks and credit. Between 2001 and 2006, the number of accounts in the banking system increased by 52%. Savings account was the most popular service provided and increased 50%, while the growth of checking accounts was 37%. The popularization of banking services became possible due to technological advances which included the installations of ATM machines and credit card readers in locals of great movement. These indirect banking facilities increased the supply of banking services without the need of an increase in the number of bank agencies. Popular credit programs offered by commercial banks also originated an expansion in the economy's consumption demands.

Presently, the Brazilian financial system structure is formed by 2.218 operating financial institutions. In December, 2011, the total assets of the Brazil's whole financial system exceeded BRL 5,135 billion. Its stock of credit operations reached BRL 2 trillion, which corresponds to 49% of the country's GDP in the same period. The banking system is a part of the financial system, composed by independent institutions and financial conglomerates which must contain at least one institution from the following list: a commercial bank, a savings bank, or a multiple bank, since it is authorized to receive demand deposits. In March 2012, the banking system's assets totaled BRL 4,486 billion, a share of 84% of the whole financial system's total assets. These institutions' evolution of total assets is illustrated by Figure 1.

< Place Figure 1 about Here >

The Brazilian's banking system's history shows periods of concentration alternating with periods of increase in the number of banks. In the early 90's, as stated above, the banking system went through a structural transformation. In that period of banking crisis, privatizations and incentives to the entry of foreign banks, the domestic banking system went through a decrease. In 1994, there were 271 commercial and multiple banks; by 2002, they were 167. Presently, there are 160 banks.

Figure 2 shows the division of the Brazilian banking system by type of control (in number of banks and percentages). The participations of each of these categories in the aggregated credit operations and total assets in the same period are shown in Figure 3. Additional measurements of the financial system concentration are the HHI and CR4 indexes¹. The levels of concentration in the Brazilian financial system are monitored by the Central Bank of Brazil. These indexes are calculated for assets totals, credit operations and deposits totals. The HHI values of the system for the second half of 2011 indicate that the Brazilian banking system is non-concentrated to moderate concentrated from the point of view of all these three quantities (respectively 0.13, 0.14 and 0.1509). The CR4 for the three quantities in the same period were 67.21%, 69.2% and 72.55%, respectively.

< Place Figures 2 and 3 about Here >

3. Effects of subprime crisis on Brazilian Banking System

Since 2007, important events have been taking place in the international banking scenario. The American banking system crises occurred in 2008 spilled over on economies around the world. The collapse of large banks in the US and the domino effect along the many strands of the international economy led to the collapse of even entire economies, as occurred in Greece in the late 2000s. The impact of this historic event on the Brazilian's banking system and economy wasn't as catastrophic. Due to more strict regulations and controls imposed to the national financial system in 1995, the Brazilian's banking system remained relatively solid when facing the international crises and has been preserved without relevant losses. Also, the macroeconomic politics of fiscal austerity and the regime of inflation targeting adopted allowed Brazil to stand out among the other emergent countries and remain attracting foreign interest. The

¹ HHI is the Herfindahl–Hirschman Index. According to the Horizontal Merger Guidelines published by Department of Justice and Federal Trade Commission (EUA), HHI less than 0.15 means that the market is not concentrated, HHI between 0.15 and 0.25 means that the market is moderately concentrated, and HHI above 0.25 indicates market highly concentrated. CR4 stands for four-firm concentration ratio. It measures the market share of the four largest banks in the system. Values between 50% and 80% indicates medium concentration.

liquidity situation of Brazilian banks in recent years can be shown by the evolution of the system-wide liquidity index in the figure 4.

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The index is calculated by the Central Bank and is the ratio between a) the institutions total liquid assets available to honor their obligations and b) the possible losses in liquidity that the institutions would be subject to in stress situations. The situations of stress include unexpected deposit withdrawals and sudden changes in the market scenario. The BCB publishes an aggregated IL for the whole banking sector in the financial stability report along with a detailed liquidity analysis of the financial system. More details on calculation of IL and its use to monitor the financial system liquidity will be presented in section 4.

Volatility in exchange and interest rates usually increase the liquidity required in case of stress situations (has negative impact on the index). Figure 5 can illustrate the behavior of the volatility of these rates since 2008. The highest volatility occurred, of course, when the crises started. Figure 6 shows the finance of credit expansion and liquid assets since 2008.

< Place Figures 5 and 6 about Here >

From the figures 4 and 5, it can be observed that the international financial crisis had a greater impact on the Brazilian financial system's liquidity during the year of 2008. During the period, the volatility of the exchange and interest rates were very high and certainly increased the possible losses that the institutions would be subject to in concrete stress situations. This is related to a decrease on the liquidity index on the period. After 2008, the trajectory of the system's liquidity had a recovery and the trend for the following year was of healthy liquidity conditions. According to the Financial Stability Report (FSR) from the Central Bank, in the second half of 2009, the banking system presented an expressive amount of high quality liquid assets and had low dependency on foreign resources. These conditions reduced Brazil's vulnerability to liquidity risks and international turbulence. By the first half of 2010, the liquidity of Brazilians financial institutions had returned to the pre-crisis level (BCB, 2010).

The Financial Stability Report (BCB, 2012) concerning the year of 2011 concludes that the banking system's liquidity is in a very favorable situation. The Brazilian banking system had the ability of financing its own operations, mostly with funds raised in the domestic market. In the first half of 2011, the system's funding increased by BRL 186.1 billion, representing a 9.1% increase compared with the previous semester. The stock of liquid assets growth (composed basically of federal

government bonds) was remarkable, favored by the slower growth of the volume of credits (BCB, 2011). In the second half of 2011, the system's funding increased by BRL 246.9 billion (an 11.2% increase). In this period, the credit expansion was reduced by the available resources from domestic and foreign market. The liquidity index remained at a good level even after the negative shock caused by the volatility of the interest and exchange rates. (BCB, 2012).

Deposits (including savings, on demand and time deposits) have been the major funding source for Brazilian banks. Deposits presented a declining trend in terms of share of total funding from December 2005 to December 2007. However, in 2008, this trend was reversed due to the crisis effects on time deposits. The time deposits interest rate increased to attract funds which would compensate the reduction of other sources of liquidity, especially foreign funding. Consequently, the amount of time deposits increased 31.1% in the second half 2008 (BCB, 2008 and 2009). Savings deposits have been tracking the funding growth, remaining stable in terms of relative shares. From 2008 to 2011, savings accounted for 17% to about 20% of total funding (see Figure 7). An analysis of the distribution of these deposits among its holders shows that, in 2006, 54.1% of the total amount was concentrated at the level of up to BRL 100 per account, with 41,565,238 depositors (BCB, 2007). Regarding on demand deposits, one can see in Figure 7 that their relative shares declined from 10% in December 2009 to 7.8% on December 2011. These three types of deposits accounts, on average, for more than 60% of total funding between 2008 and 2011. Deposits up to BRL 70,000 are guaranteed by the Credit Guarantee Fund (the *Fundo Garantidor de Créditos* (FGC)). From the total amount of time deposits, the largest holders are households, followed by legal entities (see Figure 8).

< Place Figure 7 about Here >

< Place Figure 8 about Here >

Financial bills became a more interesting source of funding due to an exemption on reserves requirements for its holders, which became effective on late 2010. Since then, financial bills have presented a growth trend; however, they account only for a small share of the system's total liabilities (BCB, 2012). Financial bills are a source of long-term funding and have contributed to the lengthening of the banking system liabilities profile, as they cannot be redeemed total or partially before its maturity date (according to the *Resolução BCB nº 3.836/2010*). This is desirable since the loans average term has increased due to an also increased share of mortgages in the credit portfolios (BCB, 2011).

Between 2008 and 2011, liabilities on loans have accounted, on average, for about 16% of total funding. These sources of funding include foreign funding. Most of the banks that use foreign funding are small foreign banks, whose business model is not related to credit. Nevertheless, only a small part of these banks' funding comes from

abroad. The large foreign banks rely mainly on domestic funding. Besides this, liabilities in foreign currency reduced since the subprime crises (see Figure 9). Thus, turbulences in international markets have had a limited impact on the Brazilian banking system (BCB, 2012). Liabilities on loans also include loans from the Brazilian Development Bank (BNDES).

< Place Figure 9 about Here >

A general look at banks' funding structures highlights the existence of institutional differences. Large banks have more diversified sources of funding, and due to a wide network of branches, these banks have more access to retail deposits. This source of funding is more stable, reducing the liquidity risk. On the other hand, smaller banks rely mainly on time deposits and have a not so diversified funding structure. Financial bills provide a more stable source of funding to their issuers, while being more attractive for its holders, especially if they are large banks, due to a reserve requirement exemption associated to it, larger than the one related to time deposits. As smaller banks have already an exemption from reserve requirements due to their low amount of funding, holding financial bills are not as interesting for these banks (see figure 10).

< Place Figure 10 about Here >

The funding source patterns also differ sharply among the type of control segments. Foreign banks concentrate their funding on time deposits, while public banks tend to emphasize savings. On the other hand, private banks are more focused on repo operations. (BCB, 2008)

Altogether, the Brazilian banking system relies mainly on domestic sources of funding and is prepared to cope with an occasional liquidity stress. However, liquidity is not equally distributed among banks. Smaller banks that rely on time deposits from large costumers are subject to higher liquidity risks during stress periods. These banks can get funding from credit assignment transactions. Due to recent problems concerning this market, the Central Bank of Brazil created the Credit Transfer Bureau, in which banks must register the credits' assignments, fostering the disclosure on this market. (BCB, 2011)

Brazilian banks have a more stable funding source as the reliance on retail deposits it's higher than on wholesale funding. Nonetheless, for some banks institutional investors may represent an important funding source. Therefore, in moments of stress these banks may incur in liquidity problems. To overcome these problems during the recent financial crisis the central bank of Brazil has created a new type of deposits that are guaranteed by FGC.

The FGC had an important role in the security assurance of the national financial system. In March of 2009, the FGC's Special Guarantee of Time Deposits (DPGE) was implemented. This measure helped the small size institutions to recover its emissions (the amount of term deposits of small banks grew about 24% from March to May of the same year). The improvement of the rediscount regulation was also implemented. The deadlines of the rediscount operations were extended and the CB was authorized to impose restrictive prudential measures to manage the financial institutions. (Mesquita and Torós, 2010)

The BCB took measures to address the liquidity constraint both in domestic and foreign currencies: bank reserve requirements were lowered; lines of credit in foreign exchange were provided to the private sector; Central Bank offered USD in spot market auctions and foreign exchange swap contracts².

Figure 11 shows an increase in time deposits, from BRL 270 billion in December, 2007 to over BRL 500 billion in October, 2008. The largest growth in deposits was observed in financial institutions and households, followed by companies with a more modest growth. Institutional investors' deposits were maintained at about the same level.

< Place figure 11 about Here >

Conventional wisdom would expect more informed investors to seek better rates in tranquil times, and safer investments in riskier times. That was also evident in the time deposits from institutional investors in Brazil. In 2006 large banking institutions and conglomerates had the lion's share of time deposits from institutional investors, about BRL 15 billion, whereas the medium banks' share was about BRL 6 billion. From January, 2007 to December 2007 this was inverted, with about BRL 19 billion in time deposits in medium banks and about BRL 3 billion in large banks. In January, 2008 the situation was once again reversed, as time deposits shifted towards large banks, which are usually regarded as less risky. That movement can be seen quite clearly in Figure 12 and signals a "flight to quality" movement in time deposits.

< Place figure 12 about Here >

This "flight to quality" is also evident in correlation contagion tests. Regarding financial contagion as "*a significant increase in linkages after a shock to one institution*"³, a series of tests was run based on the FR statistic as devised by Fry and alii.(2008). In these tests the log difference of the weekly stock deposits was tested for contagion using a Vector Auto Regressive model and 30-week crisis windows. The test

² For more details about the measures took by Brazilian authorities see Mesquita and Tóros (2010) and Silva and Harris (2012).

³ Adapted from "*a significant increase in cross-market linkages after a shock to one country (or group of countries)*", by Forbes and Rigobon, 2002.

results indicate how many institutions were affected by contagion within each crisis window, and are summarized in Figures 13 and 14. The contagion results indicate that most banks affected by contagion were small and medium banks. Regarding ownership, foreign institutions were the most affected by contagion, followed by Brazilian private domestic banks. The peak of contagion was in the windows starting from September to November, 2007, and ending in March to May, 2008. These time deposit movements and time deposit contagions seem to indicate that during the 2007/2008 crisis there was an investor movement towards assets such as guaranteed time deposits or time deposits at large national institutions which were deemed safer at the time.

< Place figures 13 and 14 about Here >

4. Liquidity stress tests in Brazil

4.1. Central Bank approach

In Brazil, liquidity risk monitoring is part of the banking supervisory process and includes a continuous follow-up of the systemically important financial institutions and a liquidity stress test. The liquidity stress test conducted combines the bottom-up and top-down approaches: it considers, for each individual financial institution, the different classes of assets and raised funds, but doesn't take into account the linkages among institutions, resulting in a liquidity index (IL) for each institution. This index is a short-term liquidity index similar to the Basel III's LCR (Figure 4).

The IL is the ratio between the Total Liquidity (LT) and the Estimated Liquidity Needs (NEL). The LT is the amount of liquid assets each institution can dispose of to pay its obligations. It is calculated as the sum of active market operations with maturity on the next day (e.g. involving federal securities, active interbank deposits (DIs) and bank deposit certificates (CDBs) maturing on the next day), with active DIs and CDBs maturing after the next day, weighted by coefficients associated with a possible early redemption of these instruments. The calculation of LT also considers the balance of other accounting assets: cash, shares, foreign currencies and investments in mutual funds, gold and foreign federal securities.

The NEL is the liquidity level an institution needs to keep to withstand funding volatility and losses under market stress. It is calculated from:

- Deposits' volatility under stress on a 2-week horizon;
- Deposits' concentration index (excluding DIs), taking into account value ranges and client profiles (natural persons, firms, financial institutions and institutional investors);
- DIs raised maturing after the next working day, considering, for short-term DIs, that they will not be renewed, and a possible early redemption for the remaining DIs;

- Remaining liabilities on the balance sheet;
- Stressed market net positions.

Liquidity stress tests are very useful to assess whether specific banks have liquidity vulnerabilities. In this case bank supervision can follow up bank's risks and make accurate interventions. Furthermore, it is useful to design proper public policies to reduce shocks that stem from systemic liquidity problems. This is the case that happened in the recent financial crisis and the worsening of liquidity conditions was assessed and specific measures were taken to attenuate its effects and help banks that had liquidity issues (See BCB (2009), BCB (2012), and Mesquita and Torós (2010))

An important measure in the case of Brazil has been the DPGE that has helped create a liquidity cushion for medium size banks, which were suffering from liquidity shortage immediately after the crisis. These measures have proven to be very successful and at relatively low costs and have increased confidence in the financial system, which is crucial in the middle of the crisis.

The main lesson that can be drawn from the recent financial crisis is that liquidity is crucial. Evaluating it on a continual basis is important and the results from liquidity stress tests can be a very useful monitoring tool and suggest whether liquidity problems are local, specific to certain banks, or systemic in which case public policies can be triggered to help circumvent these problems.

4.2 Individual Banks' approach

This section presents some results from the liquidity stress testing survey carried out by the Central Bank of Brazil on June 2012. The survey aimed to better understand the methods and scenarios that banks used in their liquidity stress tests. It is similar to the survey applied to European banks (ECB, 2008).

To mitigate liquidity risks, banks need to make an effective risk management. Fundamental for this task, liquidity stress tests allow banks to assess the possible impact of exceptional but plausible stress scenarios on their liquidity position and can help them to determine the size of liquidity buffers.

The respondent banks claim that liquidity risk is considered the second most important type of risk in their risk management: the most important is the credit risk. Although some banks have been performing liquidity stress tests for over 10 years, the majority of them began to perform these tests after 2008.

A total of 46 large banks received the survey and 27 banks provided information about their liquidity stress tests, including the largest Brazilian banks. From these banks, 23 perform internal liquidity stress tests while 4 of them use vendors' models.

All but 1 bank in the survey quantify liquidity risk tolerance. In the sample, 17 banks affirm they quantify risk tolerance by a system of limit settings. These limits usually are defined based on experts' judgment. In 8 banks, the quantification of

liquidity risk tolerance is based on stress tests. Other forms less frequent used to quantify the liquidity risk tolerance are: cash flow forecast (6 banks), concentration of the liquidity sources (2) and survival horizon (1). ECB (2008) affirms that banks focus on risk containment, i.e. systems of limits interrelated with liquidity risk tolerance, rather than the quantification of liquidity risk tolerance per se. The explanation for this is that the quantification of liquidity risk tolerance is a difficult task. The major problem in the area of liquidity risk management is that liquidity risk events are low probability - high impact, which implies that is not feasible to assign probabilities to all (reasonably well-defined) possible liquidity shocks. It seems that Brazilian banks have the same focus.

4.2.1 Time horizon

The majority of banks (17) perform liquidity stress tests monthly and some banks (8) perform them daily. Time horizons for stress test scenarios mainly vary between four weeks and three months, although longer time horizons are also cited. (see Figure 15) Almost every bank use short or medium-term time horizon to perform their stress tests. However, the period considered as short, medium or long term is not uniform among banks. A short-term period may comprise from one to twelve weeks, while a medium-term period comprises from two to twelve months. The most commonly time horizons considered are four weeks, for a short-term period, and three months, for a medium-term period.

< Place Figure 15 about Here >

4.2.2 Scenarios

Most banks (15) perform tests under market-wide stress scenarios, but only six banks use idiosyncratic scenarios. A considerable number of the surveyed banks (13) use a combination of adverse market conditions and idiosyncratic shocks to their institutions. Of these banks, only 9 run the combined scenario, while 3 also run both market and idiosyncratic scenarios separately and one bank also runs the market scenario. Of those banks that do not run tests with combined scenarios, the majority (15) rely exclusively on either tests with market stress scenarios (9 banks) or tests with a firm-specific stress scenario (1). Five banks declared that they considered other types of stress test scenarios and 1 bank did not respond to the question. (Figure 16)

< Place Figure 16 about Here >

The surveyed banks described a multiplicity of scenarios with different sets of assumptions concerning the effect that these scenarios were expected to have on both assets' and liabilities' sides of their balance sheet. However, there are some sources of stress that are common in most scenarios:

- reduction in asset prices;
- increased collateral and margin calls;

- increased delinquency;
- reduced access to funding markets ;
- increased deposits withdrawals;
- non-rollover of term deposits;
- utilization of credit lines previously approved.

Although most banks claim they perform combination of adverse market conditions and idiosyncratic scenarios tests, it is not defined which shocks they consider as coming from market conditions or from bank-specific situations. Only few banks consider bank-specific sources of stress, like downgrade and liquidity problems in the group.

Most banks make assumptions about deposits in their stress scenarios. These assumptions are consistent with the structure of the BBS and the economic outlook. In the BBS, banks rely on domestic funds provided mainly by deposits. Other source of stress, usual for more than one-third of the banks, is an increase in delinquency. Brazil has experienced a fast credit growth; thus banks seem to be aware about the effects of credit risk on liquidity.

According to IMF (2012), Brazilian financial sector is exposed to international commodities and capital markets' volatility effects, but the risks related to them are significantly mitigated by a flexible exchange rate, strong macro and microprudential policy frameworks, and the financial institutions' sound balance sheets, high capital and profitability, and abundant liquid assets. However, banks consider this source of stress by means of assumptions about collateral or margin calls.

The vast majority of the banks consider prospective approaches. Most banks forecast their cash flows by means of assumptions about the impact on inflows and outflows. However, it is not clear how these assumptions are made. It seems to be based on expertise judgment.

Concerning scenario revisions, all respondents informed that liquidity stress scenarios are revised, with 19 banking conducting revisions regularly. From these banks, 8 review their scenarios annually and 6 do it monthly. The events that trigger adjustments in the stress scenarios include, in no particular order of importance: changes in the macroeconomic scenario; changes in policies, guidelines and practices at the group level; changes in regulations; changes in monetary policy; business developments; changes in the levels of delinquency; changes in markets. From the 27 banks, 23 need either Asset and Liability Committee or Risk Committee or Board of Directors approval for significant adjustments to the liquidity stress test scenarios. Regarding the stress tests level, 11 banks perform them at the entity level, while 8 perform stress tests at the group level. However, only 6 banks perform stress tests at both levels. Five banks perform liquidity stress tests at other levels, such as the currency level.

< Place Figure 17 about Here >

Banks use more than one approach to quantify their liquidity risk exposure (see Figure 17). According to the survey, the most common type of measurement approach (23 banks) is the cash flow maturity mismatch, followed by other cash flows analyses (18 banks). The main advantages of the cash flow maturity mismatch seem to be that it is transparent, flexible, and simple and gives a general overview of risk (ECB 2008). Matz and Neu (2007) argue that measures built on maturity mismatch and cash flow modeling help to reflect the dynamic nature of liquidity. The main disadvantage is that it is considered to be a short-term tool which does not reveal long-term liquidity problems (ECB 2008).

Banks are reluctant to disclose the results of their stress tests, doing this on demand mainly to rating agencies and supervisors. Only few banks disclose frequently their stress test results to auditing firms, committees and board. What possible reasons do banks give for this reluctance? Although most banks agree that disclosure would enhance market discipline in liquidity risk management and see value added in disclosing the results of liquidity stress tests, all banks agree strongly (19) or agree (8) that the results of liquidity stress tests cannot be interpreted without a detailed understanding of the scenarios and the considerations underlying them.(Figure 18)

< Place Figure 18 about Here >

5. Conclusions

This paper discusses the effects of the recent financial crisis on the Brazilian banking system. The financial crisis has had major impacts worldwide and liquidity risks have risen accordingly. The urgent need for macroprudential measures that helped banking systems regain confidence and increase their liquidity to cope for additional risks.

We present the liquidity stress testing approach that is under use in the Central Bank of Brazil and results from a survey on liquidity stress testing that has been applied to banks that operate in the Brazilian banking system.

Overall, the Brazilian Banking system has had a small impact due to several macroprudential measures and a strong bank supervision and regulation. This impact affects banks differently. Medium banks experienced a strong liquidity constraint due to a “fly to quality” movement in time deposits. Regarding ownership, foreign banks were the most affected by contagion. To avoid a confidence crisis BCB took measures both in domestic and foreign currencies that helped banks to overcome liquidity problems.

The survey applied to the largest Brazilian banks showed that liquidity risk is the second most important risk in their risk management. It seems that the crisis led an improvement in the banks' risk management, since most of them started to perform liquidity stress tests after the recent period of turbulences. There is a considerable diversity in the liquidity stress test scenarios. However, most banks use a combination of adverse market conditions and idiosyncratic shocks scenarios. The findings show that banks do not rely on any single measure of liquidity but they have preference for measurement related to cash flow.

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Figure 1

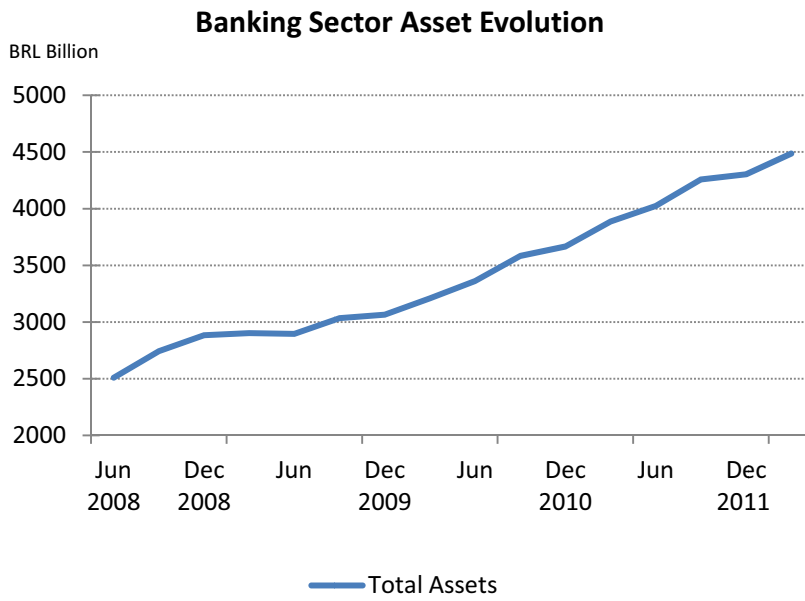


Figure 2

Distribution of the banking sector by capital source (December 2011)

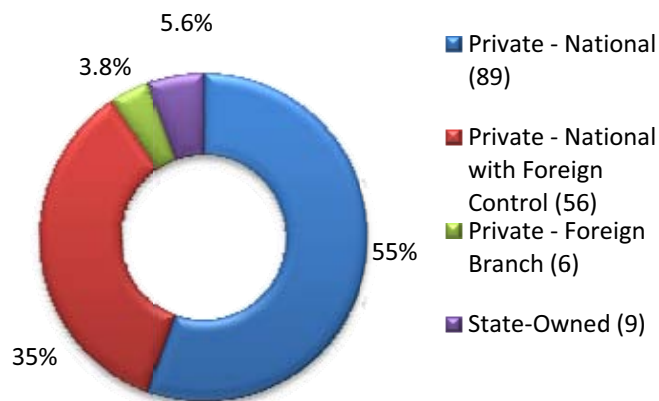


Figure 3

Distribution of the banking sector by Assets and Credit Operations

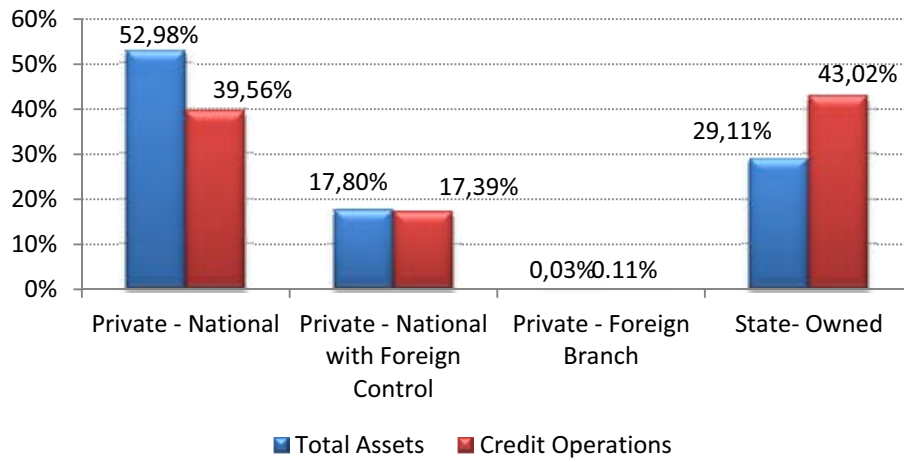
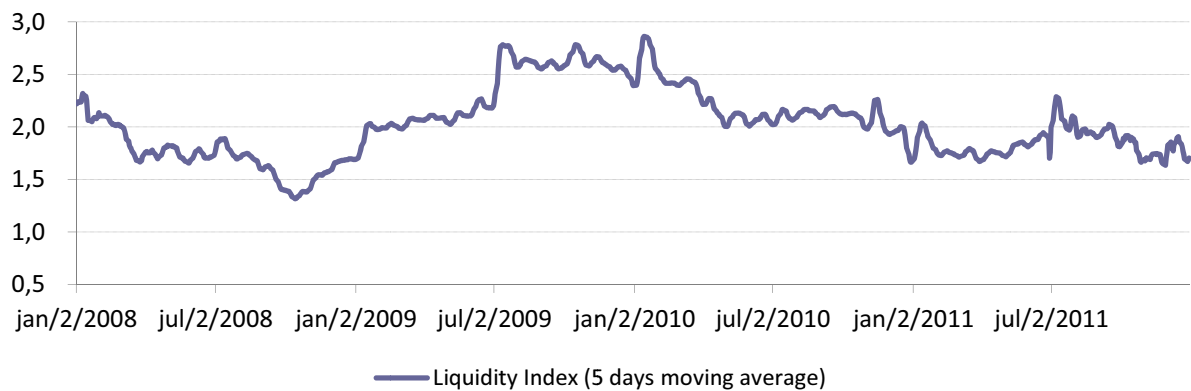


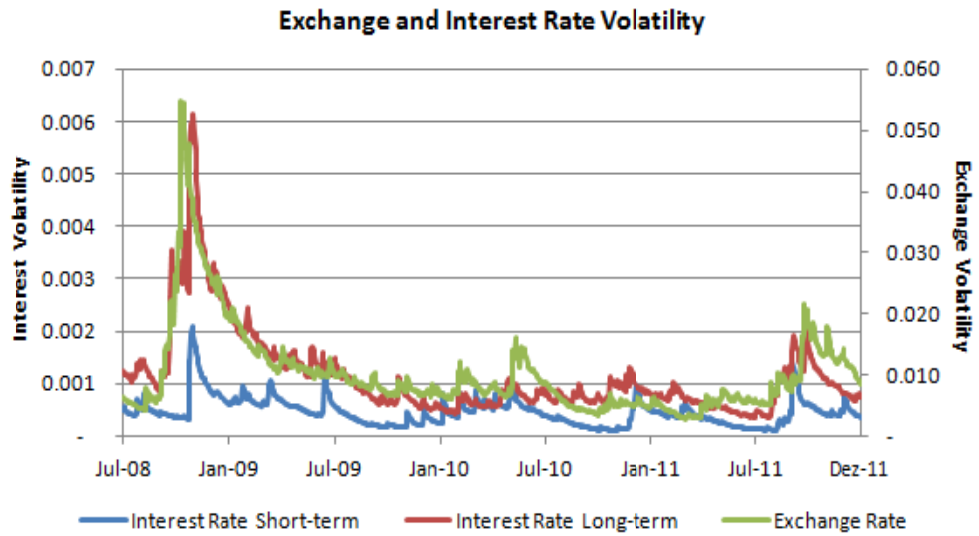
Figure 4

Liquidity Index



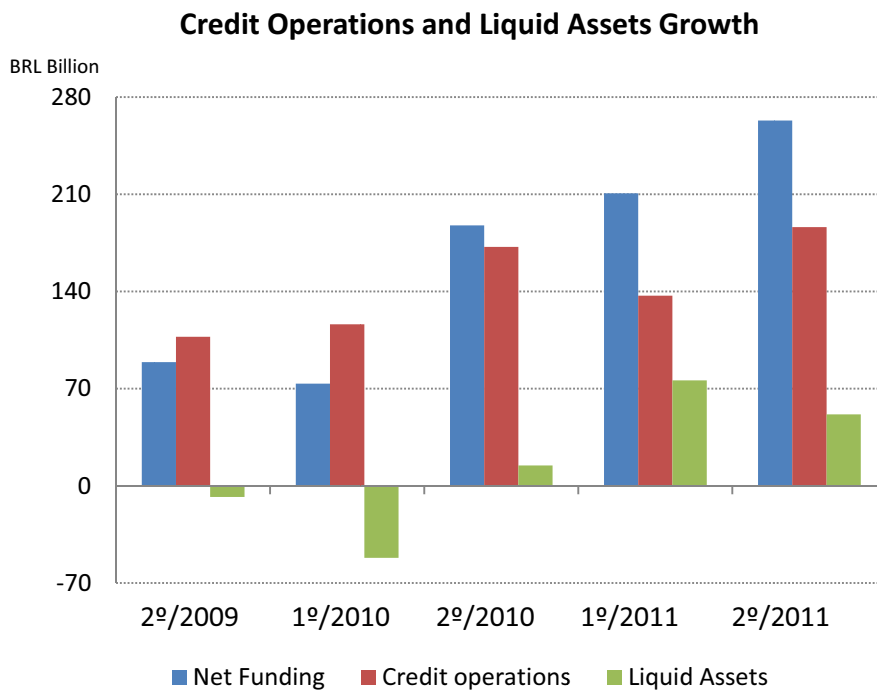
Source: Financial Stability Report - Macrh 2012

Figure 5



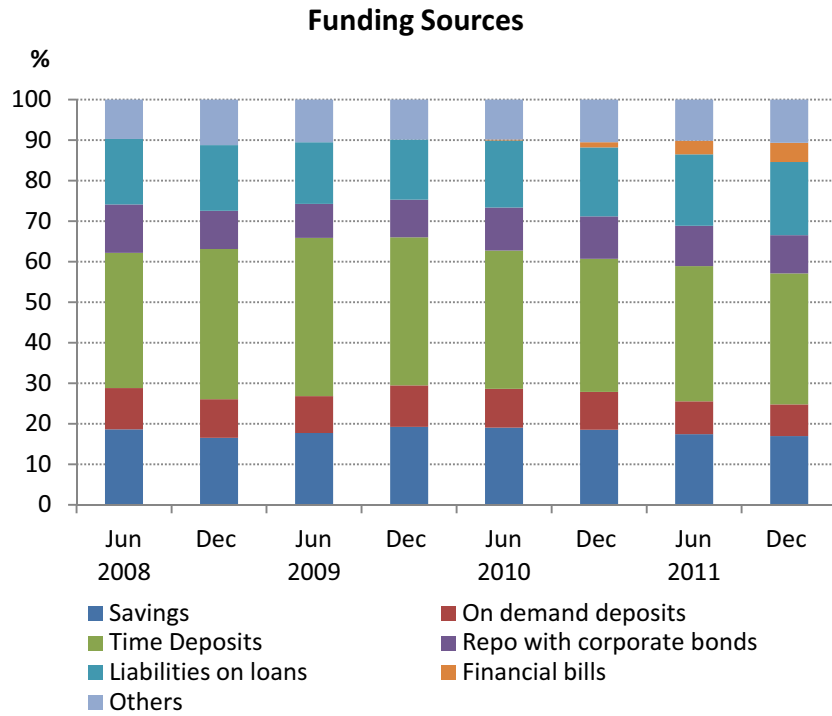
Source: Financial Stability Report - March 2012

Figure 6



Source: Financial Stability Report 2012

Figure 7



Source: Financial Stability Report - March 2012

Figure 8

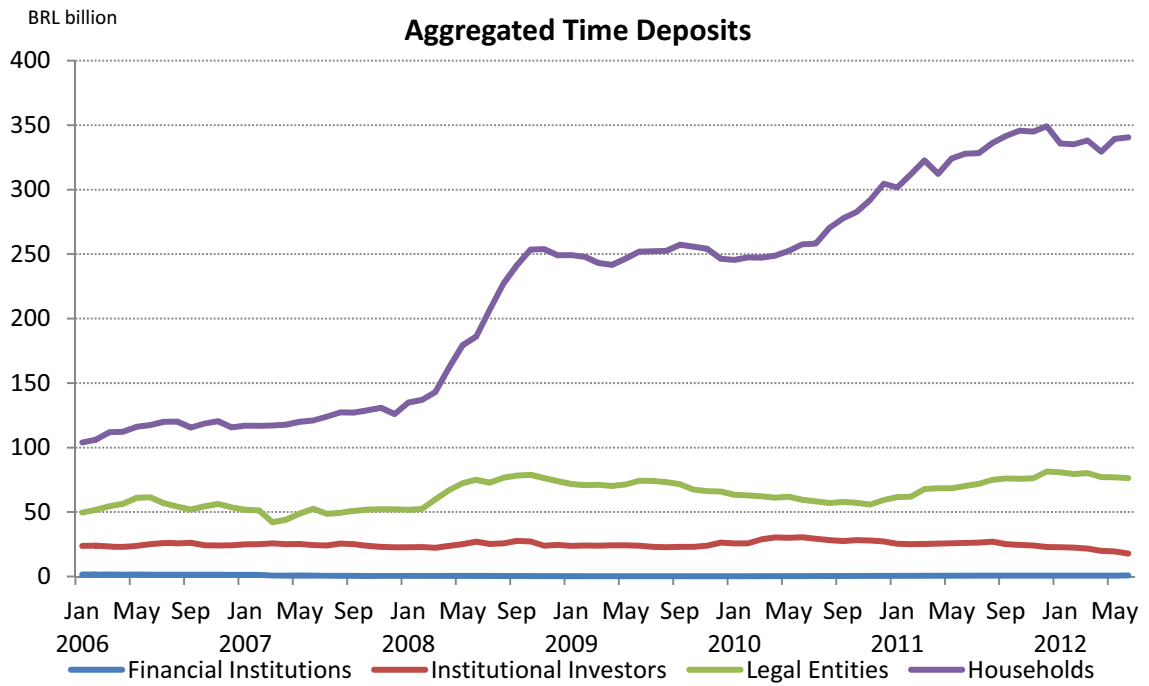
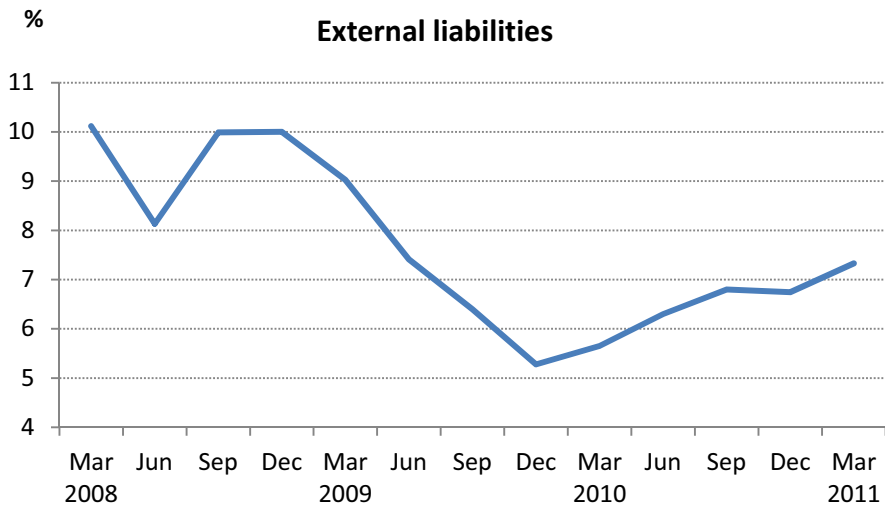
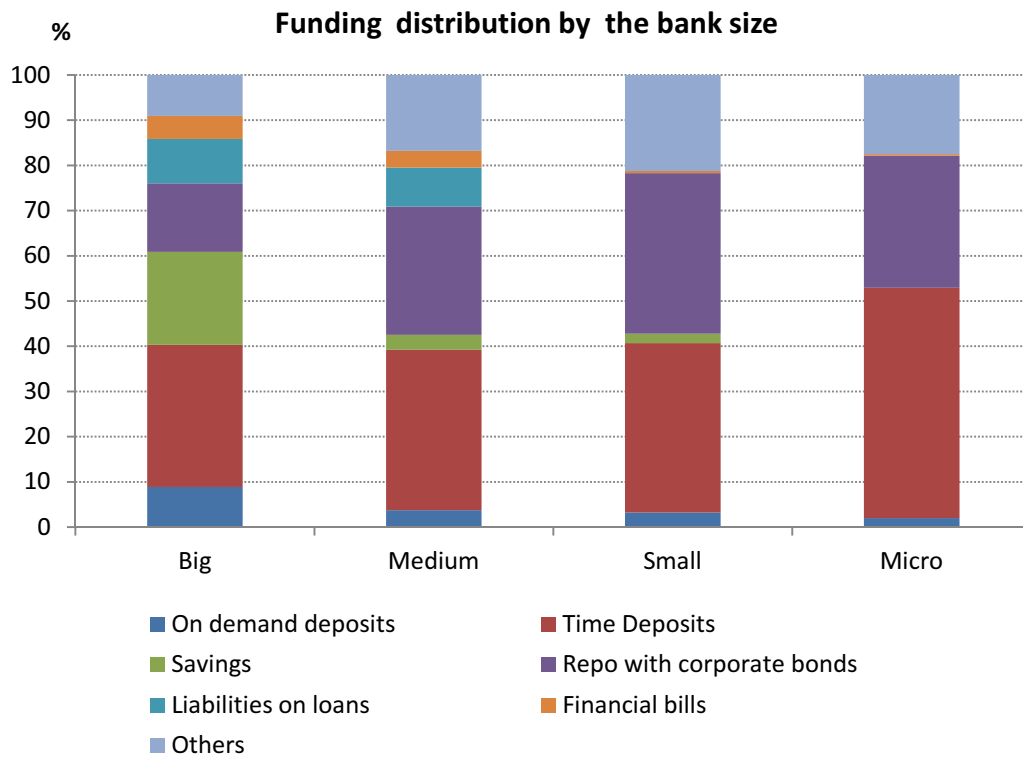


Figure 9



Note: Operations with foreign currency or foreign counterpart
 Source: Financial Stability Report - March 2012.

Figure 10



Source: Financial Stability Report - March 2012

Figure 11

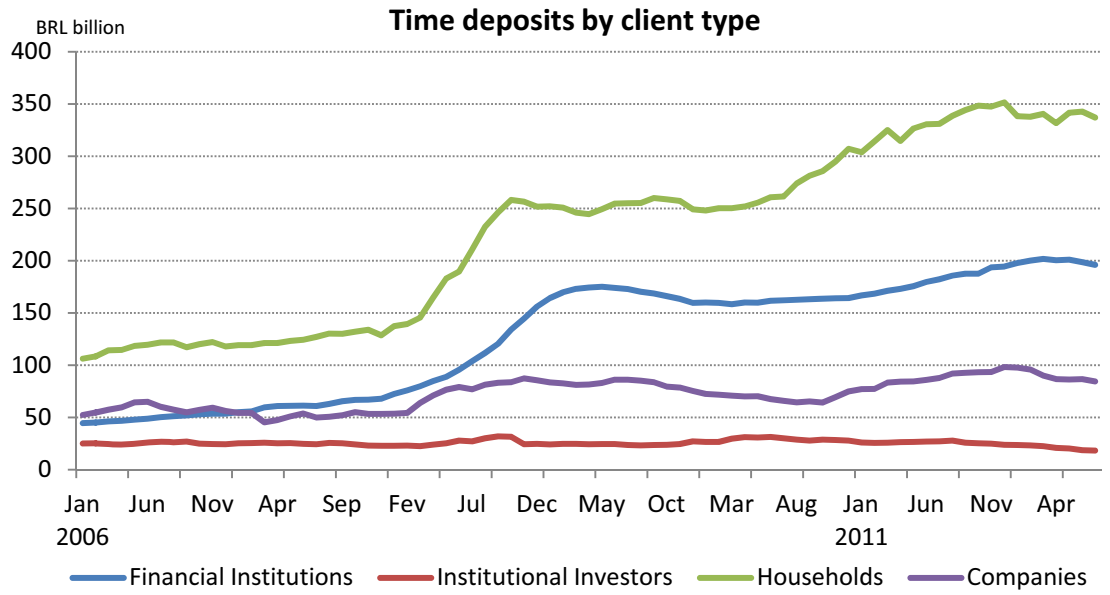


Figure 12

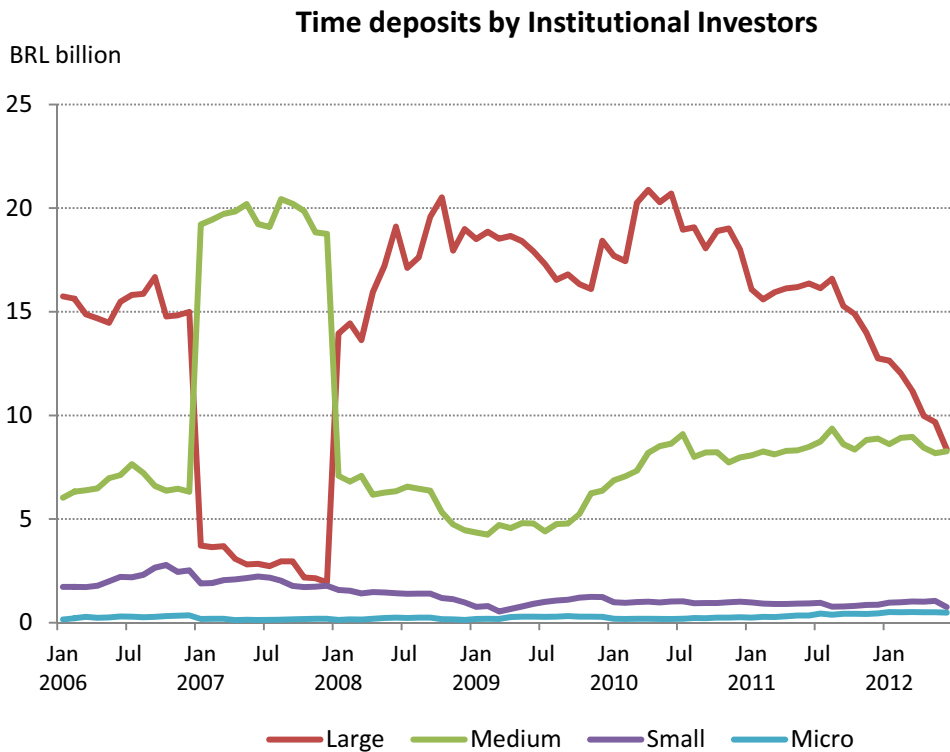


Figure 13

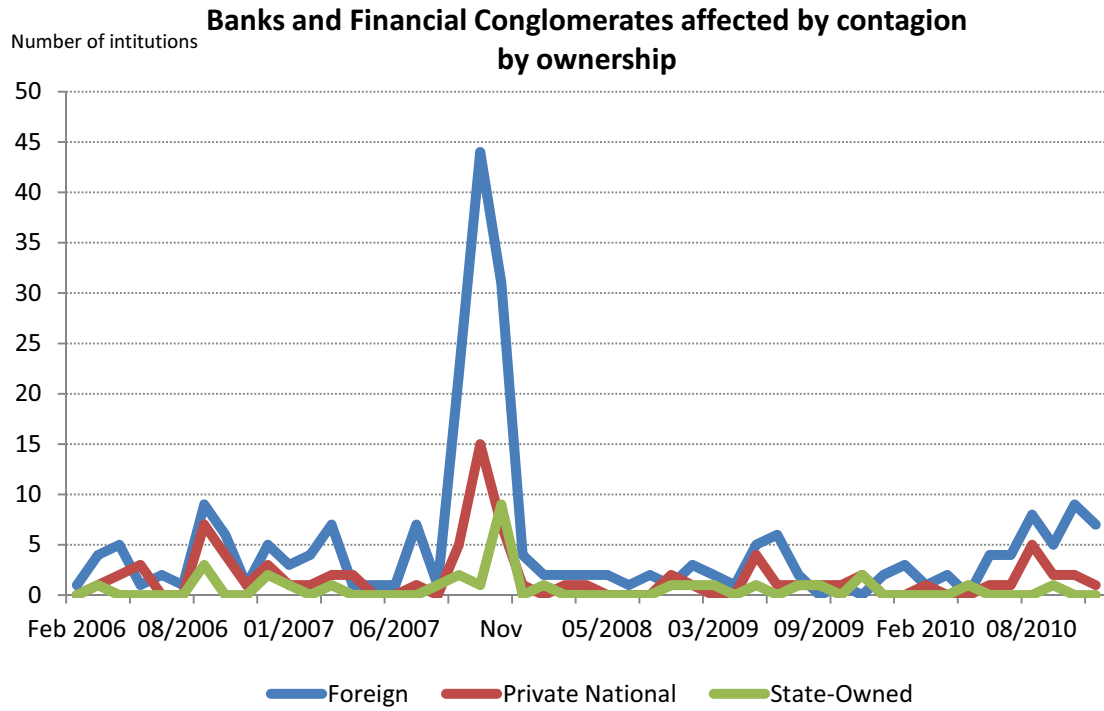


Figure 14

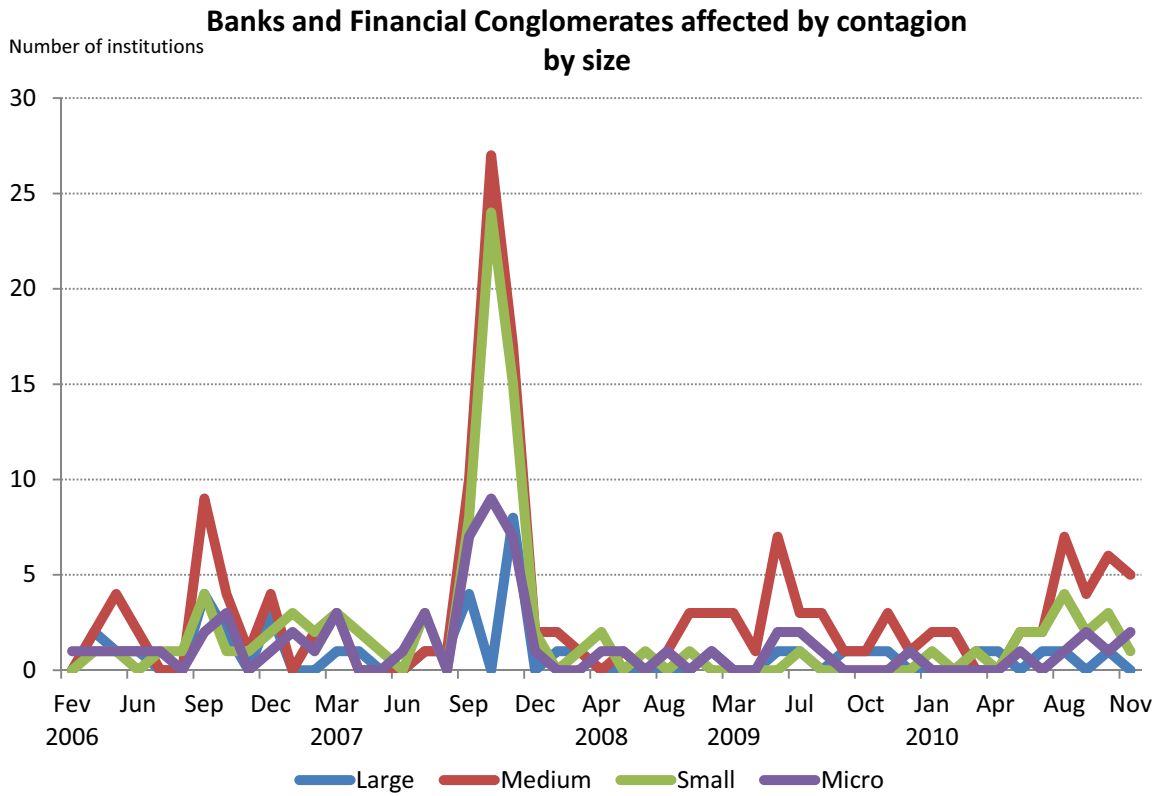


Figure 15

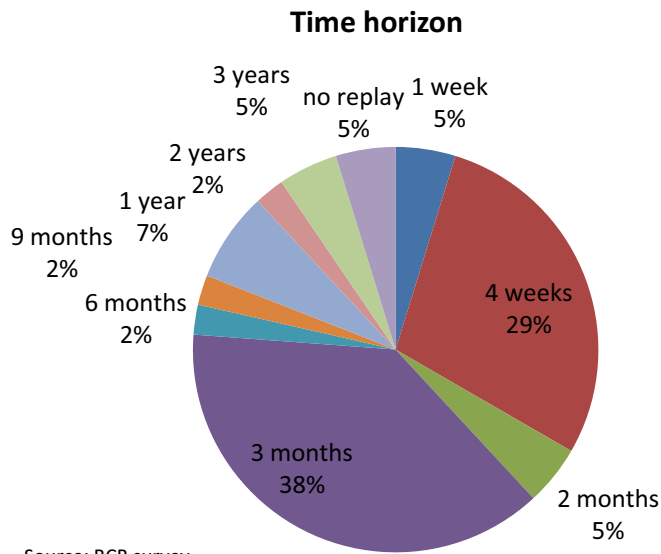


Figure 16

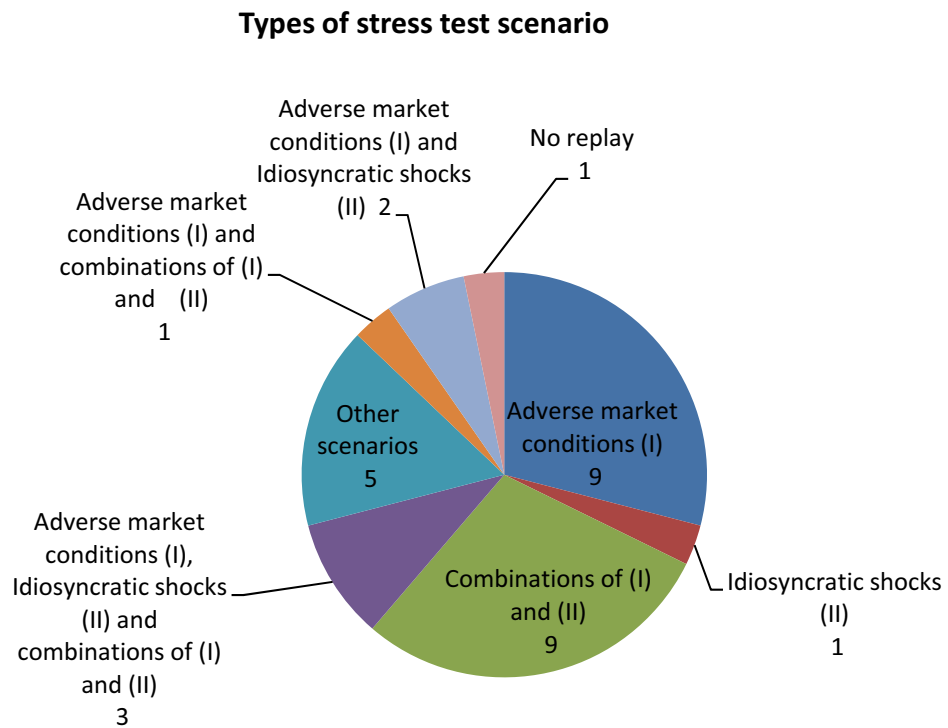
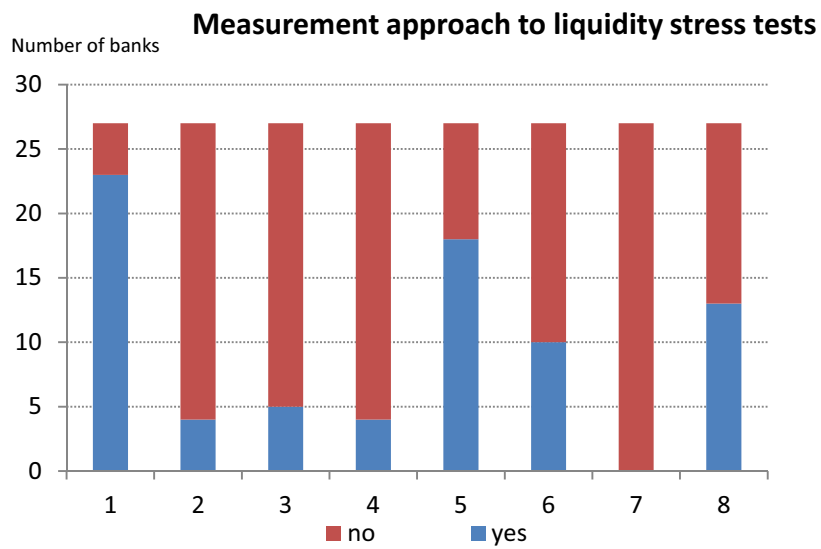


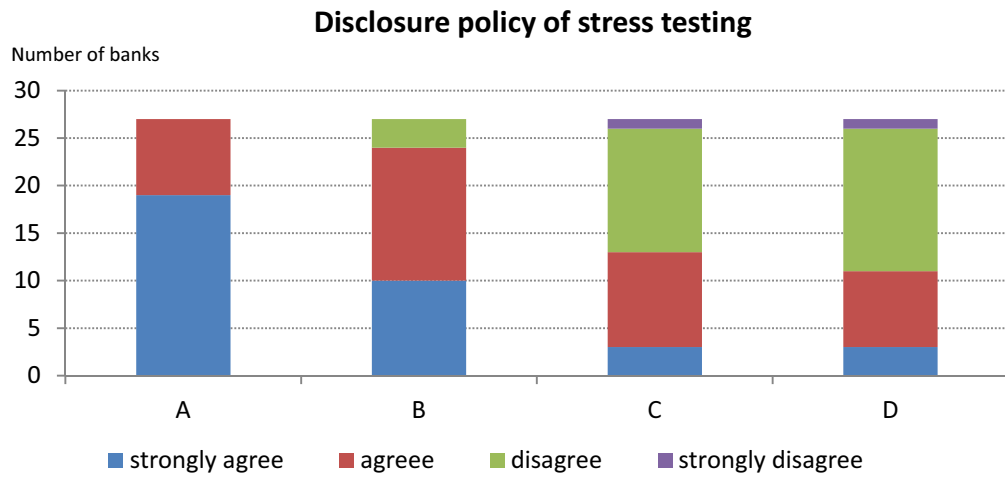
Figure 17



- 1 - Cash flow maturity mismatch
- 2 - Liquidity stock approach
- 3 - Balance-sheet maturity mismatch
- 4 - Mixture of cash flow and liquidity stock approach
- 5 - Other cash flow analysis
- 6 - Liquidity coverage ratio
- 7 - Current liquidity ratio
- 8 - Other

Source: BCB survey

Figure 18



A - Results cannot be interpreted without detailed understanding of the scenarios and the considerations underlying them

B - Lack of comparability across banks

C - Our bank does not see value added in disclosing liquidity stress test results

D - Disclosure would not enhance market discipline

Source: BCB survey

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