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A Macro Stress Test Model of Credit Risk for the Brazilian Banking Sector

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Abstract

This paper proposes a model to conduct macro stress test of credit risk for the banking system based on scenario analysis. We employ an original bank level data set with disaggregated credit loans for business and consumer loans. The results corroborate the presence of a strong procyclical behavior of credit quality, and show a robust negative relationship between (the logistic transformation of) NPLs and GDP growth, with a lag response up to three quarters. The models also indicate substantial variations in the cyclical behavior of NPLs across credit types. Stress tests suggest that the banking system is well prepared to absorb the credit losses associated with a set of distressed macroeconomic scenarios without threatening financial stability.

Key Words: banking system, stress tests, financial crisis, credit risk.

JEL Classification: G1, G15, G32.

[1]International Monetary Fund.

[2]DEPEP, Banco Central do Brasil.

[3]International Monetary Fund.

1 Introduction

There has been a growing literature on stress testing in the recent years. The importance of these exercises has been highlighted by the recent crisis that has hit hard many countries around the world and the cascade of bank failures. A deep understanding of the resilience of the banking system to shocks is of crucial importance for the proper evaluation of systemic risk and has a direct impact on the development of new regulatory and prudential tools. Therefore, the development of new stress testing methodologies is of crucial importance.

This paper describes a model to conduct macro stress test of credit risk for the Brazilian banking system based on scenario analysis. The proposed framework comprises three independent, yet complementary modules, that are combined in sequence. The first one applies time series econometrics to estimate the relationship between selected macroeconomic variables, and uses the results to simulate distressed, internally consistent, macroeconomic scenarios spanning two years. The second module uses panel data econometrics to estimate the sensitivity of NPLs to GDP growth, and uses the results to simulate the evolution of credit quality for individual banks and credit types under distressed scenarios[4]. This module exploits a rich database that tracks the evolution of non-performing loans (NPLs) for 78 individual banks and 21 categories of credit between 2001-2009[5]. The third module uses the predicted NPLs as a proxy for distressed probabilities of default (PDs) and combines this information with data on the exposures and concentration of bank credit portfolios to estimate tail credit losses, using a credit value-at-risk (VaR) framework.

This paper has two main contributions to the literature on stress testing. First, we propose a model that is useful for the evaluation of credit losses for different economic sectors. Second, we present and discuss the results for the Brazilian banking system, which is one the largest banking systems in Latin America. Furthermore, we discuss how to implement a stress test model and construct scenarios.

The results corroborate the presence of a strong procyclical behavior of credit quality. The models show a robust negative relationship between (the logit transformation of) NPLs and GDP growth, with a lag response up to

[4]The non-performing loans variable (NPLs) is defined as the ratio of non-performing loans to total loans in a bank's lending portfolio.

[5]The data comes from information reported by the supervised institutions to the credit registry of the Central Bank of Brazil. In general, the credit portfolios analyzed in this paper represent about $\frac{2}{3}$ of total bank credit, partly due to the exclusion of credit operations granted under statutory conditions (i.e., directed lending).

three quarters. No statistically significant differences in the sensitivity of NPLs to GDP growth were found across bank types. Comparative static exercises indicate that a 2 percentage point drop in yearly GDP growth, which is akin to the maximum drop observed during 1996-2008, would cause a two-time increase in NPLs from their March 2009 levels, to about 7 percent. In addition, credit quality displays a strong inertial behavior across all credit types, with autoregressive coefficients implying that a one percentage point increase in NPLs in a given quarter produces a 0.4 percentage increase in NPLs in the next quarter. Credit to individuals, vehicles, and retail commerce were found to be relatively more sluggish.

The models also indicate substantial variations in the cyclical behavior of NPLs across credit types. Overall, the higher NPLs ratios were obtained for consumer loans (particularly medium- and small-sized operations), sugar and alcohol, textile, vehicles, and electrical and electronic equipment. At the same time, some credit types appear to be more sensitive to changes in economic activity, particularly agriculture, sugar and alcohol, livestock, small consumer credit, and textile. Consequently, these credit types would tend to be more affected under a protracted drop in economic activity. Banks with higher exposures to these types of credit may need to be followed up more closely.

Stress tests suggest that the banking system is well prepared to absorb the credit losses associated with a set of distressed macroeconomic scenarios without threatening financial stability. Four alternative macroeconomic scenarios, each one projected over two years, were analyzed. These comprised a Baseline reflecting the expected path of GDP growth, and three distressed scenarios that were deemed to be extreme but nevertheless likely under current circumstances. Overall, the results of the Baseline scenario indicate that NPLs on credit with free resources would peak to slightly more than 5 percent during the third quarter of 2009, followed by a quick and sustained recovery during 2010. In turn, a distressed scenario entailing a parallel, downward-shift of the expected path of GDP growth by 2 percentage points, would cause an increase in NPLs to about 7 percent at the end of the first year of the projection, followed by a sluggish behavior in the second year of the projection. Overall, the banking system seems well prepared to absorb the credit losses associated with this scenario without threatening financial stability.

The remainder of the paper is structured as follows: Section 2 presents a brief literature review, whereas section 3 discusses the methodology. Section 4 presents the empirical results. Finally, section 5 concludes the paper.

2 Literature Review

The term stress testing describes a range of techniques used to gauge the vulnerability of a portfolio in the case of adverse changes in the macroeconomic scenario or in the case of exceptional but plausible events or shocks. Stress testing means choosing scenarios that are costly and rare, and putting them to a valuation model. The objective of such tests is to make risks more transparent through calculating the potential lost of a portfolio in abnormal markets, so that it is possible to evaluate the robustness of banks. They are also commonly used in order to support internal models and management systems used by the financial institutions to make decisions of capital allocation. The tests involve three major steps. First, it is necessary to evaluate a model which relates financial and macroeconomic variables. Secondly it's necessary to devise the adverse scenarios and third the scenarios need to be mapped onto the impact on bank's balance sheets. The main macroeconomic variables that enter most of the stress test models used to assess the vulnerability of a banking system are: GDP, GDP growth or GDP gap, unemployment, interest rate, exchange rate, inflation, money growth and property prices.

Several authors, between them Gerlach et al. [2003], Pesola [2001] and Frøyland and Larsen [October, 2002], realized that macroeconomic developments and financial conditions affect banking performance. Pesola [2001], for instance, found out that high indebtedness associated with negative macroeconomic surprises contribute to banking crises and he showed the effects of lending boom on bankruptcies and loan losses. Barnhill et al. [2006] concluded that the utilization of forward looking risk evaluation methodologies is an important instrument to identify potential risks before they materialize. Moreover, Frøyland and Larsen [October, 2002] defend that although the results of each test will depend on the models used and the assumptions about the baseline scenario, those stress tests can indicate how vulnerable the financial system may be to adverse economic events. Nonetheless, according to Berkowitz [1999], it is important to understand that stress-testing can only be taken seriously if it is conducted with a probabilistic structure. Management should be careful with scenarios that are chosen subjectively and with no probabilities related to them.

Other studies did stress tests exercises to asses the vulnerability of different countries' economies. According to the results of Pesola [2001], high indebtedness, combined with negative macroeconomic surprises, contributed to the banking crises in the beginning of the 1990s in Sweden, Norway and Finland. Denmark did not suffer a banking crisis because the macroeconomic surprises were smaller there and the initial debt burden was lighter that in other Nordic countries. Nonetheless, more recently, Hagen et al. [2005] stressed the Norwegian financial system and showed that the risk of stability problems is limited to the short-term and that the banking sector as a whole could withstand the consequences of a reduction in the quality of loan portfolios resulting from changes in key macroeconomic variables. Sorge and Virolainen [2006] run a stress test to Finland and the results suggest a significant relationship between industry-specific default rates and key macroeconomic factors including the GDP and the interest rate, but the impact on GDP is bigger and more persistent than on the interest rate. Mawdsley et al. [2004] demonstrate that, for the Irish economy, there weren't significant changes in the solvency rates, under scenarios of euro appreciation and increase in the nominal interest rates. Hoggarth et al. [2005] estimate that the effects on UK banks are expected to be quite small in all scenarios devised. This suggests that major UK banks would have enough cushion in profits to absorb shocks without exhausting their capital. According to Wong et al. [2006], credit risk of Hong Kong's banking system is moderate, since the banks continue to make profit in most stressed scenarios, even at high confidence levels. Barnhill et al. [2006] show that a sharp reduction in the interest rate spreads of Brazilian banks reduces bank profitability and increases the probability of default, but banks, in general, are well-capitalized, so that, most Brazilian banks have low probability of bankruptcy. Most of these papers look at aggregate loans and non-performing loans for the entire economy.

According to Blavy [2006], while the Venezuelan banking sector appears sound under current favorable economic conditions, it remains significantly vulnerable to cyclical downturns. Besides, foreign banks appear less vulnerable than domestic private banks, which are particularly exposed to interest rate and credit risks. The capital of the latter, on average, would be almost entirely exhausted by the necessary increase in provisions and the losses associated with the interest rate shock. The impact of changes in macroeconomic variables on the ratio of non-performing loans for Indonesia is also significant. Hadad et al. [2006] shows that the result of the multivariate regression suggests the importance of price stability in order to maintain financial stability in terms of credit quality.

The recent subprime crisis that has hit hard the US banking system, banks in continental Europe, the UK and the rest of the world shows that the implementation of meaningful stress testing exercises is crucial. Assessing the overall risk within the banking system is needed and in times of stress it may be hard to do. Both the US and UK banking systems experienced large shocks that were not accounted for in previous stress testing exercises. In the recent period the rapid transformation of bank's assets have provoked substantial changes in the sensitivity of banks to large financial shocks, which were not perceived before the crisis.

Overall, most of the literature has presented models to stress test that do not take into account that loans are granted for different economics sectors, which may have different sensibility to the distressed scenarios. Our paper fills this gap and develops a model that is run for 21 economics sectors, which allows that different economics sectors have diverse sensibility to the macro conditions.

3 Methodology

3.1 Overview of the Methodology

The stress test framework presented in this paper comprises three components that are integrated in sequence:

- A macroeconomic model calibrating the relationship between selected macroeconomic variables with the help of times-series analysis. This model is used to simulate distressed, internally consistent, macroeconomic scenarios, projected over two-years.

- A microeconomic model assessing the sensitivity of loan quality to macroeconomic conditions with the help of dynamic panel econometrics. The results of this model are used to simulate the path of NPLs for each bank and for each of the 21 categories of credit, under the distressed macroeconomic scenarios produced in the previous stage. In other words, the second module produces a full set of bank-specific NPLs for each credit category, conditional on the projected macroeconomic scenarios.

- The third model uses the resulting distributions of NPLs for each bank and credit type as a proxy for the distribution of distressed PDs, combines this information with data on the credit exposures of individual banks, and computes a credit VaR using the Credit Risk+ approach with the programs developed by Avesani et al. [2006].

3.2 The Macro Model

The model outlined in this section uses times series econometrics to capture the relationship between selected macroeconomic variables. As mentioned before, the results are used to build distressed scenarios projected over two years.

Macroeconomic data on key target series are available at a quarterly frequency, from the first quarter of 2001 to the first quarter of 2009[6]. While the length of the time series is somewhat short, the period covers some important macro events, including a substantial shock in 2002-2003, when the referential interest rate shoot up by almost 10 percentage points to 26.5 percent and the exchange rate depreciated to almost 4 Brazilian Real per US Dollar (USD). (up from 2.3 Brazilian Real per Us Dollar). The memory of this shock is important to help model the dynamics of the global financial crisis, which also impacted Brazil, particularly since the third quarter of 2008. The substantial contraction in GDP is an important consideration for the VAR specification as it will, mechanically, force the factor to rebound in a way that may not be completely consistent with macroeconomic dynamics going forward.

The selected specification captures linkages between GDP growth, credit growth (CG), and changes in the slope of the domestic yield curve. We choose a parsimonious specification given the relatively short length of the time series. The variables were selected after exploring the relationships between a larger set of macroeconomic variables restricting the factors to those that were statistically more relevant to the VAR specification, also yielding tighter error bands[7]. The selected specification includes: (i) GDP GROWTH, computed by taking the first difference to the natural log of the seasonally-adjusted GDP series; (ii) CREDIT GROWTH, computed by taking the first difference to the natural log of total bank credit[8]; and (iii) the slope of the domestic yield curve, YC, measured by the difference between the monetary policy rate (i.e., the Selic), and the long-term interest rate. Summary statistics of the selected variables are presented in Table 1. In order to control for the impact of the global financial crisis in the system, we add a dummy variable that equals one for the last two quarters of the sample (i.e., Q_4 2008 and Q_1 2009) and zero otherwise[9]. This variable is treated as

[6] Before 2001 we had the peg regime in exchange rate and a transition to the floating rate regime. After 2001, floating rate regime was in permanent regime.

[7] The set of variables used in the selection of the specification include: the short-term policy rate (i.e., Selic), the spread between bank lending and deposit rates, the US yield curve (measured by the difference between the 7-year and 3-month treasury bill rates, the Chicago VIX index, the EMBI spreads, a commodity price index (proxied by the Commodity Research Bureau index), the unemployment rate, and the Brazilian Real US Dollar (USD) exchange rate. We have estimated the correlation for slope between estimations with the 7 years - 3 months and 10 years - 3 months, and it is above 99%.

[8] It is the amount of the loans in the bank's lending portfolio.

[9] We have tried a number of variables to capture external effects (US GDP growth, EU growth, commodity prices, EMBI, VIX) with poor (insignificant) t-statistics. Therefore, this may suggest that a decline in foreign demand was not the main reason affecting Brazil.

exogenous. Unit root tests indicate that GDP growth and credit growth are stationary, but fail to reject the null for the slope of the yield curve, probably due to the short size of the sample. We therefore use the first difference of the series to achieve stationarity. All variables were used as end of period and are in nominal terms.

Table 1: Summary Statistics of Selected Variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
ΔYC_t	52	-0.0012	0.586	-0.2188	0.1957
ΔCG_t	35	0.0399	0.0318	-0.0736	0.0878
ΔGDP_t	52	0.0067	0.0128	-0.0372	0.0342

The model is of the form:

$$y_t = c + \sum_{s=1}^{p} A_s y_{t-s} + Bx_t + \varepsilon_t \quad (1)$$

where

$$y_t = \begin{bmatrix} \Delta YC_t \\ \Delta \ln(CR)_t \\ \Delta \ln(GDP)_t \end{bmatrix}$$

and the x stands for the exogenous regressors. The ordering of the variables reflects the conjecture that credit markets play role in the transmission of interest rate shocks to economic activity. The number of lags is set to four, taking into account the frequency of the data and the results of alternative lag order selection criteria (which indicate 2 to 5 lags).

The estimated coefficients are consistent with *a priori* expectations on the relationship between the selected variables. The results of an unrestricted VAR are presented in columns [1] to [3] of Table 2. According to these, a tightening in monetary policy is associated with a drop in credit growth and GDP growth, and there is a strong positive relationship between the last two variables. There is also evidence that the decline of GDP growth during the last quarter of 2008 and the first quarter of 2009 was larger than otherwise explained by the interaction between the endogenous variable included in the model, as indicated by the coefficient of the dummy variable, which is negative and statistically significant. The results also indicate that the domestic credit markets were somehow isolated from the effects of the global

It could have come through the exchange rate shock, with corporate exposition to exchange rate derivatives, which prompter a number of monetary actions from the government.

financial crisis, which is likely attributable to the strong expansion of credit by public banks to compensate for the collapse of credit growth by private banks during this period. Similar conclusions can be extracted from the results of a restricted VAR, presented in columns [4] to [6]. Post-estimation tests (not reported to save space), indicate that the models are stable, and that the errors are not autocorrelated and pass standard normality tests. The impulse response functions, together with 95 percent confidence error bands are presented in Figure 1.

Place Table 2 About Here

Place Figure 1 About Here

The first difference of the slope of the yield curve would represent a change in the yield curve slope from one period to the next. Changes in yield curve slope are associated with investors' perception about future monetary policy, vis--vis current interest rates. For example, if GDP decreases from one period to the next, investors may expect the interest rates to go down in the future changing the yield curve slope from flat to downward, for example.

3.3 Microeconomic Model

Data on credit portfolios were gathered from the credit registry of the Central Bank of Brazil, which contains rich information on individual credit operations granted by the supervised banks. The registry covers the bulk of credit in the system, leaving aside operations lower than a minimum reporting threshold, and credits granted by unsupervised entities (such as non-financial corporations)[10]. The data used in this exercise, however, focuses on lending granted with non-earmarked resources, which accounts for about 70 percent of total credit, as information on directed lending was not available[11]. For the purposes of the analysis, the data were aggregated at the level of individual banks and classified in 21 categories (Table 3). For each one, we have: (i) total (gross) loans, (ii) non-performing loans (NPLs), (iii) number of loan operations, (iv) number of loan operations in default, and (v) (specific) loan-loss provisions.

[10]It is important to highlight that: 1. The registry cover credit operations above which represent more than 80% of the total volume of credit, and 2. In Brazil most credit operations are performed within the financial system. Therefore, the database is highly representative of the credit operations in Brazil.

[11]Non-earmarked resources are credit granted by financial institutions without implicit or explicit subsidies from the government.

Place Table 3 About Here

Overall, the database covers the credit operations of 78 banks during 2003-09. The size of the credit portfolios included in the analysis is rather continuous throughout the sampled period (Table 4). The sample, however, is unbalanced due to the exit or merge of some banks and the incorporation of new ones. As of March 2009, the sample included 49 banks jointly accounting for about [85] percent of total bank credit[12]. The time coverage was dictated by data availability. In particular, the construction of time series going further back in time was not possible due to a change in accounts and data reporting definitions introduced in 2002.

Place Table 4 About Here

The quality of the data was deemed to be good, and several filters were applied to the data to identify potential inconsistencies. The filters signaled some data reporting issues, generally associated with a specific subgroup of banks.

A look at the bank-level data indicates that credit quality has been relatively poor and extremely heterogeneous across credit types. Overall, NPLs averaged 3.6 percent during the sampled period, which is relatively high considering the favorable macroeconomic environment and the rapid expansion of credit portfolios. Furthermore, credit quality has been dispersed across banks and throughout time, as indicated by size of the standard deviations of NPLs, which are generally 2-3 times larger than their corresponding mean values (Table 5). The extent of the dispersion of credit quality and the severity of loan nonperformance in some institutions is also illustrated by the NPL ratios of banks in the 90th percentile of the distribution, which exceeded 10 percent in many sectors. Across credit types, the higher average rates of NPLs have been associated with credit to individuals (particularly small and medium-sized loans), firms operating in the services sector, producers of livestock, and electric and electronic equipment.

Place Table 5 About Here

Credit quality has been also diverse across bank types, with public institutions performing generally better throughout the sampled period. The evolution of NPLs was also diverse across bank types (Figure 2). Overall, public banks displayed better loan quality during the sampled period, only

[12] Credit is highly concentrated in Brazil with the largest 5 banks accounting for approximately 70% of total credit.

interrupted by a sharp increase in NPLs on exposures to the petrochemical and food industries in 2005-06. Remarkably, the segments of private and foreign banks experienced a moderate, but sustained increase in NPL ratios after 2005, despite rapid credit growth and the supportive economic environment. More recently, since the third quarter of 2008, credit quality deteriorated rapidly and across-the-board, reflecting the impact of the global financial crisis on the macroeconomic and financial environment. As mentioned before, however, these aggregate figures mask large differences in loan quality across individual banks. In general, the smaller banks have tended to under-perform, also displaying higher concentration in their loan exposures to specific credit types.

Place Figure 2 About Here

Mirroring these medium-term facts, the current quality of credit portfolios also displays significant variation across banks and credit types. At end-March 2009, the last point of the sample, several small banks had overall NPL ratios in excess of 10 percent, with significant concentration in their credit portfolios (Table 6). This situation may be excessive if we look at large banks but there are cases in which the NPLs are way above 10% for small banks and it's not an issue, depending on the relevance of the credit portfolio on total assets, its profitability and the volume of capital.

Place Table 6 About Here

The model discussed in this section analyzes the sensitivity of non-performing loans to macroeconomic conditions with the help of dynamic panel econometric techniques. The specification was selected after exploring the sensitivity of NPLs to a combination of candidate macroeconomic variables encompassing, inter-alia, GDP growth, the unemployment rate, credit growth (both aggregated and bank-specific), long-term and short-term interest rates, bank lending spreads, and the change of the exchange rate (both in nominal and real terms). The estimations are based on bank-level, quarterly data on the evolution of loan quality for 21 types of loans, over the period Q_1 2003 to Q_1 2009. The selected specification links bank-level NPLs to GDP growth. The results are consistent with a procyclical behavior of loan quality, and the estimated coefficients are extremely robust across a variety of estimation methods. The main criteria guiding model selection was the precision of the parameter estimates and the robustness of the results, reflecting the purpose of the exercise (i.e., simulating loan quality under alternative macroeconomic scenarios). In particular, we postulate that the logit-transformed NPLs of each credit type of bank i follow an AR(1) process and are influenced by past GDP growth, with up to S lags:

$$\ln\left(\frac{NPL_{i,t}}{1-NPL_{i,t}}\right) = \mu_i + \alpha \ln\left(\frac{NPL_{i,t-1}}{1-NPL_{i,t-1}}\right) + \sum_{s=0}^{S} \beta_{t-s} \Delta \ln(GDP)_{t-s} + \varepsilon_{i,t} \tag{2}$$

Where NPL_{it} stands for the (logit of) the ratio of non-performing loans of each credit type of bank i in period t, and GDP_t stands for GDP in quarter t [13]. The inclusion of the lagged dependent variable is motivated by the persistence of NPLs. The term μ_i refers to the bank-level fixed effects, which are treated as stochastic, and the idiosyncratic disturbances $\varepsilon_{i,t}$ are assumed to be independent across banks and serially uncorrelated (i.e., after the inclusion of the lagged dependent variable). The coefficient α is expected to be positive but less than one, and the β coefficients are expected to be negative, reflecting deteriorating loan quality during the economic downturn.

Under this specification, the short-term effect of a change in quarter-on-quarter GDP growth on the logit of NPLs is given by the sum of the estimated β coefficients. By the chain rule, the effect of a shock to GDP growth on the untransformed NPL ratios, evaluated at the sample mean of NPLs is given by:

Short-term effect:

$$\frac{\Delta NPL}{\Delta \ln(GDP)} = \overline{NPL} \times (1 - \overline{NPL}) \times \sum_{s} \beta_{t-s} \tag{3}$$

Long-term effect:

$$\frac{\Delta NPL}{\Delta \ln(GDP)} = \frac{1}{1-\alpha} \times \overline{NPL} \times (1 - \overline{NPL}) \times \sum_{s} \beta_{t-s} \tag{4}$$

As a first approximation, we estimate equation (2) for the overall NPL ratios of individual banks, without making any distinction between credit types. The estimation was carried out using several alternative methods to assess the robustness of the results. We then select a preferred estimation method and re-estimate equation (2) for each of the 21 credit types. All the models were estimated over the entire sample of banks and separately for public, private domestic, and foreign banks with the help of interacting

[13] Since the non-performing loan ratio is bounded in the interval [0, 1], the dependent variable was subject to the logit transform $\log\left(\frac{NPL}{1-NPL}\right)$, to avoid problems associated with non-Gaussian errors.

dummies. The latter was used to explore for differences in the sensitivity of loan quality to macroeconomic conditions across bank types, possibly induced by systematic differences in loan origination practices and bank clientele across public, private, and foreign banks. However, due to lack of evidence of systematic differences across bank types, the final specification was estimated over the entire sample to increase efficiency.

The higher the NPL, ceteris paribus, the higher the likelihood of a bank defaulting, since the credit quality of its lending portfolio is deteriorating. The NPL variable is defined as the ratio between non-performing loans and total loans. An increase in NPL could mean only one thing: an increase in non-performing loans bigger than the increase in total loans, regardless of whether credit growth is constant or not. Even if credit growth is not constant, the likelihood of a bank defaulting will increase, ceteris paribus, if the non-performing loans increase more than total loans. However, a disorderly and irresponsible growth in credit (e.g. due to lax lending practices), could lead to a bigger growth in non-performing loans, leading to an increase in NPL and in the probability that a bank will default, and we have tried to capture this effect exactly by adding the credit growth variable.

The results of the exploratory regressions were consistent with expectations, and extremely robust under alternative estimation methods. After exploring with various lag structures, we selected four lags of GDP growth, also reflecting the frequency of the data (Table 7). Overall, the coefficients of the lagged dependent variable are around 0.6, reflecting the strong persistence of NPLs. In turn, the coefficients of the lagged GDP growth are negative, as expected, and significant for up to three lags, falling within a relatively narrow interval.

Place Table 7 About Here

Based on a comparison across estimation methods, we select the specification presented in column [4] as the preferred model. In particular, the estimation in column [1] uses OLS in levels, which produce upward-biased estimates of the coefficients associated with the lagged dependent variable (the α_i's) due to the positive correlation between the latter and the fixed-effects. The Within Groups estimator in column [2] eliminates the fixed-effects by subtracting the mean from the series, but introduces a downward bias stemming from negative correlation between the lagged dependent variable and the transformed errors. Therefore, the consistent estimator of α is expected to fall between the OLS and the Within Groups estimators, which is in fact the case for all the models that follow, which are based on the Generalized Method of Moments (GMM) estimators. The results presented in columns

[3] and [4] use the Arellano-Bond GMM estimator in first differences, treating GDP growth as strictly exogenous in the first case, and as predetermined in the second. The latter seems to be the preferred treatment, as indicated by the results of the Hansen test presented at the bottom, which fail to reject the null of orthogonality between the instruments and the error term. In turn, the results presented in columns [5] and [6] use the Arellano-Bover System GMM estimator, which exploit additional information from the equations in levels, but require the additional assumption that GDP growth is uncorrelated with the bank-level fixed effects, which may not be realistic. In all the GMM estimations, the number of instruments was limited by setting a maximum of 6 lags, to avoid problems associated with instrument proliferation.

The estimates of a full set of parallel regressions, one for each credit type, are also consistent with expectations and broadly robust. All the coefficients of the lagged dependent variable are positive in the interval [0, 1] as expected, and statistically significant at conventional levels (Table 8). The average value across all credit types is 0.4, which is slightly below the estimate obtained for the entire loan portfolios, likely reflecting the stronger sluggishness of the latter induced by diversification. The results also indicate that the AR(1) specification is adequate to eliminate the autocorrelation of the errors, as the tests of autocorrelation of order 2 in the first-differenced errors fail to reject the null in all cases. In turn, the sum of the coefficients of lagged GDP growth are negative in all cases, with the exception of credit to transport and the "other credits" categories, and statistically significant in $\frac{3}{4}$ of the cases. The largest autoregressive coefficients are obtained for small credits to consumers, retail, textiles, and vehicles, indicating higher sluggishness in loan quality to these sectors. In turn, the largest coefficients for GDP growth are obtained for agriculture, sugar and alcohol, and energy. In order to gauge the sensitivity of NPLs to economic activity, however, these coefficients have to be rescaled by the average NPLs of the corresponding credit types, as shown in equations [3] and [4].

Place Table 8 About Here

Using these results we compute "rule-of-thumb" estimates of the impact of a change in GDP growth on NPLs. Overall, a 2 percent drop in yearly GDP, which is akin to the maximum drop observed between 1996-2008, would cause NPL ratios to double from their March 2009 levels to about 7 percent, as shown at the bottom of Table 9. Using equation (2) and taking the general average of NPLs (2.8 percent) and the sum of the estimated coefficients of GDP growth (-24.4), a 2 percentage point drop in GDP growth would cause a 1.3 percentage point increase in NPLs in the short-term (i.e., $0.028 \times$

$(1 - 0.028) \times 24.4 \times 2)$. In turn, from equation [3], the predicted long-term increase in NPLs would be 3.3 percentage points (i.e., $1.3 \div (1 - 0.6)$), entailing a two-times increase from their March 2009 levels. Across credit types, the higher NPL ratios are obtained for consumer credit, which reaches 7.6 percent for medium-sized loans, and 10.4 percent for small loans. Among lending to firms, the sectors reaching the highest NPL levels include textile, electric and electronic equipment, retail trade, and vehicles. In relative terms, the distressed NPL ratios are generally $1\frac{1}{2}$ and 2 times higher than their March 2009 values, with the most sensitive sectors being electricity and gas, livestock, agriculture, food, sugar and alcohol, and retail trade.

Place Table 9 About Here

4 Empirical Results

4.1 Stress Tests

This section summarizes the results of stress test exercises of credit risk based on scenario analysis. It describes the criteria used in the construction of the scenarios and provides a brief comparison of their evolution. It also discusses the main characteristics of the out-of-sample forecasts of NPLs under selected scenarios. Finally, the section presents the results of a credit VaR calculation based on these projections.

The exercises to assess credit risk are based on four macroeconomic scenarios, including a Baseline that reflects the expected path of GDP growth, and three distressed scenarios. Designing relevant stress scenarios is not a trivial issue. One can use history as guidance to construct the shocks, but history hardly repeats itself and the circumstances surrounding the shocks are almost always different, bringing questioning to their validity. Alternatively, the shocks can also be constructed more arbitrarily, considering current conditions and incorporating forward-looking considerations. In this paper we abstract from this discussion and use a mix of both history, current conditions, and arbitrary considerations to suggest a set of hypothetical shocks to the framework. The idea is to illustrate the model sensitivity to these various scenarios.

The evolution of GDP growth under the four scenarios considered was determined as follows:

- *Baseline Scenario*: This scenario is taken as reference and aims at capturing the expected evolution of economic activity. Under this, GDP growth is assumed to drop from 5.1 percent in 2008 to -0.6

percent in 2009, followed by a resumption to above 3 percent in the subsequent two years.

- *Scenario 1*: This scenario is ad-hoc, constructed by subtracting two percentage points to the quarterly path of GDP growth under the Baseline.
- *Scenario 2*: Uses the results of the VAR to simulate the effects of a negative shock to credit growth equal to 2.4 percentage points in Q_2 2009. The shock is akin to the mean quarterly credit growth during 2001-09 minus 2 standard deviations.
- *Scenario 3*: Uses the results of the VAR to simulate the effects of a negative shock to GDP growth equal to 1.9 percentage points in Q_2 2009. The shock is akin to the mean quarterly GDP growth during 2001-09 minus 2 standard deviations.

A comparison on the evolution of GDP growth under these four scenarios is provided in Figure 3.

Place Figure 3 About Here

Using the results of the panel estimations we conduct an out-of-sample forecast of NPLs for each bank and credit type under the four scenarios. The results under the Baseline indicate a deterioration in loan quality during the first half of 2009 (Figure 4). In particular, NPLs peak to 5.2 percent in the third quarter of 2009, followed by a relatively quick and steady recovery in 2010. This out-of-sample forecast tracks reasonably well the ex-post observed data on NPLs on reference credit operations during the second and third quarters of 2009 (NPLs reached 5.8 percent in September 2009). The results for Scenario 1 entail an increase in NPLs throughout 2009, followed by a sluggish behavior during 2010. The peak level of NPLs reaches about 7 percent, which is high at about two times the maximum observed during the sample period. Scenarios 2 and 3 entail an even more severe deterioration of credit quality, with NPLs reaching a peak of almost 10 percent, which is consistent with the severity of the scenario, which entails a double dip recession. Across credit types, the higher levels of NPLs are associated with credit to consumers, sugar and alcohol, textiles, electricity and gas, and vehicles, which is roughly consistent with the results of the static exercise.

The simulations suggest that the banking system is well prepared to absorb the credit losses stemming from the distressed scenarios considered without threatening financial stability.

Place Figure 4 About Here

4.2 Credit VaR

This section presents the results of a credit VaR calculation using the bank-specific estimates of NPLs for each credit type under Scenario 1 as a proxy for distressed PDs. In particular, we take the average of the out-of-sample prediction of NPLs for each bank and credit type under Scenario 1 as a proxy for distressed PDs of the corresponding credit categories. To account for uncertainty on the true value of the PDs we use the standard deviation of the NPLs over the two-year out-of-sample projection. The credit VaR calculation is based on the exposures of each bank as of March 2009. For each credit type, we compute the average exposures to individual borrowers by dividing the total exposures over the number of loan operations. Admittedly, this treatment may underestimate portfolio concentration and therefore the results of the credit VaR. We thus compute an alternative exercise that assumes that 80 percent of the exposures under each credit category are concentrated in 20 percent of the number of credit operations (and the reminder 20 percent of the exposures correspond to 80 percent of the number of credit operations). Since we do not have information on losses given default (LGDs), we choose a generic value of 50 percent for all credit types. We further assume that defaults by individual obligers follow a Poisson distribution and are independent, conditional on the realization of the distressed scenario.

The results suggest that the banking system is well prepared to undergo the credit losses associated with the distressed scenarios considered without threatening financial stability. The (unexpected) credit losses associated with a 99 percent credit VaR for the 18 banks with the largest credit portfolios in the sample amount to around 30 billion Brazilian reais, of 3.9 percent of their gross exposures (Table 10). As a reference, these losses are roughly equivalent to about 15 percent of the joint tangible capital of these banks. Our measure of tangible capital equals regulatory capital minus the sum of specific loan loss provisions included in banks' own resources, deferred taxes, and goodwill. Therefore, the capital cushions of the largest banks appear sufficient to absorb the credit losses associated with the scenarios considered without threatening financial stability.

Place Table 10 About Here

5 Final Considerations

The econometric estimations presented in this paper provide evidence of a cyclical behavior of loan quality in Brazil. The estimations substantiate the existence of a robust inverse relationship between GDP growth and NPLs, with the effects operating with up to three quarter lags. The results also indicate differences in the persistence of NPLs across credit types, and in their sensitivity to economic activity. Loan quality appears to be more sensitive to GDP growth for small credit to consumers, credit to agriculture, sugar and alcohol, livestock, and textile. In addition, credit for vehicle acquisition and electric and electronic equipment displayed high level of NPLs under distressed macroeconomic scenarios. Banks with relatively higher exposures to these sectors are likely to experience larger credit losses under distressed macroeconomic conditions.

The banking system appears to be well prepared to absorb the credit losses associated with the scenarios analyzed without threatening financial stability.

Future research could focus on how the banking system concentration may affect the results. Furthermore, an important in Brazil is how a relevant player such as the government, that controls approximately one third of the banking system, can act to alter the results.

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Table 2: Macro Model Specification

	Unrestricted Model			Restricted Model		
Variables	ΔYC$_t$	$\Delta \ln(CG)_t$	$\Delta \ln(GDP)_t$	ΔYC_t	$\Delta \ln(CG)_t$	$\Delta \ln(GDP)_t$
ΔYC$_{t-1}$	0.594***	-0.575**	-0.263***	0.618***	-0.595***	-0.259***
	[0.000]	[0.022]	[0.004]	[0.000]	[0.007]	[0.004]
ΔYC$_{t-2}$	-0.027	-0.16	-0.135			-0.054
	[0.885]	[0.580]	[0.205]			[0.536]
ΔYC$_{t-3}$	-0.089	0.178	-0.207**			-0.269***
	[0.605]	[0.511]	[0.038]			[0.002]
ΔYC$_{t-4}$	-0.03	0.316	-0.059			
	[0.868]	[0.261]	[0.566]			
$\Delta \ln(CG)_{t-1}$	0.209**	-0.391***	0.148***	0.239***	-0.306**	0.159***
	[0.013]	[0.003]	[0.002]	[0.001]	[0.014]	[0.000]
$\Delta \ln(CG)_{t-2}$	0.167*	0.051	0.177***	0.180***	0.197*	0.197***
	[0.054]	[0.705]	[0.000]	[0.006]	[0.074]	[0.000]
$\Delta \ln(CG)_{t-3}$	-0.119	0.212	0.079	-0.137*	0.315***	0.065
	[0.162]	[0.112]	[0.106]	[0.074]	[0.008]	[0.135]
$\Delta \ln(CG)_{t-4}$	-0.264***	0.261**	0.04	-0.304***	0.230**	
	[0.001]	[0.032]	[0.371]	[0.000]	[0.028]	
$\Delta \ln(GDP)_{t-1}$	0.039	1.100***	-0.514***		0.918***	-0.504***
	[0.856]	[0.001]	[0.000]		[0.000]	[0.000]
$\Delta \ln(GDP)_{t-2}$	0.182	1.129**	-0.524***		0.656*	-0.482***
	[0.557]	[0.020]	[0.003]		[0.089]	[0.002]
$\Delta \ln(GDP)_{t-3}$	-0.001	0.779*	-0.425**			-0.436***
	[0.997]	[0.097]	[0.014]			[0.001]
$\Delta \ln(GDP)_{t-4}$	-0.107	0.606	-0.279*			-0.304**
	[0.696]	[0.159]	[0.078]			[0.019]
dummy.crisis	-0.01	-0.004	-0.044***			-0.044***
	[0.280]	[0.788]	[0.000]			[0.000]
constant	-0.002	0.009	0.008***	-0.001	0.014*	0.009***
	[0.674]	[0.264]	[0.005]	[0.802]	[0.061]	[0.001]
R-squared	0.63	0.63	0.63	0.56	0.56	0.56

p-values in brackets *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 3: Structure and Quality of Credit Portfolios across Bank Types, March 2009 In Percent

	Non-Performing Loans			Share in Loan Portfolio		
	Private Domestic (%)	Public (%)	Foreign (%)	Private Domestic (%)	Public (%)	Foreign (%)
Consumer (Large)	2.9	2.0	3.3	1.4	5.8	2.5
Consumer (Medium)	6.5	2.0	7.1	7.5	13.4	10.7
Consumer (Small)	8.9	2.9	7.2	28.3	20.3	25.8
Agriculture	2.7	1.0	3.8	2.0	2.2	2.7
Food	3.2	1.4	2.8	2.2	2.7	2.5
Livestock	2.4	1.2	3.9	3.0	3.9	3.2
Vehicles	4.4	2.3	5.1	3.0	2.6	2.5
Electrical and Electronic	6.8	2.9	5.0	1.4	1.5	1.5
Electricity and Gas	0.0	0.0	1.1	3.2	3.0	3.7
Wood and Furniture	2.9	2.5	2.8	8.8	6.0	8.8
Recreation Services	4.7	3.3	4.8	1.8	1.6	1.8
Petrochemicals	2.3	0.7	2.4	3.1	5.6	2.6
Chemicals	3.8	1.6	2.3	1.5	1.6	2.2
Health Services	2.7	1.9	2.6	1.9	1.6	2.5
Other Services	3.9	3.0	4.0	3.8	1.9	3.2
Metal products	1.3	0.4	1.5	3.2	4.4	2.6
Sugar and Alcohol	1.2	1.4	1.4	3.8	1.5	3.1
Textile	6.5	3.1	5.5	2.5	3.3	3.0
Transportation	1.8	1.0	2.2	6.5	3.2	4.2
Retail Trade	3.8	1.8	2.9	2.7	3.4	2.6
Other	1.4	0.8	1.3	8.5	10.3	8.2

Source: Central Bank of Brazil and IMF staff estimates

Table 4: Sample Coverage

	Number of Sampled Banks				
	Public	Private	Foreign	Total	Total Loans (in million R$)
Q_1 2003	6	37	25	68	214,838
Q_2 2003	7	39	23	69	214,368
Q_3 2003	7	39	22	68	219,499
Q_4 2003	7	38	20	65	239,102
Q_1 2004	6	38	20	64	242,760
Q_2 2004	6	38	19	63	258,230
Q_3 2004	6	37	19	62	268,066
Q_4 2004	6	37	20	63	277,670
Q_1 2005	6	37	21	64	291,032
Q_2 2005	6	36	21	63	303,805
Q_3 2005	6	36	21	63	316,163
Q_4 2005	6	35	21	62	343,966
Q_1 2006	5	36	21	62	357,901
Q_2 2006	5	35	20	60	380,806
Q_3 2006	5	35	19	59	401,241
Q_4 2006	5	35	19	59	438,637
Q_1 2007	5	35	19	59	456,863
Q_2 2007	5	34	18	57	490,680
Q_3 2007	5	33	18	56	533,389
Q_4 2007	3	27	15	45	533,458
Q_1 2008	5	33	18	56	619,536
Q_2 2008	5	32	18	55	676,095
Q_3 2008	4	32	17	53	733,894
Q_4 2008	4	32	16	52	767,665
Q_1 2009	4	29	16	49	779,501

Source: Central Bank of Brazil and IMF staff estimates

Table 5: Selected Statistics of Loan Quality Across Credit Types and Bank Ownership, In Percent, Q_1 2003 - Q_1 2009

	Private Domestic			Public Banks			Foreign Banks			Total Sample		
	Mean	Std. Dev.	Pct. 90	Mean	Std. Dev.	Pct. 90	Mean	Std. Dev.	Pct. 90	Mean	Std. Dev.	Pct. 90
Consumer (Large)	4.6	14.7	7.3	4.0	6.2	14.0	1.5	4.7	2.7	3.6	11.8	7.1
Consumer (Medium)	7.4	12.2	17.6	3.3	3.9	7.9	4.3	7.6	9.9	6.1	10.6	14.7
Consumer (Small)	6.9	9.0	14.0	3.0	1.7	4.8	4.7	8.2	10.2	5.9	8.4	12.9
Wood and Furniture	5.0	11.1	12.7	3.6	4.8	7.4	1.3	4.1	2.8	3.8	9.1	8.5
Transportation	4.7	13.6	8.9	5.5	11.5	12.2	1.5	6.9	2.1	3.8	11.8	7.7
Petrochemicals	3.9	10.1	9.6	9.7	23.6	26.8	0.7	2.4	1.8	3.6	11.4	7.4
Metal products	2.9	12.4	4.2	2.8	6.8	8.8	0.3	1.6	0.8	2.1	10.0	2.9
Electricity and Gas	1.8	7.9	3.1	1.3	5.9	1.5	0.6	3.9	0.7	1.3	6.0	1.5
Livestock	5.4	16.7	8.0	5.8	11.4	17.2	1.4	4.5	2.6	4.2	13.8	6.9
Other Services	6.3	14.6	19.3	5.7	8.4	13.6	1.8	5.2	3.1	5.0	12.3	12.7
Sugar and Alcohol	0.5	2.9	0.5	0.3	1.2	0.7	0.8	6.7	0.2	0.6	4.3	0.5
Retail Trade	4.5	13.0	9.0	5.2	8.9	15.5	1.4	7.5	2.3	3.7	11.3	7.1
Textile	4.2	10.1	10.1	5.3	9.2	11.5	2.8	10.7	4.4	3.9	10.2	9.2
Vehicles	3.8	11.5	7.2	3.2	9.1	6.0	0.9	2.1	2.5	3.0	9.6	5.5
Food	4.0	11.7	8.2	14.0	27.2	60.3	1.2	3.9	2.7	4.3	13.5	7.7
Agriculture	2.2	8.9	4.0	2.3	7.3	4.0	0.6	2.5	1.0	1.7	7.3	2.9
Health Services	3.9	12.2	6.7	2.2	3.8	5.2	1.8	7.5	2.1	3.2	10.5	5.0
Chemicals	2.5	9.6	4.3	3.3	4.1	8.8	0.9	3.2	2.3	2.2	7.8	4.1
Recreation Services	5.4	14.6	15.3	4.7	5.4	10.0	2.4	7.1	5.3	4.5	12.4	9.9
Electrical and Electronic	5.9	16.1	13.3	5.4	6.1	16.6	2.2	7.1	3.4	4.9	13.4	11.1
Other	3.6	10.7	7.2	4.7	10.5	11.5	1.3	6.2	1.4	2.9	9.5	6.6

Source: Central Bank of Brazil and IMF staff estimates

Table 6: Characteristics of Credit Portfolios of the Sampled Banks, In Percent Unless Indicated, March 2009

		Indicators of Credit Quality Overall Portfolio			
		NPLs	Loan Operations in Default	Concentration Index	Share of Credit in Sample
Private Domestic Banks	Mean	7.3	8.3	24.6	1.8
	Std. Dev	8.280	6.132	2.188	5.184
Public Banks	Mean	2.3	3.0	17.3	6.5
	Std. Dev	0.495	1.014	13.911	11.851
Foreign Banks	Mean	2.0	4.6	18.1	1.4
	Std. Dev	1.813	4.795	8.777	3.766

Source: Central Bank of Brazil and IMF staff estimates

Table 7: Results of Exploratory Panel Regressions

	(1) Pooled OLS	(2) Within Groups	(3) Difference GMM GDPP Exog.	(4) Difference GMM GDPP Pred.	(5) System GMM GDPP Exog.	(6) System GMM GDPP Pred.
$Logit(NPL)_{t-1}$	0.905***	0.569***	0.589***	0.597***	0.602***	0.631***
	[0.024]	[0.064]	[0,124]	[0.123]	[0.088]	[0.082]
$\Delta\ln(GDP)_t$	-7.481***	-7.853***	-9.529***	-8.804***	-7.767***	-6.928***
	[2.032]	[1.903]	[2.198]	[2.132]	[1.927]	[1.939]
$\Delta\ln(GDP)_{t-1}$	-2.569	-4.544**	-6.081***	-5.729***	-3.922*	-3.086
	[2.282]	[1.935]	[2.254]	[1.990]	[2.026]	[2.023]
$\Delta\ln(GDP)_{t-2}$	-7.482**	-6.877**	-10.675***	-9.152***	-8.123**	-5.971*
	[3.197]	[3.081]	[3.627]	[3.361]	[3.138]	[3.077]
$\Delta\ln(GDP)_{t-3}$	1.597	1.067	0.423	-0.734	1.225	0.828
	[3.273]	[3.172]	[3.433]	[3.130]	[3.337]	[3.322]
Observations	1201	1201	1121	1121	1201	1201
R-squared	0.83	0.341				
Hansen test (p-value)			0.02	0.13	0.04	0.11
AR(1) p-value			0.00	0.00	0.00	0.00
AR(2) p-value			0.184	0.175	0.184	0.191
Number of Instruments			11	17	13	17
Number of banks		70	69	69	70	70

Robust standard errors in brackets: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 8: Results of the Dynamic Panel Regressions for Individual Credit Types Q_1 2003 - Q_1 2009

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
	Consumer (Large)	Consumer (Medium)	Consumer (Small)	Wood and Furniture	Transport ation	Petroche micals	Metal Products	Electricity and Gas	Livestock	Other Services	Sugar and Alcohol	Retail Trade	Textile	Vehicles	Food	Health Agriculture
aux_{t-1}	0.351	0.379	0.665	0.335	0.380	0.398	0.483	0.423	0.498	0.409	0.340	0.628	0.543	0.522	0.465	0.451
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.004]	[0.000]	[0.003]	[0.000]	[0.000]	[0.000]
$\Delta \ln(GDP)_t$	-6.129	-4.186	-5.906	-3.235	3.759	-2.008	-1.526	-16.453	-7.283	-2.102	-6.134	-0.798	-0.684	-2.170	-7.343	-11.447
	[0.136]	[0.008]	[0.025]	[0.070]	[0.296]	[0.385]	[0.581]	[0.003]	[0.144]	[0.265]	[0.485]	[0.722]	[0.855]	[0.370]	[0.005]	[0.006]
$\Delta \ln(GDP)_{t-1}$	-7.951	-2.931	-2.168	-8.643	-4.182	-8.169	-6.355	-3.671	-14.080	-3.057	-11.806	-6.651	-10.950	-2.901	-6.508	-11.446
	[0.071]	[0.032]	[0.148]	[0.005]	[0.045]	[0.010]	[0.044]	[0.609]	[0.271]	[0.143]	[0.117]	[0.004]	[0.000]	[0.116]	[0.032]	[0.000]
$\Delta \ln(GDP)_{t-2}$	-2.797	-6.578	-1.730	-4.565	3.592	-2.753	-6.047	-17.539	-0.978	-0.498	-24.826	-4.095	-7.673	-1.249	-0.124	-5.723
	[0.602]	[0.011]	[0.377]	[0.097]	[0.379]	[0.282]	[0.383]	[0.008]	[0.876]	[0.897]	[0.005]	[0.239]	[0.026]	[0.689]	[0.971]	[0.213]
$\Delta \ln(GDP)_{t-3}$	-8.132	-0.023	0.333	-2.059	-3.089	1.284	-3.086	-23.542	8.514	-2.879	-24.430	-3.719	-2.667	-5.113	-1.821	-6.605
	[0.258]	[0.992]	[0.887]	[0.498]	[0.538]	[0.705]	[0.486]	[0.006]	[0.245]	[0.442]	[0.122]	[0.189]	[0.557]	[0.040]	[0.628]	[0.029]
Observations	376	889	983	726	561	570	412	287	477	659	184	502	577	509	549	377
No. of banks	37	58	61	54	43	41	35	25	38	51	18	41	44	36	42	30
Hansen test (p-value)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AR(1) (p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
AR(2) (p-value)	0.19	0.25	0.95	0.03	0.14	0.57	0.90	0.39	0.92	0.84	0.18	0.11	0.88	0.42	0.35	0.08
No. of instruments	146	146	146	146	146	146	146	146	146	146	144	146	146	146	146	146
Sum of GDP Coeff.	-25.009	-13.72	-9.47	-18.50	0.08	-11.65	-17.01	-61.21	-13.83	-8.54	-67.20	-15.26	-21.97	-11.43	-15.80	-35.22
P-value	0.04	0.02	0.09	0.01	0.99	0.06	0.06	0.00	0.55	0.26	0.01	0.01	0.01	0.07	0.03	0.00
Long-term Effect	-38.535	-22.090	-28.272	-27.823	0.129	-19.346	-32.909	-106.075	-27.544	-14.443	-101.812	-41.030	-48.083	-23.918	-29.525	-64.155
P-value	0.03	0.01	0.14	0.02	0.52	0.07	0.09	0.02	0.25	0.18	0.12	0.08	0.26	0.20	0.00	0.00

Table 9: Effect of a 2 pp. drop in GDP Growth on NPLs, by Sectors In Percent, Unless Indicated

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
			Estimates of Panel Regressions				Increase in NPLs		Stressed NPLs	
	Average NPLs 2003-09	NPLs March 2009	Coef. Lagged NPLs	Sum Coef. GDP Growth	Long-term Effect [a]	Scale Factor [b]	Short-Term (Pencentage Points) [c]	Long-Term (Percentage Points) [d]	Level [e]	Times Increase
Consumer (Large)	3.6	2.5	0.4	-25.0	-38.5	0.035	1.7	2.7	5.2	2.1
Consumer (Medium)	6.1	5.0	0.4	-13.7	-22.1	0.057	1.6	2.5	7.6	1.5
Consumer (Small)	5.9	7.3	0.7	-9.5	-28.3	0.055	1.0	3.1	10.4	1.4
Wood and Furniture	3.8	2.8	0.3	-18.5	-27.8	0.036	1.3	2.0	4.8	1.7
Transportation	3.8	1.7	0.4	0.1	0.1	0.037	0.0	0.0	1.7	1.0
Petrochemicals	3.6	1.7	0.4	-11.6	-19.3	0.035	0.8	1.3	3.0	1.8
Metal Products	2.1	1.0	0.5	-17.0	-32.9	0.021	0.7	1.4	2.4	2.4
Electricity and Gas	1.3	0.3	0.4	-61.2	-106.1	0.013	1.6	2.8	3.1	10.0
Livestock	4.2	2.4	0.5	-13.8	-27.5	0.041	1.1	2.2	4.6	2.0
Other Services	5.0	3.7	0.4	-8.5	-14.4	0.047	0.8	1.4	5.1	1.4
Sugar and Alcohol	0.6	1.3	0.3	-67.2	-101.8	0.006	0.8	1.2	2.5	1.9
Retail Trade	3.7	3.0	0.6	-15.3	-41.0	0.035	1.1	2.9	5.9	2.0
Textile	3.9	5.2	0.5	-22.0	-48.1	0.038	1.7	3.6	8.8	1.7
Vehicles	3.0	4.0	0.5	-11.4	-23.9	0.029	0.7	1.4	5.4	1.3
Food	4.3	2.6	0.5	-15.8	-29.5	0.041	1.3	2.4	5.0	1.9
Agriculture	1.7	2.6	0.5	-35.2	-64.2	0.017	1.2	2.2	4.7	1.8
Health Services	3.2	2.5	0.4	-8.8	-15.8	0.031	0.5	1.0	3.5	1.4
Chemicals	2.2	2.8	0.5	-3.9	-7.2	0.021	0.2	0.3	3.1	1.1
Recreation Services	4.5	4.4	0.2	-14.4	-17.4	0.043	1.2	1.5	5.9	1.3
Electrical Equipment	4.9	5.3	0.4	-14.0	-21.6	0.046	1.3	2.0	7.3	1.4
Other	2.9	1.2	0.3	3.8	5.3	0.029	-0.2	-0.3	0.9	0.7
Overall Sampled Credit	2.8	3.9	0.6	-24.4	-60.6	0.027	1.3	3.3	7.2	1.8

Memo: Change in yearly GDP growth: -2

[a] C omputed as: $[5] = \frac{[4]}{1-[3]}$

[b] T he scale factor is computed as: $[6] = \frac{[1]}{1-[1]}$ (i.e., $NPL \times (1 - NPL)$)

[c] A ssuming a 2pp drop in GDP growth, the short-term increase in NPLs is computed as: $[7] = [4] \times [6] \times (-2)$

[d] T he long-term increase in NPLs is computed as: $[8] = \frac{[7]}{1-[3]}$

[e] T he stressed PD are computed as: $[9] = [2] + [8]$

Table 10: Results of the Credit VaR Exercise, In Million of Brazilian Real Unless Indicated

Bank	VaR	VaR/Net Exposure (Percent)	VaR/Gross Exposure (Percent)	Gross Exposure	Share of Loans in Sample (Percent)
1	97	5.5	2.7	3,538	0.5
3	17	0.5	0.3	6,348	0.8
10	241	5.3	2.7	9,046	1.2
12	3,632	3.8	1.9	189,052	24.3
18	296	8.6	4.3	6,839	0.9
21	443	14.3	7.1	6,216	0.8
25	5,082	7.5	3.8	135,276	17.4
29	463	9.6	4.8	9,642	1.2
38	271	18.2	9.1	2,985	0.4
41	1,225	7.7	3.9	31,798	4.1
47	9,248	10.7	5.3	173,172	22.2
53	154	8.4	4.2	3,675	0.5
58	60	3.9	1.9	3,113	0.4
63	902	8.5	4.3	21,118	2.7
64	6,508	11.1	5.6	116,957	15.0
70	105	8.2	4.1	2,563	0.3
71	171	9.8	4.9	3,502	0.4
74	780	5.0	2.5	31,378	4.0
Total	29,694	7.9	3.9	756,218	97.0
Parameters:					
VaR Level:	0.99				
Model:	Poisson Defaults/FFT				
LGD:	0.5				

Figure 1: Macro Model Impulse Response Functions - Response of Dlncr to Dlngdp. Dlncr is the first difference in the natural logarithm of bank's credit growth, where credit is estimated as the total loans in the aggregate banking system portfolio, at the end of each period, and growth is estimated quarter-on-quarter. Dlngdp is the first difference in the natural logarithm if GDP, where GDP is computed as the seasonally-adjusted GDP series, quarter-on-quarter, using end of period. Dyc is the first difference in the yield curve slope, measured by the difference between the monetary policy yield curve (i.e. Selic), and the long-term interest rate.

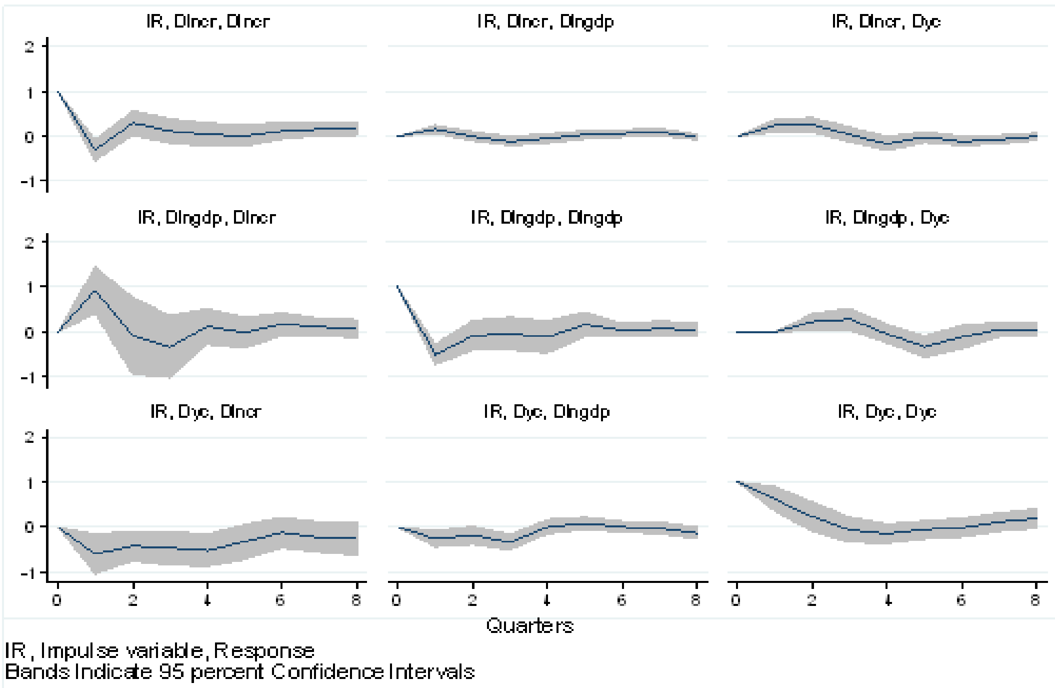


Figure 2: Evolution of NPLs across bank types

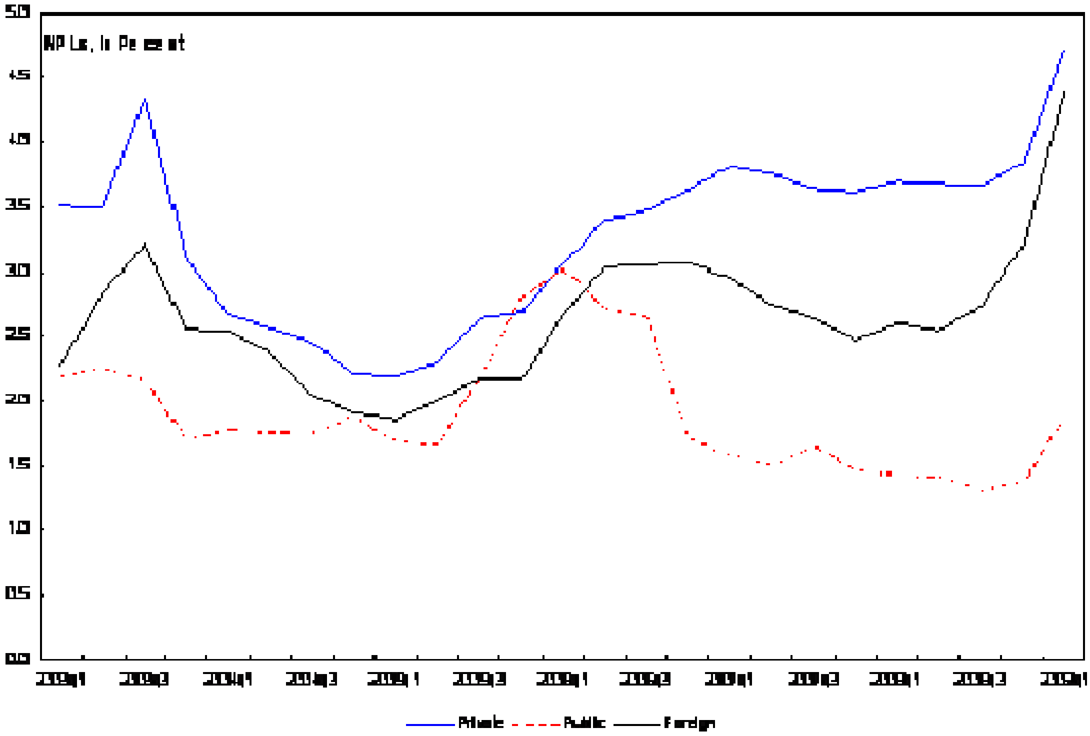


Figure 3: Evolution of GDP Growth y-o-y Under Alternative Scenarios

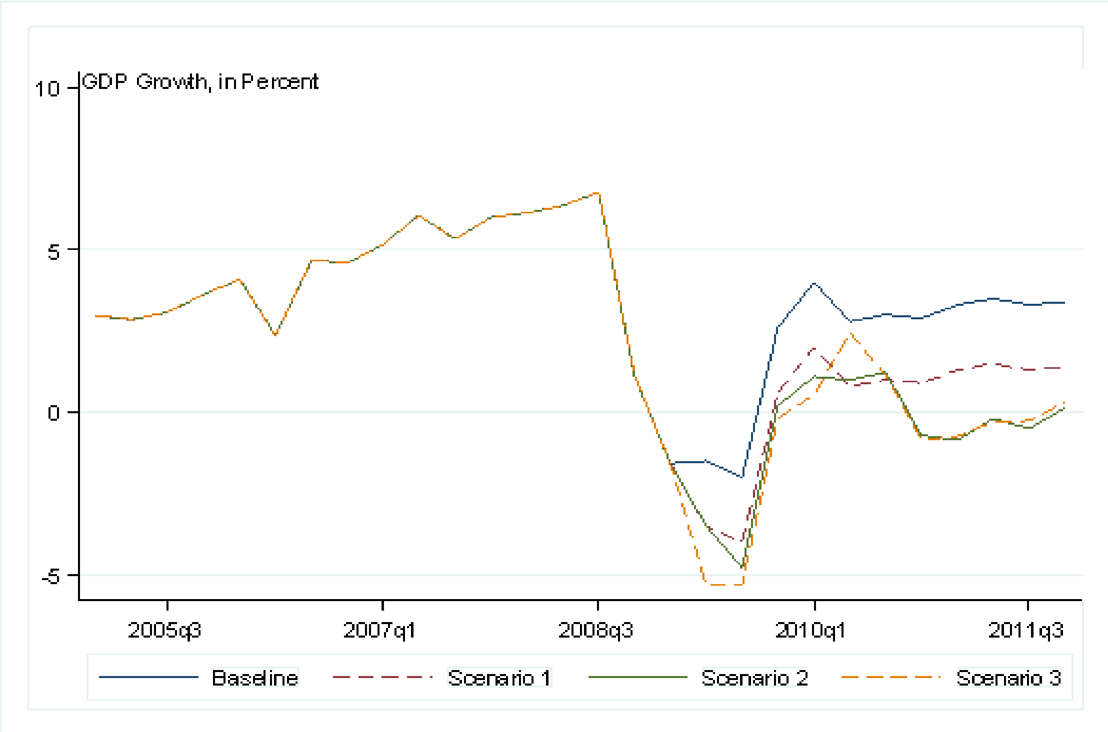
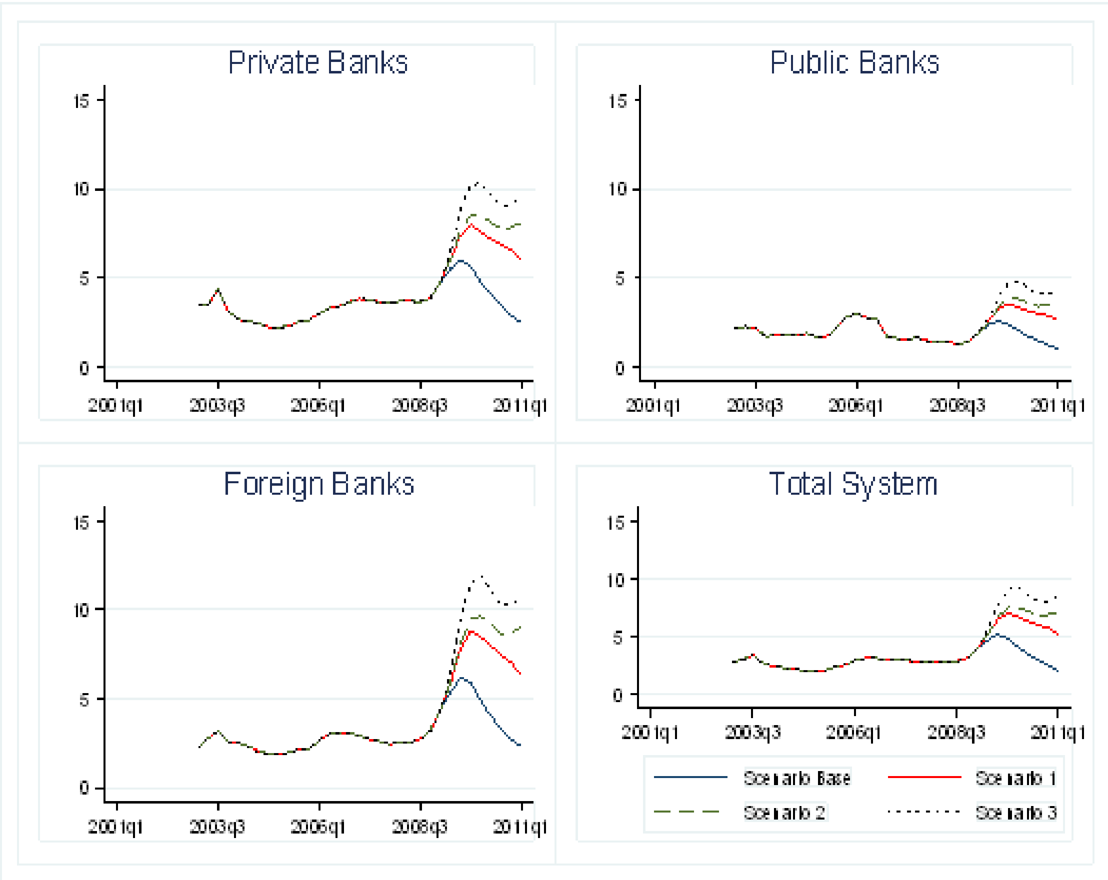


Figure 4: Evolution of NPLs Under Alternative Scenarios, In Percent



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