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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 sector based on scenario analysis. We employ an original bank-level data set that splits bank credit portfolios in 21 granular categories, covering household and corporate 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 non-performing loans (NPLs) and GDP growth, with a lag response of up to three quarters. The results also indicate that the procyclical behavior of loan quality varies across credit types. This is novel in the literature and suggests that banks with larger exposures to highly procyclical credit types and economic sectors would tend to undergo sharper deterioration in the quality of their credit portfolios during an economic downturn. Lack of sufficient portfolio granularity in macro stress testing fails to capture these effects and thus introduces a source of bias that tends to underestimate the tail losses stemming from the riskier banks in a system.

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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 and the cascade of bank failures in many countries. A deep understanding of the resilience of a banking sector to adverse macroeconomic scenarios is of crucial importance for the proper evaluation of systemic risk and has a direct connection with the development of new regulatory and prudential tools.

This paper describes a model to conduct macro stress test of credit risk for the Brazilian banking sector based on scenario analysis. The proposed framework comprises three independent, yet complementary modules that are combined in sequence. The first module uses 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 non-performing loans (NPLs) to GDP growth, and uses the results to simulate the evolution of credit quality for individual banks and credit types under distressed scenarios.[1] This module exploits a rich database that tracks the evolution of NPLs for 78 individual banks and 21 categories of credit for the 2001–2009 period.[2] 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 (gross loans) portfolios to estimate tail credit losses, using a credit value-at-risk (VaR) framework.

This paper makes three main contributions to the literature on stress testing. First, it exploits a rich partition of bank credit portfolios by borrower types (i.e., consumer versus corporates) and economic sectors, and assesses the extent of differences in the sensitivity of credit quality to macroeconomic conditions across credit types. Second, it illustrates that macro stress test models based

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[1] Non-performing loans (NPLs) for each credit type are computed as the ratio of loans past due in excess of 90 days relative to the total loans in the corresponding category.

[2] 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 cover virtually all the bank credit to the private sector under market conditions. This represents about (2/3) of total bank credit, due to the exclusion of credit operations granted under statutory conditions (the so-called directed lending).

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on insufficiently granular data on banks' credit portfolios may be biased in a material way. In particular, macroeconomic stress test models based on undifferentiated credit data may tend to underestimate the credit losses stemming from the highly procyclical credit types (and overestimate the losses associated with the relatively safer credit types). To the extent that the composition of bank credit portfolios varies across institutions, the use of insufficiently granular credit data would tend to underestimate the tail losses of riskier banks, which runs against prudent principles. Third, we present and discuss the results for the Brazilian banking system, which is one of the largest banking systems in Latin America.

The results corroborate the presence of a strong procyclical behavior of credit quality, as indicated by a robust negative relationship between (the logit transformation of) NPLs and GDP growth, with a lag response of up to three quarters. Comparative static exercises indicate that a 2 percentage point drop in yearly GDP growth, which is akin to the maximum drop observed in Brazil during 1996–2008, would cause a twofold 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, with no statistically significant differences across state-owned (public) and private banks, suggesting that the results are not due to likely differences in credit origination practices across these two types of banks.[3] At the same time, some credit types appeared to be more sensitive to changes in economic activity, particularly agriculture, sugar and alcohol, livestock, small consumer credit, and textile. Consequently, the quality of these credit types would likely undergo more severe erosion under a protracted drop in economic activity. Banks with higher exposures to these credit types may need to be followed up more closely.

Overall, the stress tests suggest that the Brazilian banking sector 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 peak to 6.7 percent in the fourth quarter of 2010, before recovering. The simulated NPLs for the distressed scenarios are higher than for the baseline. The more severe deterioration in credit quality is associated with a slowdown in GDP growth akin to two standard deviations below its 2001–09 mean, with overall NPLs reaching a maximum of 8.5 percent, which is about a twofold increase from their starting levels.

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

Since the seminal works of Wilson (1997a,b), which present a framework to examine credit risk under distressed macroeconomic conditions, several papers have applied macro stress test tools to assess the resilience of various banking systems to adverse macroeconomic shocks (Gerlach et al., 2003; Pesola, 2001, 2005; Frøyland and Larsen, 2002; Barnhill et al., 2006; Misina and Tessier, 2007; Berkowitz, 1999; van den End et al., 2006; Hoggarth and Whitley, 2003; Boss et al., 2007; Virolainen, 2004; Sorge, 2004, among others).[4] In this literature, the main objective is to gauge the vulnerability of a portfolio (market, credit, or both) to adverse macroeconomic scenarios, or to extreme but plausible events or shocks. The objective of such tests is to make risks more transparent, assessing the potential losses of a given portfolio under abnormal markets. These tools are commonly used by financial institutions as part of their internal models and management systems and to inform decisions regarding risk taking and capital allocation. In addition, these tools have become increasingly more used by financial regulators to evaluate the soundness of the financial systems under their control.

Typically, macro stress tests of credit risk involve three major tasks. First, the development of a model to capture the interrelationships between selected macroeconomic and financial variables. Second, the calibration of parameter vectors linking macroeconomic and financial variables to specific measures of loan performance. Third, the design of adverse macroeconomic scenarios, and the computation of their impact on credit quality and banks' solvency. Usually, the macroeconomic variables used in stress test models include measures of economic activity (i.e., GDP growth, the output gap, and unemployment), and measures of monetary conditions and key prices (i.e., interest rate, exchange rate, inflation, money growth and property prices).

The investigation of how adverse scenarios may impact asset quality and solvency in the banking sector can be done using two approaches: top-down or bottom-up. The first one builds on aggregated data on bank credit portfolios, sometimes split by credit types or economic sectors, and simulates evolution of aggregated credit quality under distressed macro scenarios with the help of time series analysis (see for example Virolainen, 2004; Wong et al., 2006). A key shortcoming of this approach is its limited capacity to assess the financial conditions of individual institutions, which are frequently the focus of the analysis. The bottom-up approach addresses this shortcoming by resorting to the use of bank-level data.[5] Typically, models based on this approach use panel data econometrics to gauge the evolution of asset quality under distressed macroeconomic scenarios, and the results are then mapped into banks' solvency and aggregated to get a systemic picture. Possibly due to data constraints, however, bottom-up models fail to exploit granular data on the characteristics of individual banks' credit portfolios (i.e., portfolio concentration and loan performance by credit types).[6]

Our paper contributes to this literature by presenting a macro stress test model of credit risk that combines the use of bank-level information, with a granular partition of banks' credit portfolios

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[3] Recent literature for the Brazilian banking system suggests that there may be important differences across banks due to ownership (Staub et al., 2010; Tabak and Staub, 2007; Tabak et al., forthcoming; Tecles and Tabak, 2010).

[4] See Sorge and Virolainen (2006) for an overview of stress test methodologies. See also Illing and Liu (2006), Blank et al. (2009), Rodriguez and Trucharte (2007), Castrén et al. (2010) and Cardarelli et al. (2011). Foglia (2009) provides a very interesting review of current approaches to stress testing employed by supervisory authorities.

[5] An example is Duellmann and Erdelmeier (2009) which stress-test the credit portfolio of German banks using a different approach (Merton-type multi-factor credit risk model) from ours. The authors show that it is crucial to capture credit risk dependencies between sectors. The focus is on the automobile sector (key sector) and its interdependencies with other sectors.

[6] There is to date little research using the bottom-up approach. Interesting examples are the works of Coffinet and Lin (2010) and Coffinet et al. (2009), which perform a bottom-up stress test for French banks profitability and income subcomponents, respectively.

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