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Brazil: Technical Note on Stress Testing the Banking Sector

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FINANCIAL SECTOR ASSESSMENT PROGRAM

BRAZIL

STRESS TESTING THE BANKING SECTOR

TECHNICAL NOTE

DECEMBER 2012

INTERNATIONAL MONETARY FUND
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GLOSSARY

BCB	Central Bank of Brazil
BCBS	Basel Committee on Banking Supervision
BNDES	Banco Nacional de Desenvolvimento Econômico e Social
BU	Bottom-up (stress test)
EAD	Exposure at Default
EU	European Union
FSAP	Financial Sector Assessment Program
FSI	Financial Soundness Indicator
FSR	Financial Stability Report
FX	Foreign exchange
GIIPS	Greece, Ireland, Italy, Portugal, Spain
IMF	International Monetary Fund
IRB	Internal Ratings-Based (Basel II credit risk approach)
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LTV	Loan to Value
NSFR	Net Stable Funding Ratio
PD	Probability of Default
RAM	Risk Assessment Matrix
RWA	Risk-Weighted Assets
StA	Standardized Approach (under Basel II)
TD	Top-down (stress test)
TD BCB	Top-down test run by the BCB
TD IMF	Top-down test run by the IMF mission
VAR	Vector Auto Regression
WEO	World Economic Outlook

EXECUTIVE SUMMARY

This note summarizes the stress tests undertaken for the Brazilian banking system as part of the Financial Sector Assessment Program (FSAP) Update. The focus was on tail risks and medium-term structural trends. The stress tests, which were run in a top-down (TD) manner based on granular supervisory data, were undertaken in close cooperation with the Central Bank of Brazil (BCB).

All banks were assessed against solvency, liquidity, and contagion risks. The solvency tests assessed the resilience of the system under three adverse macroeconomic scenarios as well as baseline conditions for the period from 2012 till 2016. The tests considered different definitions of capital adequacy (total capital, tier 1, core tier 1), and simulated the impact of upcoming changes in the regulatory rules (Basel III). Bank behavior conditional on stress conditions was captured by profit retention and credit growth. The liquidity tests simulated banks' resilience against a sudden withdrawal of funding and, to some degree, maturity mismatch. Contagion risk was analyzed by simulating potential knock-on effects through interbank exposure.

The banking system appears to have substantial capital buffers. In terms of solvency, banks benefit from very favorable income levels, which serve as a strong first line of defense against credit losses, their main solvency risk. Even in the case of a severe global recession—corresponding to a shock that historically occurred once in 20 to 30 years—the need for additional capital to meet minimum regulatory capital requirements (i.e., 11 percent measured under current Basel II rules based on the Standardized Approach) would be limited.

In terms of economic capitalization banks also appear resistant to considerable stress, although a severe shock would bring the system slightly below the hurdle rate. Economic capital can be measured using an internal ratings based approach (i.e., based on estimates of probability of default, loss given default, and exposure at default). The weaker performance of the system in economic terms is driven by the comparably high level of default rates under baseline conditions, low recovery rate levels in Brazil in general, and the phase-out of capital eligibility under Basel III.

The liquidity stress tests found that the majority of banks are able to cope with sizeable liquidity shocks, and will also meet Basel III standards. Liquidity risk is monitored on a daily basis by the BCB and suggests that banks have improved their liquidity positions after some strains during the Lehman period. Banks' liquidity positions are solid, thanks to high levels of liquid assets; the exceptions are some of the medium-sized and smaller banks that are more vulnerable to sizeable funding shocks due to their stronger reliance on wholesale funding. Despite their high portion of liquid assets in international terms, especially medium-sized and smaller banks will have to strengthen their funding profiles through a lesser reliance on wholesale funding.

Direct contagion risk through interbank market exposures is limited, but if it were amplified through funding markets there is some potential for a more adverse impact. Interbank contagion risks are contained due to limited bilateral exposures: there are a few net liquidity providers and receiving banks in the system, which take a systemic role in terms of contagion risks. Although the net borrowers are smaller banks, uncertainty could lead to a loss of confidence and amplify stress conditions through indirect contagion. It is also worth noting that Brazil banks' exposure to peripheral Euro Area and the rest of the world more generally is limited, except for foreign banks' link to their parents. The latter banks are subsidiaries, largely funded and lending in Brazil, as well as being ring-fenced by regulations and intensive supervision.

Structural changes could reduce banks' profitability towards levels observed in peer countries, and could amplify stress conditions in the medium/long term. In addition to potential lower interest margins the persistent high credit growth levels could magnify the level of credit losses during a downturn, which suggests that sufficient (countercyclical) buffers are being built.

I. INTRODUCTION

Macro-financial context

1. **Brazilian banks have, with some exceptions, weathered the global financial crisis relatively well, owing to their robust balance sheets, timely measures by the authorities, and a favorable domestic operating environment.** The system faced the crisis with a solid level of capital adequacy and structurally very high income levels. Aside from liquidity strains, mainly at medium-sized and smaller banks and mitigated by public measures, the impact of the global financial crisis on bank solvency was relatively short-lived.

2. **The system emerged from the crisis well-positioned to cope with adverse shocks.** The temporary slow-down of credit growth allowed banks increasing capital buffers, but the health of the banking system becomes gradually more bimodal: solid large banks on the one hand and more fragile smaller banks on the other. An important reason for that is that larger banks rely more on deposit funding while smaller and medium-sized banks tend to be more dependent on wholesale funding.

3. **However, credit has been growing strongly in recent years, particularly in some sectors.** The leverage of the real economy overall is limited—the credit-to-GDP ratio is around 50 percent, lower than in peer countries—and has a positive implicit impact on credit risks. However, there are signs of financial distress in some segments of the household sector that could lead to solvency issues in severe downturn conditions through non-linear loss effects.

4. **Financial stability analysis focused on potential stress in the banking sector, taking into account the broader macro-financial situation and upcoming regulatory changes.** At the current juncture, potential risks to financial stability can arise (i) from abroad, for example resulting from a severe global recession triggered by external shocks; (ii) from domestic sources of stress, originating, for example, from an increasing level of indebtedness of the household sector and the gradual inclusion of lower rated borrowers; or (iii) through a combined shock in international and domestic markets. An important potential channel of stress in Brazil is the reversal of capital flows, which has been captured by specific scenarios.

5. **The Brazilian financial system is diverse, complex and characterized by a high degree of conglomeration, concentration, and public sector presence.** It is organized around a few financial conglomerates, which are often headed by a commercial bank, that control over 75 percent of the system's assets,. The largest five banks account for about 40 percent of the assets in the financial system and 66 percent of the bank assets, respectively; Brazil's major development bank, Banco Nacional de Desenvolvimento Econômico e Social (BNDES), accounts for 14 percent of the bank assets, and thus the

largest six banks account for 80 percent of the assets in the banking system (Table 1). The portion of publicly owned banks is close to 45 percent, which is relatively high.[1] The remaining 140 banks and more than 1,300 credit unions account for 20 percent of the assets.

6. **The Banking system is less globally integrated compared to its peer countries.** Foreign banks (mainly from Europe and the U.S.[2]) own about 20 percent of the bank assets, down from close to 30 percent in 2002, which is lower than in other Latin American countries–while the opposite is true for the equity markets. Only about 10 percent of the banks' assets and liabilities are denominated in foreign currency, all of which are of wholesale nature.[3] Currency mismatches in the banking system are on average small, at around 7 percent of banks' capital at end-September 2011.

7. **Financial soundness indicators (FSIs) of Brazilian banks compare favorably to peers in Latin America and other banking systems (Figure 3).** At end 2010, the system ranked slightly above average in terms of capitalization in emerging market countries, medium to high in terms of liquidity,[4] and very high in terms of profitability while credit loss levels have been higher than in other peer countries in the past. Besides interest income, Brazilian banks also enjoy a high share of fees and commissions and other income. Brazil's favorable economic outlook and banking soundness is also reflected in market indicators, such as banks' stock prices, sovereign spreads, and the performance of the broader stock market and of the large financials groups.

[1] Banco do Brasil, Caixa Economica Federale and Banco Nacional de Desenvolvimento Econômico e Social are the largest universal, savings, and development banks, respectively, constituting close to 42 percent of total banking assets.

[2] Santander (fifth largest bank) has a market share of 9 percent, followed by HSBC (3 percent of the assets).

[3] Some large government-owned banks were able to tap international bond markets in late 2009 to early 2010, but foreign currency liabilities in the system remain low.

[4] The portion of liquid assets is very high, while the customer loans to customer deposit ratio ranks slightly lower, but still comfortable. However, the liquidity position of Brazilian banks varies widely, also depending on the (gradually increasing) maturity profile of their assets.

Table 1. Brazil: Financial System Structure

	2002				2007				2011			
		Financial sector assets				Financial Sector Assets				Financial sector assets		
	Number of Institutions	(R$ billion)	(Percent of total)	(Percent of GDP)	Number of Institutions	(R$ billion)	(Percent of total)	(Percent of GDP)	Number of Institutions	(R$ billion)	(Percent of total)	(Percent of GDP)
Depository institutions	1,725	1,143	65.0	77.4	1,761	2,189	54.7	82.3	1,603	4,387	59.4	105.9
Multiple and commercial banks	166	850	48.3	57.5	155	1,698	42.4	63.8	157	3,244	43.9	78.3
of which, by size:												
Large banks	14	693	39.4	46.9	14	1,382	34.5	51.9	14	2,765	37.4	66.7
Medium banks	39	129	7.4	8.8	39	258	6.4	9.7	39	371	5.0	9.0
Small banks	82	28	1.6	1.9	82	58	1.4	2.2	82	108	1	2.6
of which, by ownership:												
Federal government-owned banks	8	211	12.0	14.3	6	341	8.5	12.8	4	753	10	18
State government-owned banks	6	43	2.4	2.9	6	80	2.0	3.0	5	59	0.8	1.4
Private banks, domestically-controlled	76	340	19.4	23.0	78	845	21.1	31.8	88	1,680	22.7	40.5
Private banks, foreign participation	11	n.a.	n.a.	n.a.	9	n.a.	n.a.	n.a.	-	n.a.	n.a.	n.a.
Private banks, foreign-control	56	256	14.6	17.3	48	432	10.8	16.2	60	752	10.2	18.2
Branches of foreign banks	9	n.a.	n.a.	n.a.	8	n.a.	n.a.	n.a.	-	n.a.	n.a.	n.a.
Development banks	4	154	8.8	10.4	4	205	5.1	7.7	4	580	7.8	14.0
Savings banks	1	122	6.9	8.3	1	239	6.0	9.0	1	464	6.3	11.2
Credit Unions	1,430	11	0.7	0.8	1,461	38	0.9	1.4	1,312	85	1.2	2.1
Investment banks	23	-	-	-	17	3	0.1	0.1	14	3	-	0.1
Consumer finance companies	46	1	0.1	0.1	51	1	-	0.1	59	4	-	0.1
Real estate credit companies	18	4	0.2	0.3	18	4	0.1	0.1	14	7	0.1	0.2
Micro-financing institutions	37	-	-	-	54	-	-	-	42	-	-	-
Non-depository financial institutions	811	9	0.5	0.6	683	16	0.4	0.6	613	23	0.3	0.6
Development agencies	10	2	0.1	0.1	12	4	0.1	0.1	16	7	0.1	0.2
Exchange banks	-	-	-	-	-	-	-	-	2	-	-	-
Leasing companies	65	2	0.1	0.2	40	1	-	-	31	2	-	-
Mortgage companies	6	-	-	-	6	-	-	-	8	-	-	-
Securities brokerage companies	161	1	0.1	0.1	113	5	0.1	0.2	99	5	0.1	0.1
Exchange brokerage companies	42	-	-	-	48	-	-	-	47	-	-	-
Security Distribution companies	151	1	-	-	132	1	-	-	126	1	-	-
Consortium managers	376	3	0.1	0.2	332	5	0.1	0.2	284	8	0.1	0.2
Insurance companies	159	63	3.6	4.3	161	206	5.1	7.7	169	426	5.8	10.3
Life (long-term)	60	33	1.9	2.2	65	139	3.5	5.2	63	298	4.0	7.2
Nonlife (general)	12	1	-	-	29	3	0.1	0.1	31	7	0.1	0.2
Life and non-life	63	29	1.7	2.0	51	64	1.6	2.4	50	107	1.4	2.6
Reinsurance	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	8	14	0.2	0.3
Investment and Asset Managers 1/	-	573	33.2	38.7	472	1,712	41.5	64.3	486	2,815	36.8	67.9
Investment funds management companie	-	355	20.6	24.0	87	1,160	28.2	43.6	93	1,940	25	46.8
Pension fund management companies 1/	-	218	12.6	14.7	-	552	13.4	20.7	-	875	11	21.1
o/w open pension funds	355	30	1.7	2.0	385	120	2.9	4.5	393	261	3.4	6.3
Total financial sector 2/	2,695	1,758	100.0	119.0	2,916	4,003	100.0	150.4	2,702	7,389	100.0	178.3
Memorandum items:												
Money and capital markets 3/	n.a.	1,582	90.0	107.0	n.a.	5,715	142.8	214.7	n.a.	6,826	92.4	164.7
Money market	n.a.	159	9.0	10.8	n.a.	443	11.1	16.6	n.a.	883	13	21.3
Government Bond market	n.a.	623	35.4	42.2	n.a.	1,225	30.6	46.0	n.a.	1,783	26	43.0
Corporate Bond market	n.a.	48	2.8	3.3	n.a.	223	5.6	8.4	n.a.	455	6.7	11.0
Equity market	n.a.	438	24.9	29.7	n.a.	2,478	61.9	93.1	n.a.	2,294	33.6	55.4
Derivatives market 4/	n.a.	313	17.8	21.2	n.a.	1,347	33.6	50.6	n.a.	1,410	20.7	34.0
Nominal GDP		1,478				2,661				4,143		

Sources: ANBIMA, BCB, BM&Fbovespa, CVM, PREVIC, SUSEP.

1/ Assets are those under management.

2/ Aggregation overstates total size in absolute terms due to double-counting.

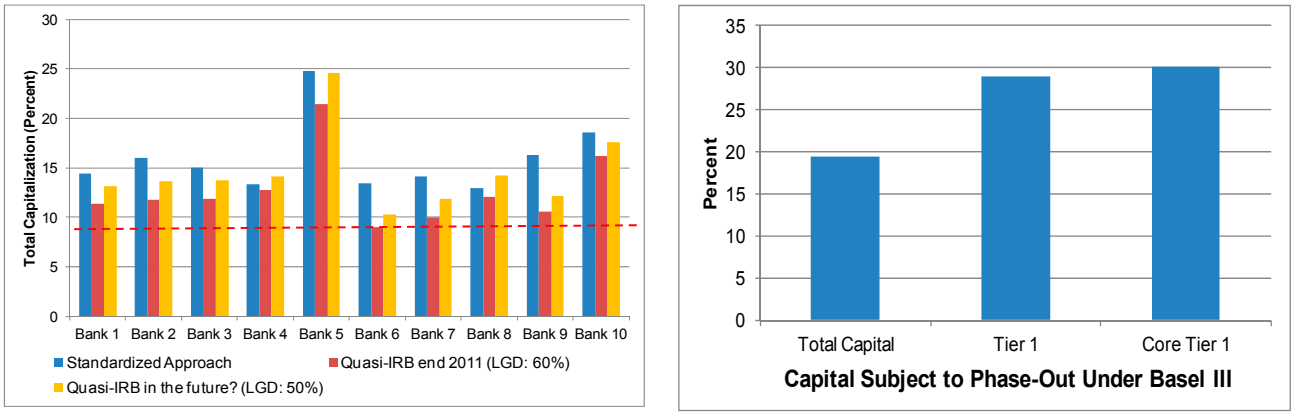
3/ Amount outstanding unless otherwise noted.

4/ Open positions on BM&FBovespa, notional value

8. **Capital adequacy in economic terms (based on simplified IRB capitalization) is lower than measured in statutory terms, and part of the capital will become ineligible under Basel III (Figure 1).** Regulatory capital is solid in terms of quantity and, with some exceptions, in terms of quality (by end 2011, total capital adequacy was at 17 percent, tier 1 capitalization at 12.8 percent and core tier capitalization at 12.3 percent). However, upon full

implementation of Basel III, 20–30 percent of capital will become ineligible, mainly due to the high level of deferred tax assets[5] (Figure 1, right hand panel), but banks are highly profitable and can therefore rapidly build buffers under baseline conditions. Banks' asset quality has been characterized by persistent high levels of credit losses in the past (see below). Accordingly, despite comparably short effective maturities at 1.8 years (up from 1.1 years in early 2007), banks' quasi-advanced IRB capitalization for the largest banks appears to be commonly 20 percent lower than under statutory rules (Figure 1, left hand panel).[6]

Figure 1. Brazil. Level and Quality of Bank Capitalization



Source: IMF Staff calculations based on supervisory data.

9. **Brazilian banks have experienced a constant flow of elevated credit loss levels during the last decade, albeit without major peaks (Figure 2).** Credit loss rates (write-off ratios) were constantly at about 3 percent of total loans during the last decade[7], driven by low recovery in case of default (i.e., high LGDs), and the rapid recognition of credit losses by banks, in line with regulation in place since the early 2000s. Given their very high income level, banks were in a position to digest these elevated loss levels using their income buffers. Going forward, banks are likely to benefit from the revision of bankruptcy law, but default

[5] Secondary Tier 2 instruments have somewhat increased in importance recently, however they still represent a small fraction of the system's capital. Tier 1 capital is lower at government-owned banks, which rely more on hybrid instruments and thus have weaker buffers to absorb credit losses under stress conditions.

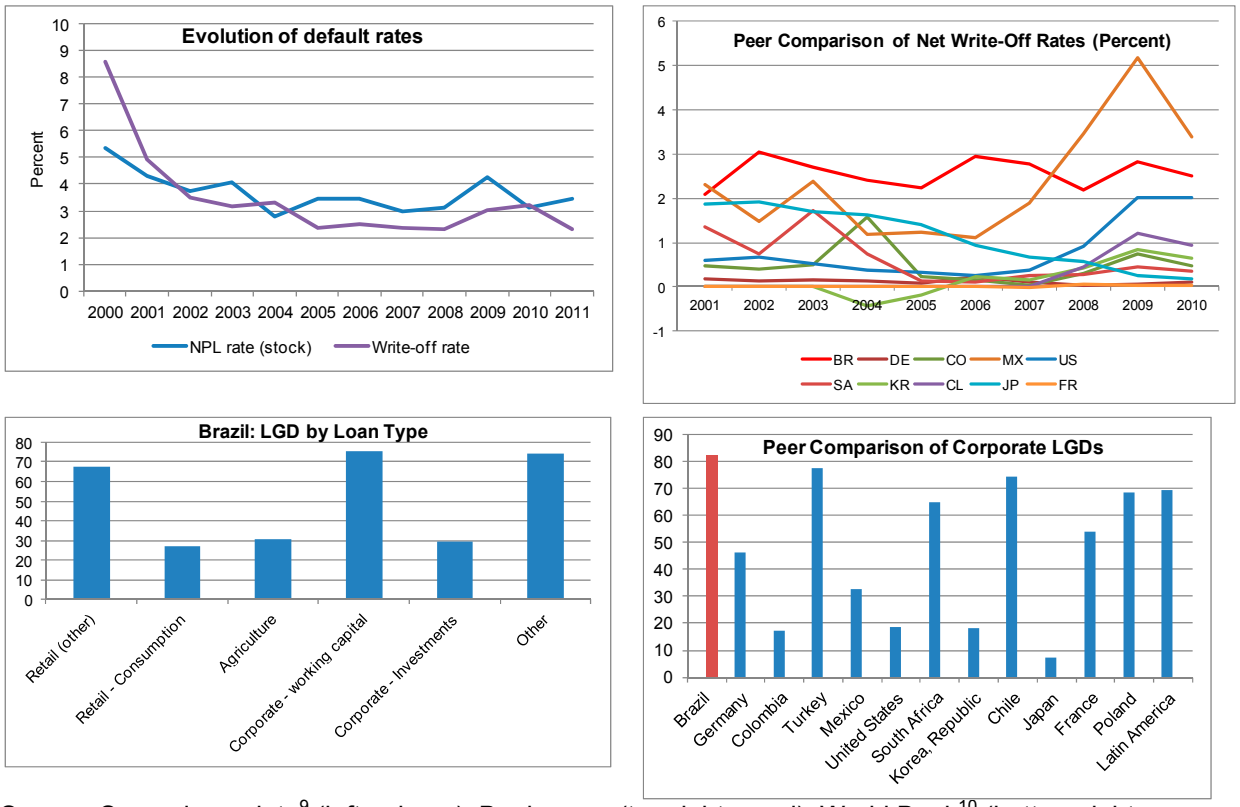
[6] The credit risk parameters (default rates, LGDs, maturities) have been used to compute a simplified, quasi-IRB capitalization for each bank. It should be noted that this is a proxy, and ultimate ratios can only be computed once banks have introduced the Basel II International Ratings based approach (IRB). Notwithstanding, the outcome is broadly in line with previous studies on the potential impact of banks moving to the Foundation IRB, e.g., Carneiro, Vivan and Krause (2005).

[7] International evidence suggests credit loss rates of about 1 to 2 percent for emerging market countries. This comparison excludes countries that experienced a banking crisis.

rates could remain elevated due to a broadening of banks' customer base and higher maturities.[8]

10. **The Loss Given Default (LGD) is higher than in other countries and increases the level of credit losses (Figure 2).** Based on a proxy computed by the BCB, LGDs are at around 65 percent for the majority of loans in terms of exposure, both for corporate and retail. For mortgages and other consumer loans backed by collateral (i.e., a limited share of total loans by now), the LGD is considerably lower at around 25 percent. While publicly available data on LGDs for Brazil remain scarce, the World Bank, for example, assigns a corporate LGD of 83 percent to Brazil, whereby Brazil ranks twenty-sixth among 157 countries (from the top, i.e., the highest LGD levels), well above the average for Latin American countries, which was estimated at 70 percent.

Figure 2. Brazil. Default and Recovery (LGD) Rates

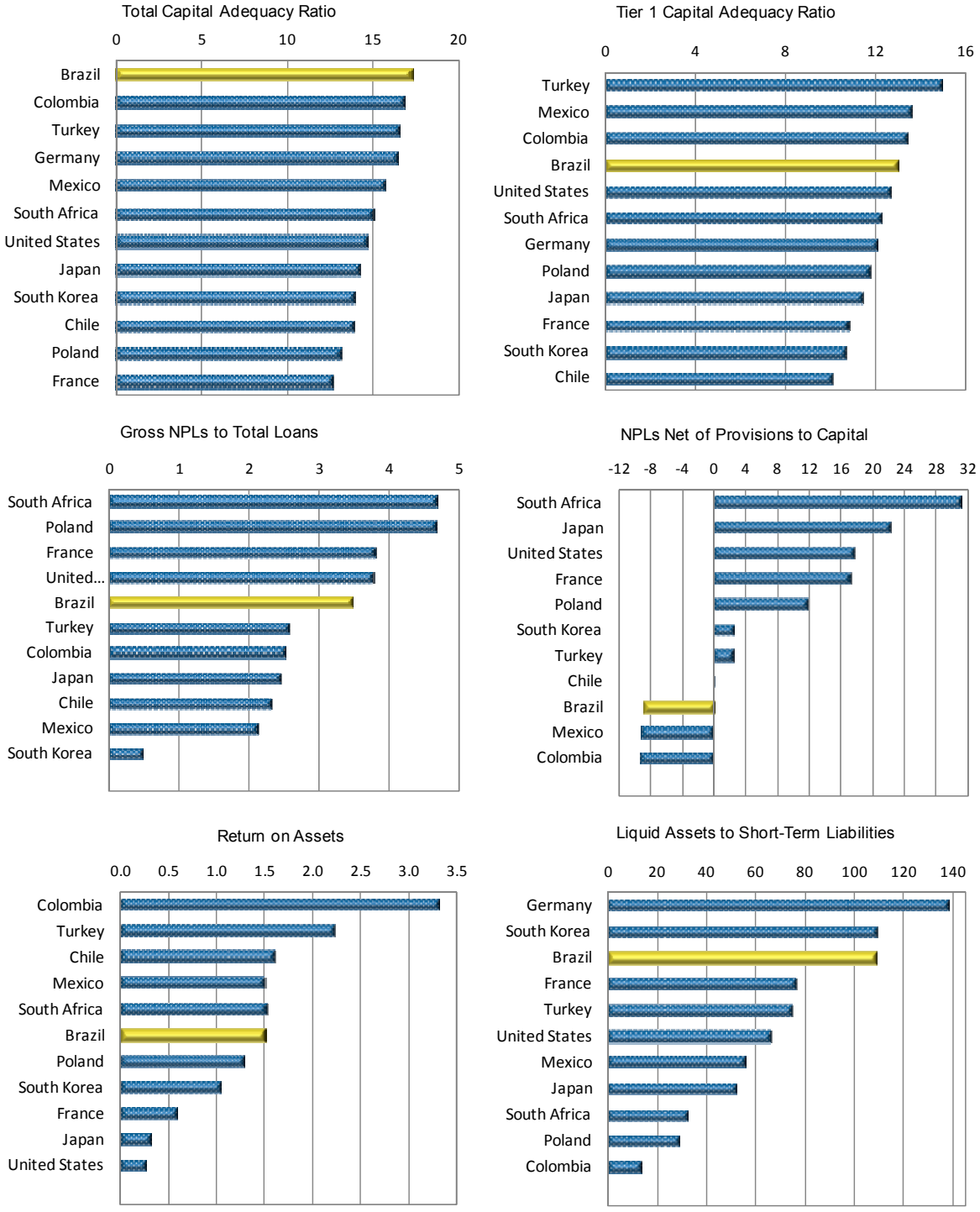


Source: Supervisory data[9] (left-column); Bankscope (top right panel), World Bank[10] (bottom right-hand panel).

[8] Although a large part of the exposures are in lower risk, secured payroll loans, the opening up toward previously unbanked segments with unproven track record may pose higher risks.

[9] Note that the figures for the LGDs are proxies. The proxies computed by the authorities compare NPLs with write-offs. As there is only little recovery in terms of the write-offs, this proxy appears meaningful at this stage.

Figure 3. Brazil: Key Financial Soundness Indicators—Cross-Country Comparison



Source: IMF

[10] The cross-country comparison by the World Bank is based on a survey among administrators simulating the recovery of a bankrupt hotel going through proceedings. As such, it is a rough proxy for corporate LGDs. In specific cases, the LGD can be highly biased into both directions, but for Brazil the LGD is broadly in line with the proxy computed by the authorities.

11. **Bank credit has grown rapidly during the last 10 years, in line with developments in other emerging markets, albeit credit growth has recently slowed (Figure AII.1).** Since the onset of the financial crisis in 2008, BNDES, and, to a lesser degree Caixa and Banco do Brasil have played a countercyclical role to compensate for the slowdown in private bank lending.

Overview of the Stress Tests

12. **The stress tests for the banking system aimed at gaining a comprehensive view on potential short- and medium-term vulnerabilities in the system, including in the tail, rather than estimating recapitalization needs (and potential liquidity shortages) for specific banks.**[11] The stress tests covered a variety of solvency risks (including credit risks, market risks, concentration risks and income risk), liquidity risks and contagion risks. An overview of the FSAP stress test framework is displayed in Figure 4. The core elements of the framework are outlined below and summarized in Annex IV.

13. **The design of the scenarios, methodologies, and the actual undertaking of the stress tests were carried out in close cooperation between the BCB and the FSAP team.** The tests were based on top-down (TD) tests for solvency, liquidity and contagion risk, using a variety of frameworks developed by the BCB ("TD BCB") and the IMF ("TD IMF"). The purpose was to thereby benefit from the specificities of each framework and from in-depth experience of the BCB on the one hand and international experience (IMF) on the other. Bottom-up (BU) tests were omitted given ample supervisory data available to carry out the tests.

14. **The stress tests focused on the main risks for banks, and covered all banks.** Banks are exposed to credit and credit concentration risks, which are their major source of solvency risk. While there are some mitigating factors (such as limited overall indebtedness of the real sector) credit has been growing fast, especially on the retail side (including in the mortgage sector),[12] and counterparty credit risk is inherent to the system through interbank exposures. Small and medium-size banks rely on wholesale funding, which proved volatile during the crisis, but substantial reserve requirements can be used—and were indeed selectively used—as a buffer. While these banks are not necessarily systemic, liquidity

[11] This is the general purpose of stress tests in FSAPs and set them apart from supervisory stress tests such as the ones conducted by the European Banking Authority (EBA) in 2010 and 2011 and the U.S. Federal Reserve Bank in 2009 and 2012.

[12] The state-owned bank that holds the majority of the (low income) mortgage market—in line with its mandate—is particularly exposed to mortgage exposure, although the riskiest loans were extended under a public policy mandate and are essentially guaranteed by the state, whereby the risk is ultimately fiscal. Moreover, the share of housing loans remains limited in overall terms at about 5 percent of GDP.

markets have been very volatile recently and indirect contagion could be an important factor, including for confidence in the system.

15. **The solvency tests assessed banks' ability to cope with a severe global recession and two distinct macroeconomic shocks in terms of capital inflows**. The severe recession scenario simulated a cumulative deviation of GDP growth from the baseline during a two year period by 2.5 standard deviations (i.e., 12 percentage points), with a return to baseline growth thereafter.[13] The other two macroeconomic scenarios, simulating short-term ("sudden stop") and persistent ("terms of trade shock") shocks in terms of capital inflows were less severe than the global recession scenario, but still sizeable and particularly relevant macroeconomic shocks for Brazil.[14] These three scenarios correspond to the main risks identified for the economy in general and the financial system in particular (Risk Assessment Matrix, Appendix I), and thereby reflect uncertainties going forward. The results under these scenarios were benchmarked against those obtained under a baseline scenario using preliminary April 2012 World Economic Outlook (WEO) projections.

16. **Bank solvency was assessed in statutory and economic terms.** In addition to simulating the impact of stress in terms of statutory capitalization (i.e., based on the Basel II Standardized Approach (StA)), bank solvency under stress was also assessed in economic (i.e., quasi-IRB) terms for all banks in the system. The purpose of including an economic measure of solvency was to anticipate that some of the banks will introduce IRB Basel II methods in the near future on the one hand, but also to capture the "true" risk profile of banks on the other hand.[15] Using economic capital ratios also allows neutralizing potential changes to capital ratios driven by macroprudential policies.

17. **The liquidity tests assessed banks' resilience against bank-run type tests and risk arising from maturity mismatch.** The tests benefitted from ample daily data available to the authorities. The scenarios included adverse conditions simulating a combination of market stress and idiosyncratic shocks. The tests simulated the established "Liquidity ratio" developed by the BCB for all banks, which is a Liquidity Coverage Ratio (LCR) type measure, as well as actual Basel III liquidity ratios for a subset of banks.

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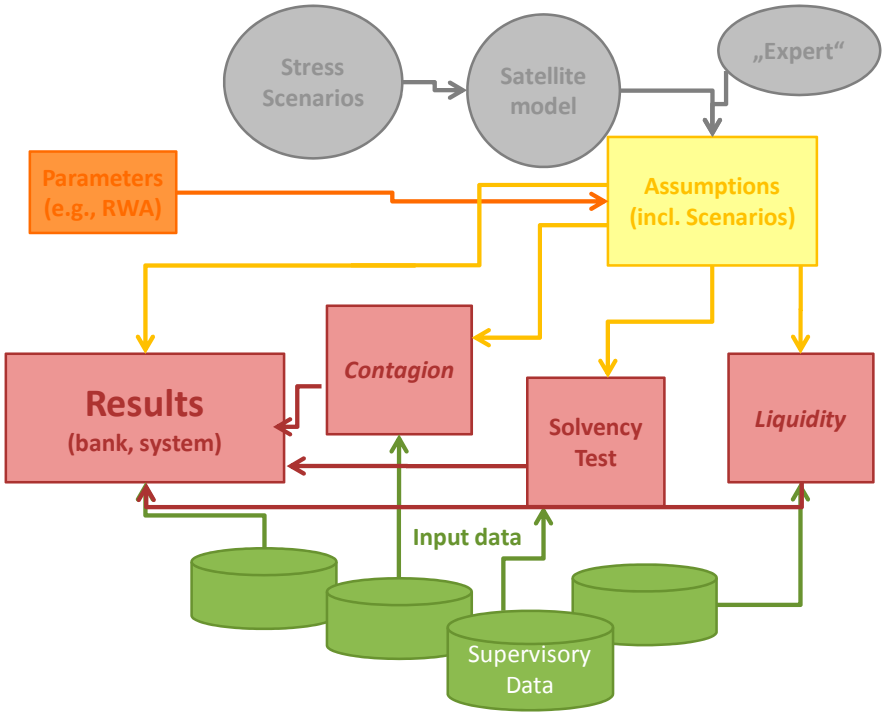
[13] This tail risk scenario constitutes a 1-in-30 year shock scenario.

[14] In historical terms, the likelihood for such scenarios is about 3–10 percent (sudden stop with unfavorable growth path thereafter), compared to about 2 percent for the global recession scenario.

[15] The difference between Basel I type capitalization (including, in principle, those for banks under the Standardized Approach) is that Risk-weighted Assets (RWAs) are adjusted for volume (credit growth, losses), but not for the change of the risk profile.; it should also be noted that the Brazilian rules for the Standardized Approach do not rely on ratings, whereby risk-adjustment is even more limited than for other banks using the Standardized Approach for credit risk. The newly developed IMF framework allows simulating economic solvency also for non-IRB banks. Other specific rules applicable only to Brazil, such as changes in risk-weights as part of macroprudential policies, are not incorporated herein.

18. **Potential contagion effects through interbank exposures was simulated based on network models.** The simulation assessed the potential impact of shocks both through bilateral exposures (i.e., direct contagion) and indirect contagion, the latter simulating the materialization of stress through funding withdrawals.

Figure 4. Brazil: Overview of the FSAP Bank Stress Testing Framework



Source: IMF Staff

II. Solvency Tests

A. Approaches and Coverage

19. **The solvency tests were based on a balance sheet approach, entailed scenario analysis and single factor shocks, and covered all banks.** The solvency tests were based on end 2011 supervisory data, and shed light on the coming five year period (2012–2016). The longer horizon was meant to assess banks' ability to cope with Basel III effects while challenged by persistent unfavorable conditions and to facilitate comparison with other G-20 FSAPs, at the expense of some precision in the outer years.

20. **The key components for solvency risk (losses, income, credit growth) were modeled through satellite models.** The satellite models benefitted from work done at the BCB and recent IMF work in this area in other countries. Banks' behavior under stress was simulated by means of payout ratios conditional on stress levels as well as credit growth, allowing for some limited deleveraging under the global recession scenario, in line with

historical evidence. Concentration risk in banks' lending portfolios assessed the impact of a default of the largest counterparts.

21. **The system was assessed against four macroeconomic scenarios, reflecting that risks to global financial stability remain heightened, while the outlook for Brazil is comparably favorable**: (i) Risks to the financial system could arise in case of a potential *severe global recession* (Scenario 1), which would have spillover effects to Brazil, for example through a drop in commodity prices. Likewise, (ii) a su*dden reversal of capital flows* (Scenario 2), and (iii) a persistent *terms of trade shock* (Scenario 3) could be felt through slowed economic activity, resulting in higher credit loss rates and lower pre-impairment income. These scenarios were (iv) benchmarked against those obtained under a baseline scenario used in the April 2012 World Economic Outlook (WEO) projections. The risks for banks' asset quality and pre-impairment income arising through these channels were captured based on scenario analyses and sensitivity tests. In the first step, the trajectories of the macroeconomic variables were simulated based on VAR analysis (see Table 3). In the next step, these scenarios were translated into financial stress at the bank level using satellite models and expert judgment (Appendix III).

22. **Scenario analysis covered a period of five years, while sensitivity analysis analyzed the immediate impact of stress (Table 2).** Scenario analysis for the outer years of the projection horizon (till 2016) were meant to capture the full impact of stress over time, including the recovery process, the impact of a period of persistent low(er) growth in case of the terms of trade shock and potential structural trends (such as lower levels of pre-impairment income). The longer time horizon also allows simulating the full impact of a long-lasting, deep recession, which typically hits banks with some time lag and lasts between three to five years. It is important to note that the outcome constitutes a tendency rather than specific point estimates, owing to the uncertainty that comes with longer time horizons (and the sensitivity of the results with respect to the assumptions).[16]

23. **The solvency tests covered all 137 Brazilian banks, based on end 2011 supervisory data.** Banks were grouped into four subsets: (i) large banks; (ii) medium-sized banks; (iii) small banks; and (iv) foreign banks. Accordingly, it was accounted for data confidentiality issues as well as for similarity in business models, respectively.

[16] Taleb et al. (2012, forthcoming) outline how the outcome of a point estimate (i.e., a scenario analysis) can be tested for robustness in order to avoid misleading conclusions.

Table 2. Brazil: Overview of Key Dimensions of the Solvency Tests

Method	Forecast period	Period	Scenarios	Percent of banking system
Sensitivity analysis	Instantaneous (end 2011) for market risk; end 2012 for credit risk	1 day (Market R); Annual (Credit R)	Market risk shock (Interest Rate Shock; FX Rate shock; Asset Price shocks to sovereign debt and equities); Credit Risk shock (Increase of PDs; LGDs; Default of largest counterparts)	100
Scenario Analysis	Q1 2012–Q4 2016	Annual	Macroeconomic scenarios: (i) Baseline, (ii) Severe global recession, (iii) Sudden Stop, (iv) Persisting terms of trade shock	100

Source: IMF Staff

B. Scenarios and Shocks

24. **The tests simulated the impact of three macroeconomic scenarios, as well as baseline conditions on Brazilian banks (see also the RAM, Appendix I):**

- **Baseline:** The preliminary IMF April 2012 WEO baseline forecast was used to simulate banks' baseline conditions. This baseline scenario assumed a three percent growth of economic activity in 2012 and a bounce back towards potential growth after 2013.

- **Severe Global Recession:** simulated a severe global recession, triggered by the sovereign debt crisis in Europe, and amplified by fiscal concerns in other major economies, slow growth in the U.S., and a potential slowdown of growth in emerging market economies, including of Brazil's main trading partners (China). This scenario is very severe in historical terms (Figure 5) and with a cumulative deviation of growth by 12 percentage points in two years (2012–13) (Table 3) it corresponds to a worst-in-30 year scenario for emerging market countries.

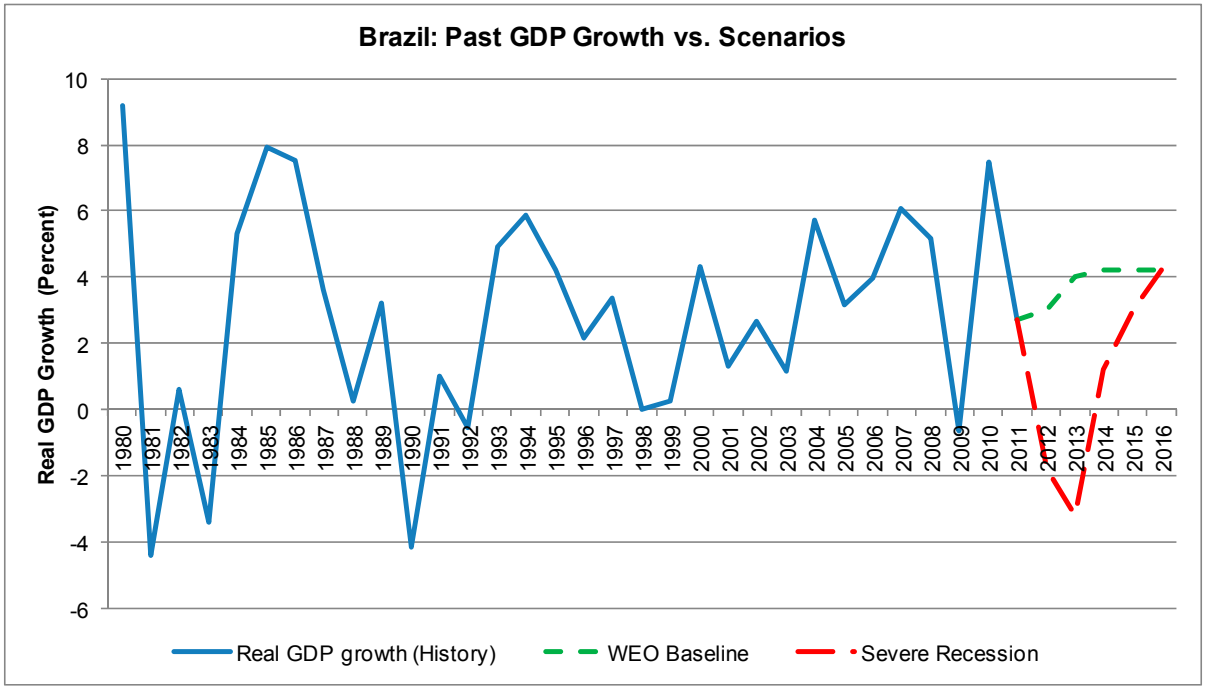
- **Sudden Stop:** A sudden stop of capital inflows could be the result of a change of investor sentiment (flight-to-quality). Such a scenario could be triggered by unfavorable economic conditions in the investors' home countries, for example, and/or by a worsening of the domestic economic outlook in Brazil. The scenario constitutes a moderate economic downturn scenario, with a cumulative deviation of output by about 6 percentage points from the baseline, and roughly corresponds to a

shock scenario twice the one in 2007–2009 in terms of the change of FX rates and interest rates, respectively (Table 3).

- **Terms of Trade Shock:** this scenario is also triggered by a worsening of Brazil's current account, i.e., a reversal of capital flows, but simulates a more persistent shock equal to the historical worst case scenario during the last 20 years in terms of current account shock (observed during the late 1990s). In terms of output, this shock leads to four consecutive years of slow growth and a cumulative deviation from the baseline by 8 percentage points through 2016 (Table 3).

25. **A persistent commodity price shock and a single factor shock for the real estate sector complemented the macroeconomic scenarios.** A commodity price shock simulated a drop of oil prices to half of today's level for three consecutive years, a shock that would heavily hit the commodity exporting Brazilian economy.[17]

Figure 5. Brazil. Illustrative Overview of the Macroeconomic Scenarios in Terms of Real GDP Growth



Source: IMF Staff

26. **The scenarios were established based on VAR analysis and panel regression models.** Financial stress was simulated based on the trajectories of real GDP growth for

[17] While Brazil is a net importer of oil, oil prices have been found to lead other commodity prices.

Brazil, the FX rate against the USD and money market interest rates.[18] These variables were used as inputs for the satellite models, whereby macroeconomic stress was translated into financial stress (Appendix III). For the global recession scenario, the GDP trajectory was chosen based on historical evidence (i.e., exogenously prescribed), and the FX rate and interest rate were forecast based on a combination of VAR analysis and panel models. For the other two macroeconomic scenarios, the GDP path was projected by means of VAR analysis, while the FX Rates and interest rates were chosen based on evidence.[19]

27. **The macroeconomic variables were projected to move in a direction that produces the most substantial financial stress, constituting a conservative projection (Table 3).** Other specifications produced opposite trajectories,[20] but were omitted as they were not relevant for stress testing purposes. The latter observation reflects the fact that interest rates and FX rates in the past did not necessarily move in directions that produce higher financial stress, which makes the establishment of meaningful macro-financial linkages challenging for Brazil (as well as for other countries, especially emerging markets). This issue was subject to extended analysis before the mission, and international evidence was used to arrive at consistent specifications, i.e., specifications that projected higher interest rates under stress[21] and a depreciation of the currency against the U.S. dollar and thus result in higher credit losses and lower pre-impairment income under stress (using the satellite models outlined below).

[18] Other macroeconomic variables (the lending rate, the U.S. t-bill rate, U.S. GDP growth) were also projected, but not used in the satellite models.

[19] For the sudden stop scenario (scenario 2), the magnitude of the shock on FX rates and interest rates observed during the financial crisis (i.e., between 2007 and 2009) was doubled. The terms of trade shock simulated the potential state of FX rates and interest rates under a scenario where the current account deficit gradually moves towards the highest level observed in the past (-3.4 percent of GDP in 1998).

[20] One example is lower FX rates in case of the severe recession scenario, which would imply a stronger relative position of Brazil under stress. Likewise, interest rates could also remain lower or decrease under stress, owing to policy intervention and a lesser risk (i.e., spread) effect.

[21] Assuming that the increase of interest rate spreads dominates a potential policy reaction towards lower interest rates.

Table 3. Brazil. Overview of the Macroeconomic Scenarios in Bank Stress Tests[22]

Overview of Scenario						
	2011	2012	2013	2014	2015	2016
Baseline						
GDP_r (change (y-o-y)	2.7	3.0	4.0	4.2	4.2	4.2
FX Rate (BRL per USD)	1.7	1.8	2.0	2.0	2.0	2.0
IR (MoneyMarketRate, percent)	10.9	9.9	10.9	11.4	11.4	11.4
Severe Global Recession						
GDP_r (change (y-o-y)	2.7	-1.4	-3.1	0.7	2.8	4.2
FX Rate (BRL per USD)	1.7	1.9	2.2	2.6	2.8	2.8
IR (MoneyMarketRate, percent)	10.8	13.7	17.4	18.9	17.9	16.4
Sudden Stop						
GDP_r (change (y-o-y)	2.7	1.5	2.0	2.8	3.5	4.2
FX Rate (BRL per USD)	1.7	2.1	2.4	2.3	2.1	2.1
IR (MoneyMarketRate, percent)	10.8	12.5	14.2	15.2	15.4	15.0
Terms of Trade Shock						
GDP_r (change (y-o-y)	2.7	2.5	1.5	1.2	2.5	3.5
FX Rate (BRL per USD)	1.7	2.0	2.2	2.4	2.5	2.5
IR (MoneyMarketRate, percent)	10.8	12.1	13.5	14.2	15.0	16.2

Cumulative deviation from Baseline	2011	2012	2013	2014	2015	2016
Severe Global Recession	0	4.4	11.5	15.0	16.4	16.4
Sudden Stop	0	1.5	3.5	4.9	5.6	5.6
Terms of Trade Shock	0	0.5	3.0	6.0	7.7	8.4

Source: IMF staff computations.

C. Concept and Assumptions

28. **The macroeconomic scenarios were linked to the evolution of bank solvency through satellite models (Table 4, Appendix III).** Specifically, satellite models were used to project the main financial variables affecting bank solvency, namely credit losses, pre-impairment income, credit growth (all three through the numerator of capital adequacy) and Risk-weighted Assets (RWAs) (through the denominator). The satellite models used for the stress tests are shown in Appendix III. In terms of RWAs, which were indirectly derived from the evolution of credit losses and credit growth, a risk-based solvency measure (i.e., based on the Internal Rating based approach, IRB) was used in addition to statutory capitalization (i.e., the Basel II StA). The profit retention rate was chosen in line with empirical evidence, and a 40 percent tax rate was applied. The phase-out of capital eligibility was projected based on bank-specific circumstances, drawing upon previous analysis at the BCB.

[22] In a separate severe recession scenario, a decrease of FX rates has been simulated, but it produced less financial stress and is therefore not reported.

Table 4. Brazil: Overview of the Modeling of Key Solvency Parameters

Parameter	Modeling
Credit Losses PDs LGD	*Use of Point-in-time parameters, based on:* Satellite model Empirical PD-LGD link[23]
Exposure at Default (EAD) (i.e., Credit Growth)	Satellite model.
Pre-impairment Income	Satellite model.
Profit retention rate	Expert judgment, conditional on severity of scenario, oriented on empirical evidence (on the conservative end).
Tax rate	40 percent in case of positive net income, 0 percent otherwise.
Basel III effects	Phase-out of capital eligibility based on BCB evidence and expert judgment for each bank; Hurdle rates as foreseen under Brazilian Basel II/III rules.

Source: IMF Staff

Data used as a starting point for stress tests

29. **The data used as a starting point for the tests were scrutinized, both with respect to outliers and with respect to their usefulness for multi-period stress tests.** Past experience has shown that using adequate stress tests parameters is crucial for meaningful multi-period tests, and are especially sensitive for the outer years. Income levels were particularly sensitive for banks with sizeable trading activities, for example, which is less relevant in the case of Brazil, though. Accordingly, 2012 income levels were adjusted to match the average during the last decade, but the outcome of the tests will remain broadly the same if one uses the actually observed profit levels for 2011.[24] Current capital adequacy levels could, in general, be affected by under-provisioning (resulting in over-estimation of buffers), but as Brazilian banks are obliged to write-off non-performing loans within twelve months there is limited room to assume that this could happen.[25] The implied levels of PDs[26]

[23] The IMF framework (based on Schmieder, Puhr and Hasan, 2011) uses an empirical relationship between PDs and workout-LGDs under stress. Accordingly, LGDs are positively correlated with PDs, i.e., both increase at the same time.

[24] To do so, a uniform scaling factor of 1.25 was used.

[25] Once banks move to the IRB approach, underprovisioning (relative to expected losses) would be accounted for through a deduction from capital

[26] For the PDs, the write-offs were used, which represents a flow ratio. A floor of 0.5 to 1 percent was set to avoid underestimating risk (e.g., in case of a bank which was "lucky" in 2011 encountering low loss levels), while ceilings between 5 and 20 percent were applied to be overly conservative for banks that has lost a substantial part of their exposure in specific sectors. PD floors were also assessed through single factor shocks for all banks (Table 7).

and LGDs[27] were set jointly by the authorities and the mission based on a combination of empirical evidence and expert judgment, the latter with a view to make credit parameters forward-looking.[28] Going forward, more granular data, including in the context of the introduction of the IRB should be used to refine the input data for future stress tests.[29] More generally, outliers were analyzed and dealt with.

Credit Risk and Market Risk

30. **The main credit risk parameters (PDs, LGDs, EADs) were stressed based on satellite models, while market risk stress was directly derived from the scenarios.** The PDs, and EADs were projected based on a satellite model, and LGDs were projected conditional on PDs using international evidence (based on Schmieder, Puhr and Hasan 2011, Appendix III). In terms of market risk, banks' were assessed against Foreign exchange (FX) risks, interest rate risk and asset price risks (see Table 7).

Income

31. **Pre-impairment income was projected based on a combination of satellite models and expert judgment, using international evidence as a benchmark.** A satellite model was used to project the evolution of pre-impairment income overall, rather than the evolution of the main sources separately. Pre-impairment income was projected to drop sharply under severe macroeconomic stress, in line with international evidence and reflecting the fact that banks rely to a noteworthy degree on income sources other than interest rate income (see Appendix III for further information).

Risk-weighted Assets (RWAs)

32. **The trajectories for banks' RWAs for credit risk under stress were simulated conditional on the definition of capital adequacy, i.e., statutory or economic capitalization.**[30] Under the statutory rules, RWAs were adjusted for the evolution of total assets only (neglecting other risk factors for simplicity, such as maturities and LTVs, which are relevant for Brazil), while RWAs were also adjusted for risk (i.e., the evolution of credit risk parameters) under the quasi-IRB risk forecast. Banks' RWAs for market risk and operational risk were assumed to evolve proportionally with credit risk.[31] Banks' RWAs for

[27] LGDs were set based on the analysis conducted by the BCB, at 25 percent for mortgages, 75 percent for retail credit and 65 percent for all other credit (Figure 2).

[28] The resulting loss rate on the bank level was compared against the observed write-off rate, which lead to specific additional adjustments using expert judgment to avoid large discrepancies between the two rates.

[29] For the banks that will remain under the Standardized Approach, evidence from the IRB banks could be used as a proxy.

[30] RWAs for credit risk make up 86.5 percent of the total RWAs.

[31] For market risk, RWAs were changed proportionally, while RWAs for operationally were changed using a factor of 0.5 based on expert judgment, but the outcome would remain largely unchanged if the RWAs for operational risk were also subject to a proportional adjustment.

other risks (which are very limited) were also left unchanged in both cases. As outlined below, Pillar 2 RWAs, such as an add-on for name concentration risk, could be an integral part of the test in the future.

33. **RWAs under the statutory rules are subject to macroprudential policies and can therefore influence stress test results.** Given the important role of changes in risk weights as part of macroprudential policies, changes in risk weights can give a false sense of stress (in both direction) when comparing the results of the same tests at a different point in time, for example. Such a bias can be avoided by adjusting statutory RWAs for changes in macroeconomic policies or using economic capital ratios.

Dividend payout and other behavioral adjustments

34. **Dividend payout was oriented on past experience, stress conditions and prudential rules.** It was assumed that banks would abstain from paying dividends in case of negative income, and that dividend payout would otherwise be in line with historical levels (at 35 percent of net income) and other countries that experienced severe stress conditions. Under the stress scenarios (for 2012–2014), banks were assumed to pay out only 25 percent of income, respecting the regulatory minimum.[32] Assuming that banks would retain all income under stress would improve the trajectories slightly except for the severe global recession, where most banks exhibit negative net income whereby the dividend payout is zero. It was also assumed that banks would not raise any capital during the forecast period.

35. **Credit growth was simulated to be uniform (i.e., the same for all banks), allowing for some deleveraging under the global recession scenario.** This assumption is line with historical evidence for both Brazil and other countries that experienced severe stress conditions (Appendix III). Sensitivity analyses were run to assess how the system would cope for different levels of credit growth and dividend payout, respectively, both under the baseline and under stress conditions. Banks were assumed not to raise capital during the forecast period or sell part of their assets (including subsidiaries, for example) other than those exposures that are part of their "normal" business (such as origination to sell in case of securitization, which is implicitly captured).

Hurdle Rates[33] and Basel III

36. **The hurdle rate of 11 percent for total capital adequacy based on BCB rules turned out to be more conservative than the hurdle rates for tier 1 capital and core tier 1 capital based on international standards.** Although the tier 1 and core tier 1 capital ratios of Brazilian banks are, on average, 25–30 percent lower than their total capital ratios,[34] the

[32] This constitutes a conservative assumption as the minimum payout applies only under specific circumstances.

[33] For economic capitalization, a minimum capital ratio of 8 percent was applied.

[34] These figures are broadly similar with data from the Quantitative Impact Study (BCBS 2010b), which was used as a benchmark for other FSAPs.

substantially lower Basel II/III minimum ratios for the higher quality capital (Table 5) make them less binding under stress. Hence, while the solvency tests revealed the results for all ratios, it is the outcome for total capital that will be reported below, because it is most relevant for most of the banks. In terms of the number of banks with shortfall, either of the hurdle rate was applied.[35]

Table 5. Overview of the Basel III Minimum Capital Requirements

Phase-In Arrangements (Shading Indicates Transition Periods) (all dates are as of 1 January)

	2011	2012	2013	2014	2015	2016	2017	2018	As of 1 January 2019
Leverage Ratio	Supervisory monitoring		Parallel run 1 Jan 2013 – 1 Jan 2017 Disclosure starts 1 Jan 2015					Migration to Pillar 1	
Minimum Common Equity Capital Ratio			3.5%	4.0%	4.5%	4.5%	4.5%	4.5%	4.5%
Capital Conservation Buffer						0.625%	1.25%	1.875%	2.50%
Minimum common equity plus capital conservation buffer			3.5%	4.0%	4.5%	5.125%	5.75%	6.375%	7.0%
Phase-in of deductions from CET1 (including amounts exceeding the limit for DTAs, MSRs and financials)				20%	40%	60%	80%	100%	100%
Minimum Tier 1 Capital			4.5%	5.5%	6.0%	6.0%	6.0%	6.0%	6.0%
Minimum Total Capital			8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Minimum Total Capital plus conservation buffer			8.0%	8.0%	8.0%	8.625%	9.25%	9.875%	10.5%
Capital instruments that no longer qualify as non-core Tier 1 capital or Tier 2 capital			Phased out over 10 year horizon beginning 2013						
Liquidity coverage ratio	Observation period begins				Introduce minimum standard				
Net stable funding ratio		Observation period begins						Introduce minimum standard	

Source: Basel Committee on Banking Supervision (BCBS 2010a)

[35] That is, a bank that does not pass the test because of a breach of any of the hurdle rates (total capital, tier 1, core tier 1) is counted.

37. **The stress tests explicitly accounted for the introduction of Basel III, both in terms of the hurdle rates and capital eligibility (Table 5).** As such, the following dimensions were considered: (i) higher capital ratios over time in terms of tier 1 and core tier 1 capitalization, using the minimum ratios for Brazil (which are slightly higher than the Basel III minimum ratios displayed in Table 6 for the earlier years);[36] (ii) the phase-out of capital eligibility over time for each bank,[37] using the most recent studies conducted by the BCB (the aggregate impact is shown in Figure 1, right hand panel); (iii) it was assumed that there is no increase of RWAs for counterparty credit. Computations by the mission show that on aggregate, banks will not be challenged by the leverage ratios, which will come into effect only in 2018.

D. Outcome of the Solvency Tests

Outcome of Scenario Analysis

38. **The vast majority of banks is in a position to withstand substantial levels of stress, including a major global recession (Figure 6).** In case of stress in terms of capital inflows (sudden stop, terms of trade shock) banks would, on average, remain profitable (although income would be close to zero in many cases) and the evolution of capital would be upwards as in case of baseline conditions, clearly reflecting the resilience of the system. The global recession scenario, a once-in-30 year crisis conditions, simulated a severe macroeconomic shock with a return to baseline growth afterwards (Table 3). Under such a severe scenario, and assuming, in addition, a gradual reduction of pre-impairment income due to structural changes,[38] the statutory capitalization of the system would remain well above the regulatory minimum, with limited recapitalization needs (0.3 percent of GDP in 2013, see Figure 6 lower right hand panel), resulting mainly from challenges at ten percent of the smaller banks.

39. **The smaller banks and foreign banks benefit from their higher average capital ratios (Figure 7), whereby the medium-sized banks are the weak end of the system in terms of solvency.** Some of the larger banks would come out close to the regulatory minimum capital ratio of 11 percent in 2013, and two very large banks (and three large banks overall) would drop slightly below this level. With 17 banks below the regulatory minimum under the severe global recession in 2013 (Figure 6, lower left hand panel), 8 medium-sized banks, 4 small banks and 2 foreign-owned banks would be below the regulatory minimum of 11 percent under severe stress in addition to the three large banks.

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[36] In 2013, the threshold is 1 percentage points higher and in 2014, 0.5 percentage points for both the tier 1 ratios and the core tier 1 ratios.

[37] See Table 6 for the portion of capital than will become ineligible as time goes on.

[38] An additional reduction of pre-impairment income to capital by one percentage point per year was simulated.

40. **Under economic capitalization, the severe recession would reveal temporary vulnerabilities, but banks would swiftly recover afterwards to their favorable income positions (Figure 6, top right and middle panel).** The purpose of including an economic measure of solvency was two-fold: (i) to anticipate that some of the banks will introduce the Basel II IRB in the near future (albeit not necessarily the advanced approach with bank-specific LGDs, which worsens the outcome), which is strongly encouraged to better capture bank sensitivities to changes in their portfolio risk; and (ii) to capture the "true" risk profile of banks on the other hand.[39] In terms of quasi-advanced IRB capitalization, banks can digest sudden stop and terms of trade shock conditions using their profit buffers, a (limited) reduction of credit growth (not leading to deleveraging) and a moderate increase of income retention rates.[40] Severe stress would bring the system down to eight percent during the peak of stress, despite some deleveraging in 2013/14, but banks would recover quickly from the shock using their income buffers.

41. **Banks can also cope with long-lasting commodity price shocks, although they could have a substantial impact on the economy.** A severe commodity price shock with a drop of current oil prices to 50 percent of today's level for three consecutive years would produce approximately similar results as observed for the severe global recession, with some of the large banks' capitalization dropping to about 10 percent.[41]

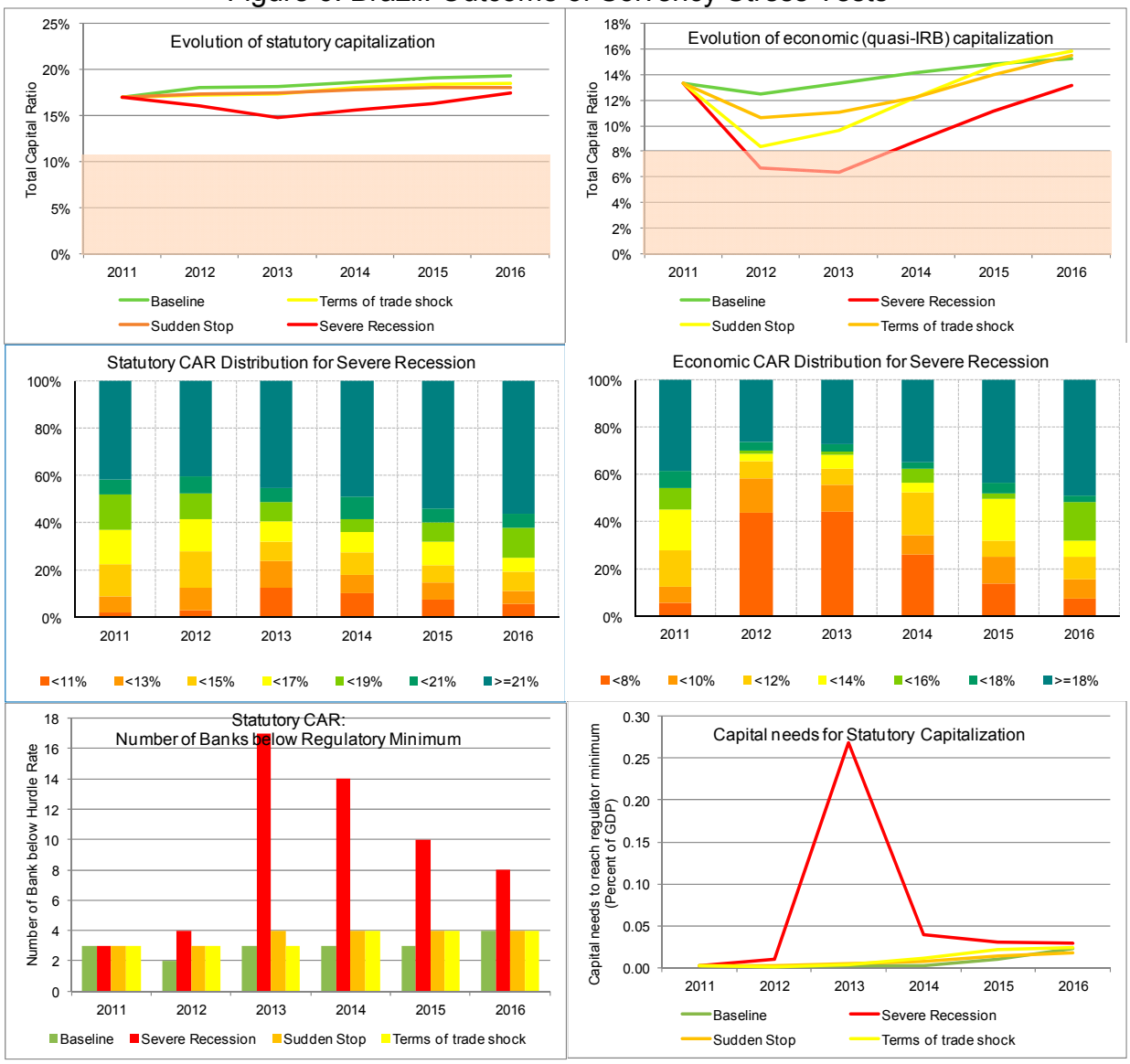
42. **Their high level of income allows banks to (re)build buffers within a comparably short period of time**. If banks were to encounter severe stress conditions, once stress vanishes banks are able to rebuild capital buffers, including through a reduction in RWAs, which happens due to explicit (i.e., negative credit growth) or implicit (through credit losses) deleveraging. If banks were to retain higher portions of their income under severe stress (100 percent instead of 75 percent), the outcome would hardly change as most banks earn little or nothing during 2012 to 2013. In all other scenarios, higher profit retention would improve banks' resilience, especially for the capital flow shock scenarios.

[39] The difference between Basel I type capitalization (including those for banks under the Standardized Approach) is that Risk-weighted Assets (RWAs) are adjusted for volume (credit growth, losses), but not for the change of the risk profile. The newly developed IMF framework allows simulating economic solvency also for non-IRB banks.

[40] Dividend payout was set to 35 percent, in line with historical evidence, and lowered to the minimum of 25 percent under the three stress scenarios from 2012 to 2014.

[41] This simulation uses a conservative translation of commodity price changes into financial stress, i.e., projects that such a sizeable commodity price shock would come along with a stress of global economic conditions. A more "isolated" shock on commodity price would produce an outcome similar to the sudden stop scenario.

Figure 6. Brazil. Outcome of Solvency Stress Tests



Source: Computations by national authorities and IMF staff based on supervisory data.

43. **Banks' behavior in terms of credit growth would alter the outcome of the tests.** Under the severe double dip scenario some deleveraging is foreseen in 2013 (credit growth at -4 percent year-on-year) and 2014 (-1 percent). Additional deleveraging by 5–10 percentage points would bring the system back to 8 percent in 2013/14. In the latter case, deleveraging would have feedback effects, though, but given the profitability of the system deleveraging at some banks might be compensated, at least to some degree, by higher credit growth in other banks (including the state-owned banks), so the overall macroeconomic impact of 10 percent deleveraging levels might be limited. In the other scenarios, slower credit growth would allow banks to build buffers, while credit growth levels above 15 to 20 percent will consume some of the capital (unless banks re-balance their portfolios towards assets with lower RWAs at the same time).

44. **Banks can absorb a structural reduction in income.** As displayed in Figure 6 banks can digest a structural reduction of pre-impairment income towards levels observed in peer countries, which could be driven by higher funding costs, for example, and have been applied to all scenarios. If there was no structural reduction in income, banks would be able to reach a capitalization of 14.4 percent in 2016 under severe stress, compared to 13.2 percent including the structural reduction.

Outcome of Sensitivity Analysis

45. **Sensitivity analysis revealed that name concentration in credit portfolios is limited, except for some of the smaller banks, and that market risk is contained, in line with the analysis by the BCB published in the FSR (Table 6).** The failure of one or more of the largest borrowers would be felt mainly by about 20–30 smaller banks, which is also reflected in the computation of additional capital needs for name concentration (Figure 7).[42] Foreign exchange rate risk is limited, predominantly vis-à-vis the U.S. dollar, [43] while interest rate risk is slightly more relevant, but manageable[44].

46. **Security price shocks would have a slightly more sizeable impact, given banks' high portion of securities' holdings, especially government securities.** As banks' security holdings are predominantly government bonds, many of which are/could be held to maturity, substantial instantaneous shocks to profitability are unlikely to happen, though. Sizable equity price shocks can be absorbed by banks given their limited exposures.

47. **Sizeable credit risk shocks "alone", such as a doubling of PDs or an increase of LGD, can be largely digested by banks by means of their income buffers.** Banks can digest both relative and absolute increases of their default rates, including default rates of 6 percent, for example. The shocks to LGDs were less sizeable given that increases in LGDs are already elevated under the baseline.

48. **By the same token, an "isolated" shock in the mortgage sector alone would only have a limited impact on bank capital.** Even if all mortgage exposure were to default, banks would "only" loose 0.7 percentage points of capital (i.e., capital ratios after the shock would be 16.3 percent) and two additional banks would be under the regulatory minimum.

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[42] These banks would fail if 5-10 of their largest counterparts defaulted and their minimum capital requirements would have to be 10 to 40 percent higher than the actual minimum, e.g., through a Pillar 2 charge.

[43] A depreciation of the foreign exchange rate by 50 percent vis-à-vis all other major currencies would lead to a drop of capitalization by 0.5 percentage points for the system. The impact would be almost similar if one stressed US Dollar positions only. No additional bank would fail in that case from FX risk alone.

[44] An interest rate shock by 200 basis points in both directions would result in a reduction of capital ratios by up to 1 percentage points.

Table 6. Brazil. Outcome of Sensitivity Analysis

	CAR (Percent)	Change of CAR (Percentage Points)	Number of Banks Below Minimum
Market Risk			
Baseline (end-2011)	17.0	NA	3
Foreign exchange rate shock (percentage change)			
20	16.8	-0.2	3
50	16.5	-0.5	3
100	16.0	-1.0	4
Interest Rate Shock (change in basis points)			
-200	16.4	-0.6	4
-400	15.7	-1.3	4
-600	15.1	-1.3	5
Securities Prices (percent)[1]			
Sovereign Bonds			
-20	14.9	-2.1	19
-30	13.9	-3.1	27
Equities			
-30	16.8	-0.2	3
-50	16.7	-0.3	3
Credit Risk			
Baseline[2]	18.4	NA	3
Default of x largest borrowers			
x = 1	18.3	-0.1	3
x = 2	17.8	-0.6	4
x = 10	15.9	-2.5	28
Relative increase in default rates of all credit risk exposures (percent change)			
100	17.5	-0.9	5
200	16.5	-1.9	8

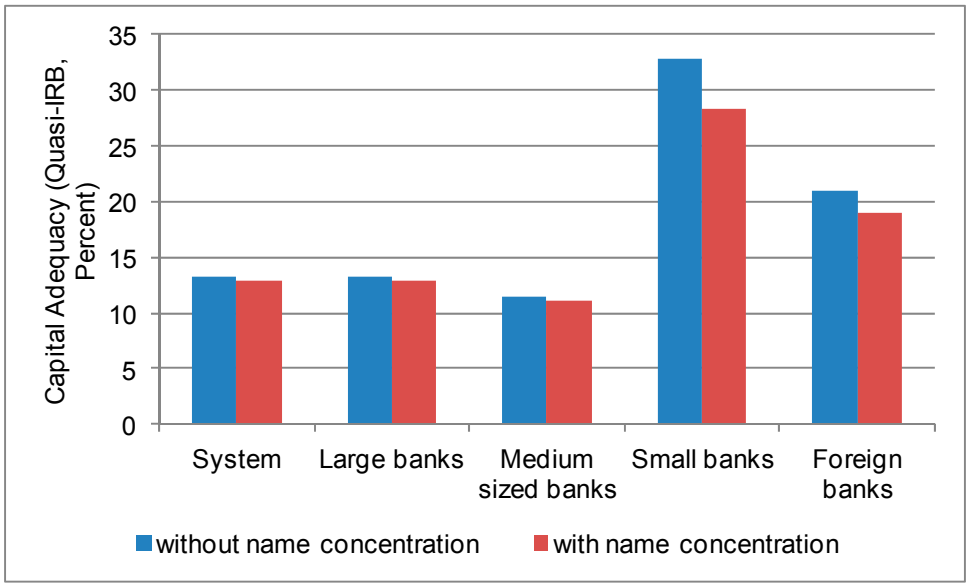
1/ Impact on all securities in the trading book and available for sale portfolio.
2/ Projected end-2012 under baseline macroeconomic scenario.

Source: Computations by IMF staff based on supervisory data.

49. **Name concentration risk translated into Pillar 2 capital needs show that some small banks would be significantly impact, although they would remain well-above the 11 percent minimum CAR.** The IMF framework was applied to the banks based on the name (i.e., credit) concentration of the 50 largest nonbank credit exposures on a borrower level, using economic capitalization. It was found that name concentration is relevant for some of the smaller banks only and would result in a reduction of total capital ratios (by adjusting RWAs only) by 0.5 percentage points on the system level (from 13.3 percent to 12.8 percent) as of end 2011 (Figure 7). For the small banks (as defined by the BCB) the drop of capitalization would be 4.6 pps (from 32.8 to 28.2) or 14 percent in relative terms, but from a high level. Specific banks would encounter a more substantial decrease of capital and could be incentivized to reduce name concentration with a Pillar 2 charge. Name

concentration has not been included in the scenario analysis based on economic capitalization, but would slightly worsen the outcome of the tests.

Figure 7. Brazil: Potential Impact of Pillar 2 Capital Charges for Name Concentration



Source: IMF Staff based on Supervisory Data.

III. Liquidity Stress Tests

Method

50. **Liquidity tests assessed short-term vulnerabilities to funding shocks and, to a lesser extent, maturity mismatch based on the NSFR.** The scenarios involved adverse conditions in line with historical maximum funding withdrawal rates. Although Brazilian banks are shielded by large portions of liquid assets, their liability structure is characterized by a comparably elevated share of wholesale funding, which makes the banks vulnerable to a sudden and substantial funding withdrawal, which could be amplified further in the future due to the structural shortage of deposit funding in Brazil (due to low savings rates) in combination with elevated credit growth. Hence, liquidity tests are an important instrument to ensure a balanced level of sufficient liquidity across the system.

51. **The tests were mainly based on the so-called "liquidity ratio" test developed by the BCB, an LCR-type ratio** that compares the liquidity inflow (the unencumbered liquid assets[45] as well as scheduled capital inflows; numerator) with potential stress funding losses[46]

[45] The assets considered to remain liquid under stress are government securities and other highly liquid assets, the latter subject to a haircut based on their quality and maturity.

[46] The run-off rates take into account the type of funding instrument (retail deposit, corporate deposits, wholesale funding), general market stress and idiosyncratic factors, including historical funding volatilities and concentration of funding sources.

as well as scheduled outflows during a 21 working day period (denominator), using a confidence level over 99 percent for all parameters derived from historical evidence (e.g., market risk impact on liquid assets, historical volatility of deposits, etc...). A bank is considered liquid if the ratio is above 1, without recourse to reserve requirements. The forthcoming Basel liquidity III ratios were computed for a subset of banks providing a general tendency for the system overall.[47]

52. **For the computation of the liquidity ratio, the following dimensions were taken into account (Table 7):** On the asset side, the availability of liquid assets (i.e., market liquidity) was computed conditional on an adverse market risk scenario (i.e., changes in interest rates, FX rates and credit spreads). On the liability side, (i) the run-off rates of funding were chosen consistently with evidence, i.e., wholesale funding is assumed to be more volatile than deposit funding; (ii) concentration of funding was simulated to have a negative impact on run-off rates; and (iii) the historical volatility of deposits at each bank were taken into account.

Outcome

53. **Ample liquid assets put the system as a whole into a position to withstand substantial stress, but there are pockets of vulnerabilities** (Figure 8). The banks that have been found to be most vulnerable are those with a high reliance on wholesale funding. The smaller banks benefit from higher portions of liquid assets and are therefore more resilient (pass rate: 80 percent) than medium banks and foreign banks (both at 70 percent) (Figure 8, top right hand panel). The larger banks pass the liquidity ratio, but some of them with a narrow margin only, but *as reserves requirements are not considered as liquid assets in the liquidity ratio metrics there are additional buffers banks could use under severe stress*.[48] Computations based on a newly developed IMF framework (Schmieder and others) using stress parameters similar to other FSAPs and publicly available data confirms the outcome: (i) larger banks are more resilient against funding shocks; (ii) a withdrawal of more than 25–30 percent of funding will be difficult to be digest by the system (Figure AIII.1).[49]

[47] See BCBS 2010c for further information.

[48] The larger banks have seen their customer loan-to-customer deposit ratios decrease slightly recently and the maturities on the asset side increasing.

[49] On the asset side, the analysis assumed haircuts of 0 percent for cash, 10 percent for government bonds, 25 percent for trading securities and 40 percent for other investment securities. All other assets were not eligible.

Table 7. Scenarios used for Liquidity Tests

Element	Outflow (funding) Percent	Haircut (liquid assets) Percent
Loss of Funding & additional funding needs		
Outflow of customer deposits	15 (Median), about 12 thereof due to historical volatility and 3 due to concentration[1]	
Bank deposits	20–90, depending on maturity	
Other deposits	70–95	
Inflow of Funds (from fire sales)		
Gov bonds (local currency)		0
Gov bonds (foreign currency)		20
Equities		20
Foreign currency assets		20
Investment funds		30
Cash[2]		40
Interbank deposits		5–20 (depending on maturity)

Source: BCB.

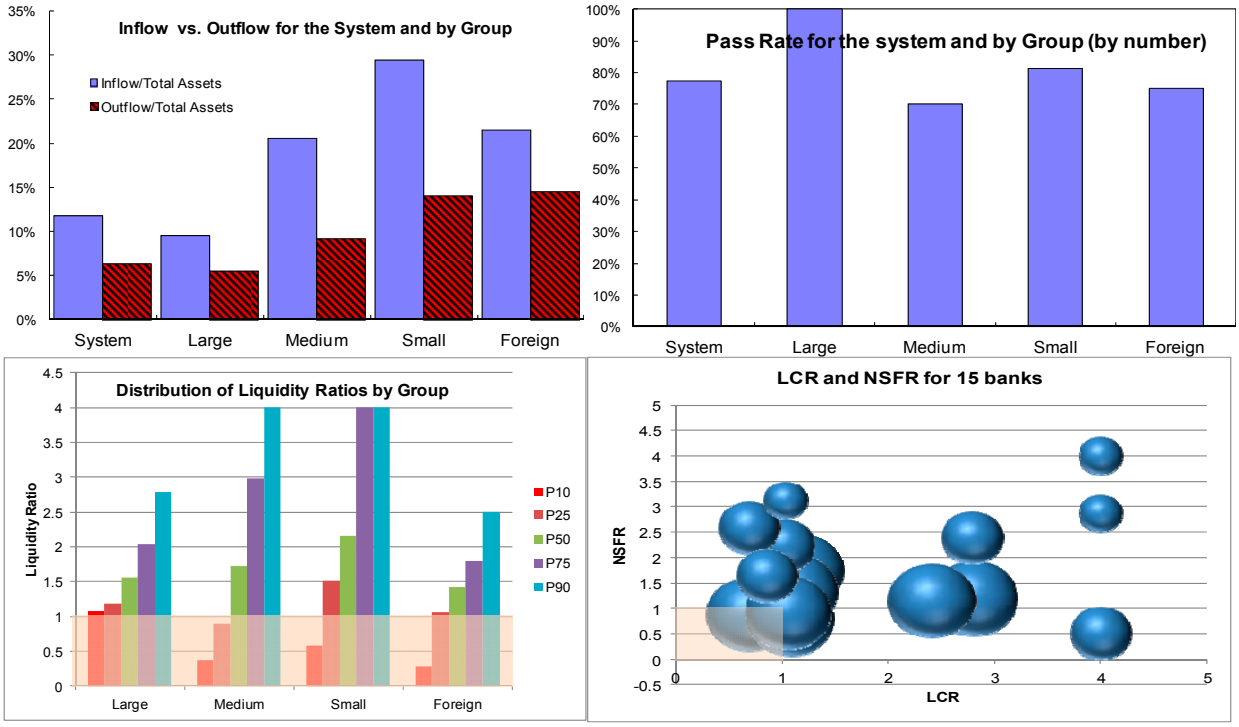
[1]The run-off rate varies widely, depending on the historical volatility and the concentration of deposits. About 80 percent of the run-off rates reflect historical volatility and 20 percent funding concentration.

[2] The high haircut for cash is because the number is volatile and (up to Dec. 2011) cash data is not on a daily basis, but from the balance sheet. It's important to highlight that in relative terms the cash volume is irrelevant to the bank's liquidity buffer.

54. **Banks will, for most part, meet the Basel III liquidity ratios.** Proxies for the LCR and NSFR computed by the BCB for a subset of 15 banks (lower right panel) confirm the outcome for the "liquidity ratio" in terms of short-term vulnerabilities and reveal that banks' maturity mismatch appears manageable (Figure 8, bottom right hand panel). Again, a full survey of the Basel III liquidity ratios will reveal some weak ends, but the system overall can be assumed to be comparably well prepared for Basel III by now.

55. **Going forward, the challenges of the system, namely limited customer deposits to cover the rapid credit growth, as well as a lengthening of maturities on the asset side, require attention.** For the NSFR, for example, banks will have to make sure that their profile will not deteriorate over time due to higher maturities on the asset side. Should the portion of loans to total assets increase due to lower reserve requirements, at least part of the banks will have to improve their funding structure. Hence, macroprudential measures targeted at liquidity will have to take into account both sides of the balance sheet.

Figure 8. Brazil. Outcome of Liquidity Stress Tests



Source: Computations by national authorizes and IMF staff based on supervisory data.

IV. Contagion Analysis

Method

56. **Given that counterparty credit risk is inherent to the system due to its high asset concentration, network analysis was applied.** TD BCB and TD IMF models[50] simulated how a default of one single bank could manifest through bilateral bank exposure (i) with and (ii) without taking into account liquidity risk, i.e., assessed direct and indirect contagion. Potential inward spillovers from a failure of a foreign parent bank were not subject to separate analysis given the self-sustainable profile of the Brazilian subsidiaries at the current juncture. It should be stressed, however, that the performed tests did not capture contagion effects from the non-financial sector through the liquidity channel (namely mutual funds and pension funds). The latter effects were discussed in qualitative terms and based on aggregate data, indicating that there is no material risk apart from a sudden and major funding shock, but an ultimate conclusion on this would require detailed analysis on a bilateral level.

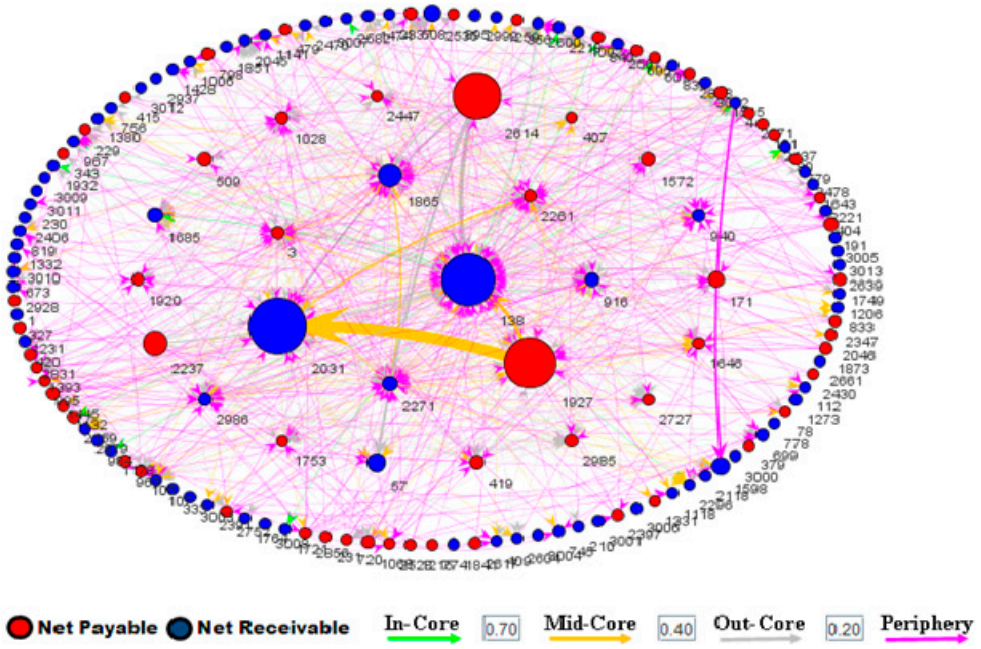
57. **Contagion risk analysis was based on a comprehensive definition of interbank exposure.** Bilateral exposure includes interbank deposits, term deposits, derivates (swaps, foreign exchange operations, forwards, boxes, flexible options), Repos with own securities, "Letras Financeiras" bonds and other expected losses to be borne by the underwriting bank.

[50] The IMF method is based on Markose (forthcoming).

Outcome

58. **A graphical representation of the net interbank borrowing and lending shows that large banks provide liquidity to smaller banks.** By mid-2010, about 10 percent of the system assets are net borrowers, which thus take a systemically important role in the funding markets as do the major net lenders (Figure 9).[51] The graph, which shows the main net borrowers (blue) and lenders (red) in the middle of the graph,[52] has changed little since mid 2010, giving some indication that interbank lending in Brazil is relatively static.

Figure 9. Interbank borrowing and lending in Brazil



Source: Computations by IMF staff based on supervisory data.

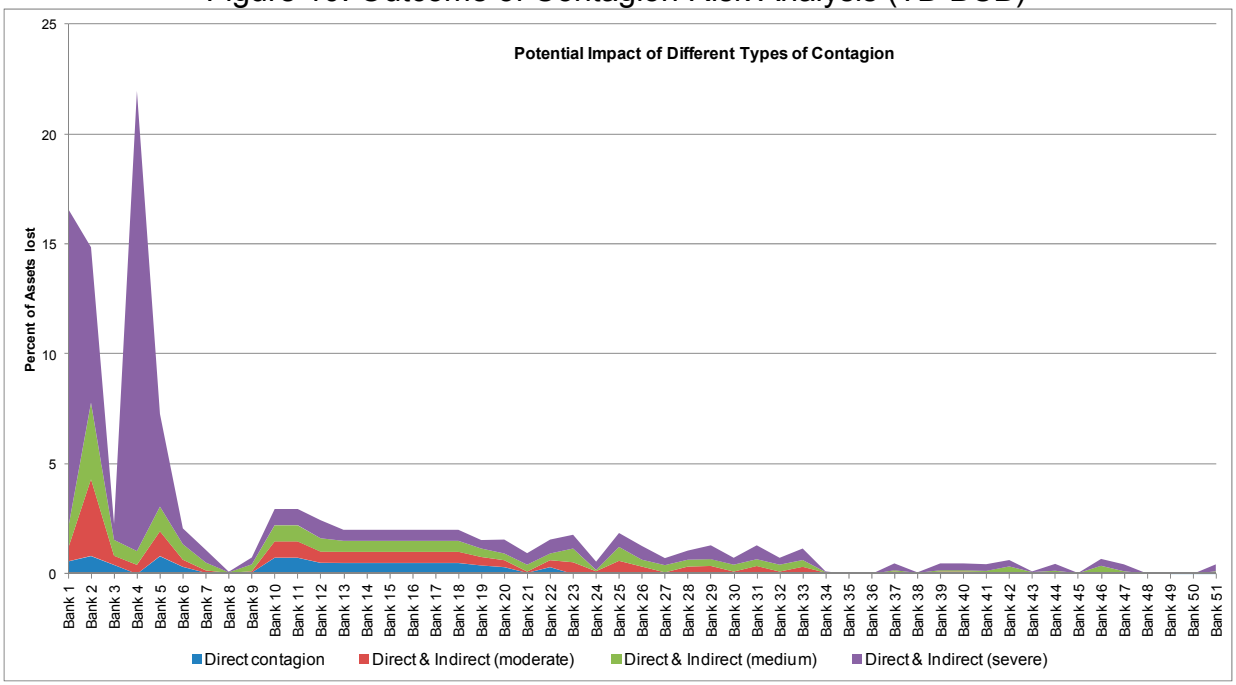
59. **Direct contagion risk through bilateral exposures is limited.** Give the high concentration of banks in the system the failure of a large(r) bank could, in principle, have a highly adverse impact on the health of the banking system. However, the analysis based on both a BCB and IMF framework simulating potential knock-on effects of a failure of one bank on all other banks reveal that direct contagion is limited: the failure of one single bank triggers at maximum a failure of 0.8 percent of the system's assets (i.e., has knock-on effects for smaller banks only) (blue area in Figure 10).

[51] The two main net borrowers are Votorantim and BMG, with Banco do Brasil and Bradesco being the main net lenders.

[52] The centrality of a bank for the system is established by computing the importance of a bank for a network through its links with other banks.

60. **Indirect contagion through funding markets could have a more adverse effect** Indirect contagion though liquidity channels would materialize if, at the same time of a default of a large banks (i.e., direct contagion), more than 20-25 percent of the customer deposits were to be withdrawn (from all banks at the same time), which is a highly unlikely scenario. The moderate shock scenario assumes a withdrawal of 15 percent of customer and wholesale deposits for all banks in case of a liquidity shortfall at a large bank, 10 in case of medium-sized bank, 5 percent for a small bank and 2 percent for a very small bank. Under medium and severe stress conditions, the corresponding withdrawal rates are 25/35 for a large bank, 17.5/25 for a medium-sized bank, 10/15 for a small bank and 4/7 for a very small bank. As displayed in the graph, only the severe scenario triggers highly non-linear default patterns and thereby constitutes a critical threshold. Again, a loss level of about 25–30 percent of funding seems to a critical threshold for the system (as found by the TD IMF analysis).

Figure 10. Outcome of Contagion Risk Analysis (TD BCB)



Source: Computations by national authorities based on supervisory data.

V. Conclusion and Recommendations

61. **Given the uncertainty of the global economic and financial outlook, the Brazilian banking system's resilience could be tested going forward, either in the short- or medium-term. Policies should focus on liquidity risks and the weak end of the banking system.** While the system has proven to be comparably resilient, caution is warranted, as structural changes could alter the situation, and contagion from abroad, including through macroeconomic channels and a loss of confidence can have adverse effects for the system. The economic solvency tests indicate that specific banks might need some additional capital to be prepared for a major downturn in the future.

62. **The BCB's well-designed stress testing framework could be further strengthened, especially through longer-term solvency analysis**. Notwithstanding its highly developed and sophisticated stress testing framework, the BCB could use its ample data to run economic solvency tests (i.e., IRB-type) and extend the projection horizon. Other areas to be explored further would be to use fully-fledged cash flow analysis in the liquidity area (to accompany the lengthening of maturities). Extending the stress tests to non-bank financial institutions could also be considered in the longer term, and bottom-up tests could strengthen further banks' own analysis of risks.

63. **The system-wide stress tests should be used to inform the macroprudential policy debate.** Standardized stress tests could be used to set countercyclical capital buffers, help determine capital charges for SIFIs, and assess contagion risks. While many of these issues could become relevant only after a few years, early preparation could facilitate the implementation later on.

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APPENDIX I. STRESS TEST MATRIX: SOLVENCY RISK AND SCENARIOS

Nature/Source of Main Risks	Likelihood of Severe Realization of Risk in the Next one to three years	Expected Impact on Financial Stability if Risk is Realized
Severe global recession	*Medium* • Loss of confidence in the credit-worthiness of Europe or other advanced economies (e.g., US, Japan) could trigger liquidity stress, higher real interest rates, and output losses. Likewise, a hard-landing in an important emerging market (e.g., China) are tail risks that could lead to a deep global recession, potentially accompanied with a liquidity crisis and/or credit crunch. • The experience from the 2008 global financial crisis shows that the Brazilian economy could be hit hard by the combination of global trade and financial shocks, especially in case of a sustained shock.	*Medium to High* • Current financial soundness indicators and stress test results show that the financial system as a whole would be resilient to considerable levels of stress. However, small- and medium banks could be severely impacted given their exposure to liquidity shocks and weaker solvency profiles. • Under a multi-year sustained adverse shock scenario, credit and market losses can be expected to increase sharply, reflecting the non-linearity of loss rates (i.e., in case of additional stress beyond a certain level the impact becomes high). Likewise, higher unemployment rates would trigger losses to consumer loans. Banks would also see their pre-impairment income reduced at the same time, amplifying stress conditions. • While the potential for direct interbank contagion effects is limited, indirect contagion effects through a stress in funding markets could be a potential source of concern, albeit only in case of substantial funding losses. • A mitigating factor is the available policy space, as well as the policy of using public bank lending counter-cyclically.
Sudden Stop/Capital Outflows or More persistent Terms of Trade Shock	*Medium* • The risk of a more generalized sudden stop/capital outflows remains intact given the lack of a final solution to the sovereign debt crisis in advanced economies, and the tendency for an increased demand for “safe haven” assets during times of financial stress. • Such a stress scenario could either materialize though a sudden, rather short-lived reversal of investor sentiment (sudden stop scenario) or a more gradual trend in capital flows (general terms of trade shock).	*Medium/High* • Further euro area bank deleveraging would have a moderate impact, given the modest level of euro area foreign bank participation and cross-border lending. European banks are also likely to try to maintain their market presence in the profitable Brazilian banking system. • A more generalized sudden stop or reversal of capital flows could have a more substantial impact on banks, but ample liquid assets reduce banks’ vulnerability. Indeed, stress tests show that even in the case of a more generalized shock to funding and market liquidity, all large banks and about 80 percent of medium and small banks would remain liquid (with the illiquid banks

Nature/Source of Main Risks	Likelihood of Severe Realization of Risk in the Next one to three years	Expected Impact on Financial Stability if Risk is Realized
		accounting for less than 4 percent of the system's assets). Only in case of extreme contagion (default of a bank leading to large funding losses for *all* banks) would the system come under significant stress. • A sudden-stop or reversal of inflows could also lead to interest rate spikes and declines in assets prices (in 2008, equity prices declined about 50 percent and sovereign spreads increased about 400 bps). Again, however, stress tests show that the direct impact of higher interest rates, a more depreciated exchange rate, and a large drop in equity prices would have only a limited impact on bank CAR, although large declines in sovereign bond prices could have a more significant impact. • The corporate sector does not appear very vulnerable to a sudden stop or reversal of capital inflows. Corporate external debt has declined and it is mostly long-term, and corporates are not engaging in the type of derivatives transactions that resulted in large losses for some large corporations in 2008. • The flexible exchange rate and high level of international reserves can help mitigate the impact of a sudden stop or reversal of capital inflows on the broader economy.
Commodity Price Shock	Medium • The risk of a substantial commodity price shock is related to the uncertainties faced by the global economy (particularly a global recession scenario, see above). In addition, recent technological challenges harvesting deep-water oil reserves have caused some uncertainty with respect to the timing of availability of the Brazilian oil reserves. • The impact of a potential sharp drop in commodity prices on Brazil also depends on the specific economic development of its main trading partners, especially China.	*Medium* • Given the growing importance of commodity exports for Brazil price movement directly affect the economy's well-being. In addition to the direct impact on the commodity sector a sharp decline of commodity prices could trigger downturn pressures for other, related sectors and, depending on the severity and duration of the shock, on the economy overall. • Stress tests show that the system is resilient vis-a-vis severe downward pressures on commodity prices for up to two years. Such shocks might be geared more towards bank solvency rather than liquidity, which is likely to be similar to that of a global economic recession.

Nature/Source of Main Risks	**Likelihood of Severe Realization of Risk in the Next one to three years**	**Expected Impact on Financial Stability if Risk is Realized**
Real Estate Price Collapse	*Low* • Given the recent rapid growth in housing prices and credit, the risk of a large decline in real estate prices has increased.	*Medium/Low* • A real estate price shock could lead to increased default rates on housing loans (10 percent of total loans on average, but are higher for some banks) as well as loans to property developers (about 1 1/2 percent of total loans). • Furthermore, a real estate price decline could have a negative wealth effect on growth, which would further negatively impact banks' asset quality. • Banks significantly exposed to real estate would not only face higher default rates, but recovery rates would also go down (reflecting lower collateral values). Given the high share of residential and commercial real estate loans in some banks' balance sheets, (notable the public banks that grant credit to low income households), the impact on those banks could be substantial. However, the impact on the system as a whole would be limited: sensitivity tests show that even in the event of all mortgages defaulting (with no second-round effects) system CAR would only decline by about one percentage point.
Failure of a foreign parent bank	*Low to Medium* • The condition of various foreign parent banks remains fragile. Even if parent banks did not fail, there could be some degree of contagion within their specific group, affecting confidence in host countries, including Brazil.	*Low* • Given the self-sustainable nature of foreign banks in Brazil (more so in terms of solvency than in case of liquidity) risks remain contained. Contagion tests also show that the failure of one bank would not have large knock-on effects given limited direct exposures. Indirect confidence effects could have a more adverse impact, but are difficult to quantify. The high level of required reserves is also a major mitigating factor.

APPENDIX II. FINANCIAL SOUNDNESS

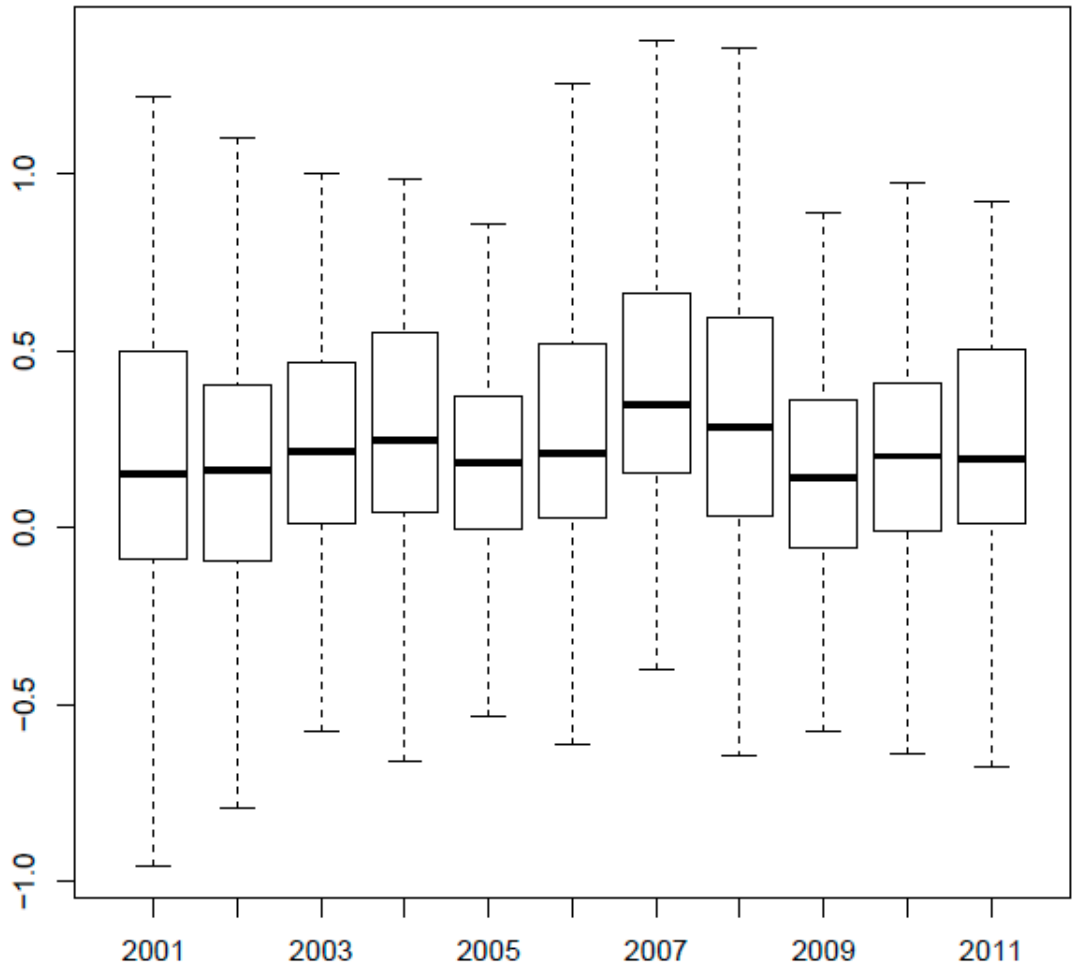
Table A.1. Brazil: Banking Sector Financial Soundness Indicators

(in percent)

	2005	2006	2007	2008	2009	2010	2011
Capital adequacy							
Regulatory capital to risk-weighted assets	18.1	19.0	18.8	18.3	19.0	17.7	17.3
Large banks	16.9	18.1	17.7	17.5	18.4	17.3	16.8
Medium banks	19.5	19.5	21.1	18.8	18.4	16.2	16.9
Small banks	31.8	28.6	29.0	27.9	27.2	26.4	26.1
Foreign controlled banks	15.8	16.1	16.3	20.1	25.9	22.5	20.8
Regulatory Tier I capital to risk-weighted assets	14.9	14.9	14.3	14.6	15.3	13.7	13.2
Large banks	13.4	13.5	12.5	13.2	14.1	12.8	12.2
Medium banks	18.6	18.4	19.3	17.2	16.6	13.6	13.9
Small banks	30.6	27.1	28.2	28.6	28.7	27.6	27.7
Foreign controlled banks	14.8	14.1	14.0	18.2	22.8	20.3	18.7
Asset composition and quality							
Sectoral distribution of loans to total loans							
Loans to households	43.6	44.5	45.0	46.8	43.8	46.5	43.5
o/w housing loans to total loans	4.7	4.8	4.6	4.8	5.9	7.7	9.2
Loans to non-financial corporations	47.8	47.5	47.5	45.4	48.5	45.6	48.0
NPLs to gross loans	3.5	3.5	3.0	3.1	4.2	3.1	3.5
Large banks	3.5	3.5	3.0	3.1	4.4	3.2	3.6
Medium banks	3.4	3.0	2.7	3.4	3.2	2.3	2.7
Small banks	3.5	3.8	3.0	3.6	3.9	3.5	3.4
Foreign controlled banks	3.1	3.5	3.2	3.7	5.8	4.2	5.0
Earnings and profitability							
Return on average assets (before tax)	3.2	3.1	3.5	1.6	2.4	3.2	1.5
Large banks	3.1	2.9	2.9	1.3	2.4	3.4	1.4
Medium banks	3.4	3.7	6.4	2.7	2.6	1.9	1.9
Small banks	3.3	4.0	5.9	2.3	2.5	3.1	3.0
Foreign controlled banks	2.2	2.6	4.5	2.0	1.5	1.9	1.5
Return on average equity (before tax)	29.4	28.7	32.0	14.3	22.0	28.9	14.0
Large banks	32.3	30.6	30.0	14.1	24.4	33.2	14.1
Medium banks	25.2	27.6	41.6	16.5	16.0	13.3	13.6
Small banks	14.5	18.1	28.1	11.0	12.0	15.0	14.3
Foreign controlled banks	16.2	22.2	37.2	13.9	8.9	11.1	9.3
Interest income to gross income	51.9	50.9	46.4	39.0	46.4	49.0	49.7
Trading income to gross income	6.7	9.4	10.4	7.5	8.5	11.3	2.2
Noninterest expenses to gross income	65.1	64.2	63.1	70.7	62.5	58.0	66.4
Liquidity							
Liquid assets to total assets	40.1	37.1	38.2	35.2	34.7	32.0	32.1
Large banks	40.1	37.3	37.9	34.6	34.2	31.0	31.1
Medium banks	37.9	35.7	39.3	37.0	35.5	36.9	38.2
Small banks	38.8	36.5	42.1	40.9	43.1	42.6	43.3
Foreign controlled banks	41.0	37.6	40.0	37.1	41.0	39.6	38.4
Liquid assets to total short-term liabilities	125.7	111.2	114.1	114.2	118.0	102.4	110.8
Large banks	132.7	117.3	119.0	118.6	121.4	100.2	107.3
Medium banks	80.8	73.5	86.0	82.3	84.7	98.8	114.5
Small banks	126.4	112.9	117.2	127.3	159.9	154.2	179.0
Foreign controlled banks	111.6	94.5	110.8	114.0	130.7	113.6	112.8
Sensitivity to market risk							
Net open positions in FX to capital	1.6	-3.6	-5.8	-7.6	-6.8	-6.4	-8.0

Source: Banco Central do Brasil.

Figure AII.1. Brazil: Credit Growth Bank-by-Bank (in decimals)[53]



Source: Supervisory Data

[53] That is, 0.5 corresponds to 50 percent.

APPENDIX III. SATELLITE MODELS

The following satellite models were used for the solvency tests:[54]

1. Default Rates (Percent)

Scenario	Constant	Coefficient (t-1) [lag term]	Coefficient Real GDP (%) ch, yoy	Coefficient IR mm ch (y-o-y)	Coefficient FX Rate ch (y-o-y)
Baseline	2	0.35	-0.2	0.05	1
Terms of Trade Shock	2	0.35	-0.5	0.15	1.5
Severe Recession	2	0.35	-1	0.3	1.5
Sudden Stop	2	0.35	-1	0.3	1.5

2. Pre-impairment income to capital (Percent)

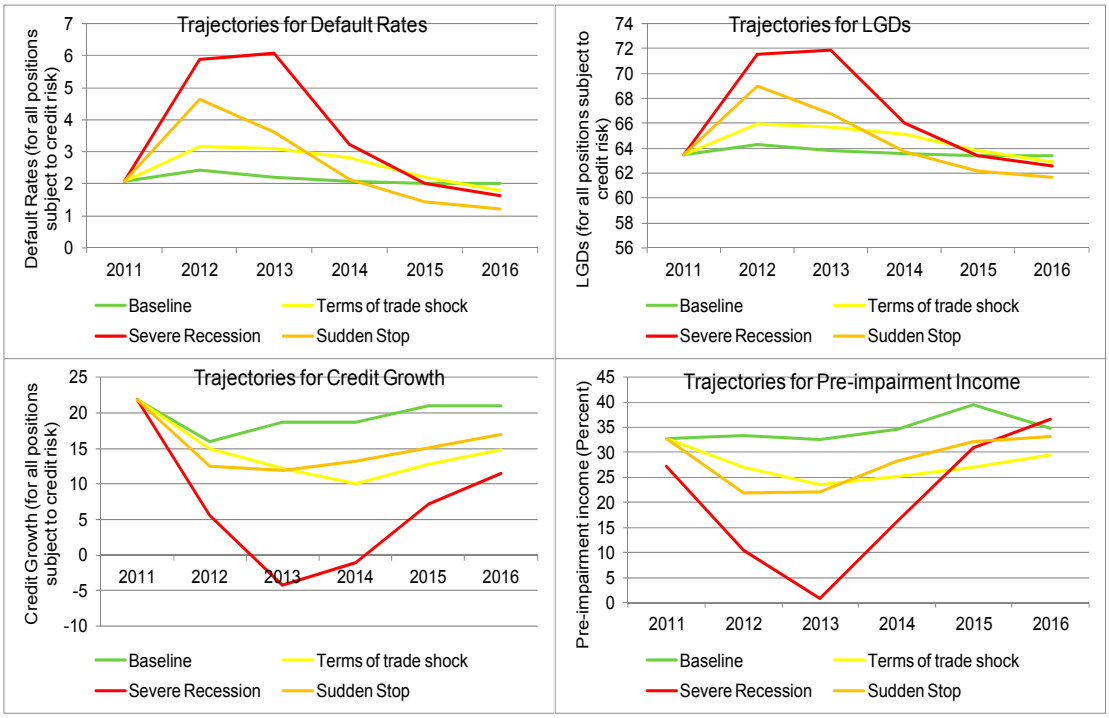
Scenario	Constant	Coefficient (t-1) [lag term]	Coefficient Real GDP (%) ch, yoy	Coefficient IR mm ch (y-o-y)
Baseline	21.8	0.19	1.2	-0.85
Terms of Trade Shock	21.8	0.19	1.84	-0.85
Severe Recession	21.8	0.19	2.5	-0.85
Sudden Stop	21.8	0.19	1.84	-0.85

3. Credit Growth (Percent, same for all scenarios)

Credit Growth (t) = Credit Growth (t-1) + 3.8* rGDP_ch (t)

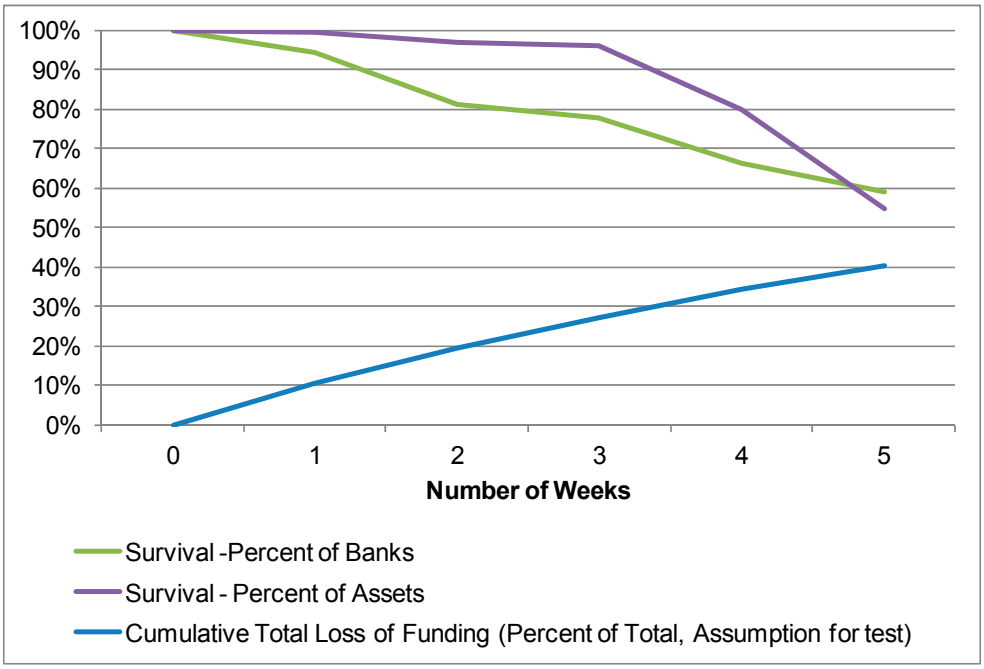
[54] International evidence from Cerutti and others (2010) and Hardy and Schmieder (forthcoming) was used as a benchmark.

Table AIII.1. Trajectories of Financial Variables conditional on the Scenario



Source: IMF staff computations.
Please note: the default rates apply to all assets subject to credit risk, i.e., also securities

Figure AIII.1. Outcome of benchmark liquidity shock



Source: IMF staff computations based on publicly available data.

APPENDIX IV. STRESS TEST MATRIX FOR SOLVENCY

Domain	Assumptions		
	Bottom-Up by Banks	**Top-Down by Authorities**	**Top-down by FSAP Team**
Institutions included	NA	• All banks (137)	
Market share		• Percentage of total sector assets: 100	
Data and baseline date		• Supervisory	
Methodology		• BCB stress testing framework (not reported)	• Schmieder, Puhr and Hasan (2011)
Stress test horizon		• 18 months	• Five years
Shocks		• Macro: severe global recession double dip (2.5 standard deviations from trend growth during two years) • Other scenarios: Sudden Stop and Terms of Trade Shock; simulation of a commodity price shock and a single factor shock for the real estate sector • The trajectories of the relevant macroeconomic variables were projected based on VAR analysis and econometric models. • Market risk shocks for relevant risks (FX Rates, IR, asset prices)	
Risks/factors assessed		• Credit losses and pre-impairment income (modeling of components) based on satellite models • Market risk.	
Calibration of risk parameters		• Point in time risk parameters for credit risk parameters or proxies	
Behavioral adjustments		• Credit growth projected by satellite model • Dividend payout depending on scenario	
Regulatory standards		• Hurdle rates based on Basel II/III minimum for Core tier 1, Tier 1, and Total Capital, in line with regulation for Brazil • Basel II/III	
		• StA	• StA & quasi-IRB
Results		• CAR/shortfall, system-wide and by bank. • Pass or fail; percentage of assets that fail. • Distribution of capital ratios across the system by bank group/type. • Sensitivity tests for concentration risk and market risk.	

Source: IMF Staff

STRESS TEST MATRIX FOR LIQUIDITY RISK

Domain	Assumptions		
	Bottom-Up by Banks (if applicable)	Top-Down by Authorities (if applicable)	Top-down by FSAP Team (if applicable)
Institutions included	NA	• All (137)	NA (Framework by Schmieder and others (2012) used for robustness checks and to shed some light on international comparisons, but not reported).
Market share		• 100	
Data and baseline date		• Supervisory data.	
Methodology		• Bank-run type test (measured through "Liquidity Ratio"), Basel III ratios (LCR, NSFR); Simulation of funding liquidity & market liquidity (idiosyncratic shock and general market shock), maturity mismatch (NSFR), concentration of funding.	
Risks		• Market and funding liquidity risks.	
Regulatory standards		• BCB "Liquidity Ratio" is used in Brazil for monitoring purposes; Basel III ratios will become binding according to Basel III schedule.	
Results		• Pass Rate (by number of banks and assets).	

Source: IMF Staff

STRESS TEST MATRIX FOR OTHER SYSTEMIC RISKS

Domain	Assumptions		
	Bottom-Up by Banks	Top-Down by Authorities	Top-down by FSAP Team
Institutions included		• All (893 financial institutions with interbank exposures (out of a total of 2,000 financial institutions), thereof 137 banks)	• Network model
Market share		• Close to 100 of assets of the financial system	
Data and baseline date		• Supervisory	• Supervisory
Methodology		• BCB's network model, simulating the impact direct and indirect contagion (the latter through liquidity)	• Network model used to analyze direct contagion through interbank exposure
Stress test iterations		• As many as new equilibrium is found	• As many as new equilibrium is found
Shocks	• Simulation of the impact of a default of whatsoever institution(s)s		
		• Simulation of bilateral knock-on effects; percentage of assets that fail	• Map of interbank lending (based on tiering) • Simulation of bilateral knock-on effects

Source: IMF Staff