ISSN 1518-3548

BANCO CENTRAL DO BRASIL

Working Paper Series 117

An Analysis of Off-Site Supervision of Banks' Profitability, Risk and Capital Adequacy: a portfolio simulation approach applied to brazilian banks

Theodore M. Barnhill, Marcos R. Souto and Benjamin M. Tabak

September, 2006

ISSN 1518-3548
CGC 00.038.166/0001-05

Working Paper Series	Brasília	N. 117	Sep	2006	P. 1-39

Working Paper Series

Edited by Research Department (Depep) – E-mail: workingpaper@bcb.gov.br

Editor: Benjamin Miranda Tabak – E-mail: benjamin.tabak@bcb.gov.br
Editorial Assistent: Jane Sofia Moita – E-mail: jane.sofia@bcb.gov.br
Head of Research Department: Carlos Hamilton Vasconcelos Araújo – E-mail: carlos.araujo@bcb.gov.br

The Banco Central do Brasil Working Papers are all evaluated in double blind referee process.

Authorized by Afonso Sant'Anna Bevilaqua, Deputy Governor of Economic Policy.

General Control of Publications

Banco Central do Brasil

Secre/Surel/Dimep

SBS – Quadra 3 – Bloco B – Edifício-Sede – M1

Caixa Postal 8.670

70074-900 Brasília – DF – Brazil

Phones: (5561) 3414-3710 and 3414-3567

Fax: (5561) 3414-3626

E-mail: editor@bcb.gov.br

Consumer Complaints and Public Enquiries Center

Address:	Secre/Surel/Diate
	Edifício-Sede – 2º subsolo
	SBS – Quadra 3 – Zona Central
	70074-900 Brasília – DF – Brazil
Fax:	(5561) 3414-2553
Internet:	http://www.bcb.gov.br/?english

An Analysis of Off–Site Supervision of Banks' Profitability, Risk and Capital Adequacy: a portfolio simulation approach applied to brazilian banks

Theodore M. Barnhill[*]
Marcos R. Souto[**]
Benjamin M. Tabak[***]

Abstract

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

In most countries, the role of off-site bank supervision involves continuous monitoring of profitability, risk and capital adequacy. The objective of this article is to demonstrate the value of bringing together advanced modeling techniques with data on banks' assets and liabilities and credit worthiness. More specifically, we apply an integrated market and credit risk simulation methodology to a group of six hypothetical banks. We show the capacity of the methodology: (i) to simulate credit transition probabilities of default close to the historical values estimated by the Central Bank of Brazil; and (ii) to simulate asset and equity returns that are unbiased estimators of average historical returns and standard deviations. Our results also indicate that: (i) a sharp reduction in the interest rate spreads of Brazilian banks reduces bank profitability and increases the probability of default; and (ii) most banks have low probability of bankruptcy. Our position is that utilization of forward looking risk evaluation methodologies in databases, such as those developed by the Central Bank of Brazil, has significant potential as an instrument of indirect supervision to identify potential risks before they materialize.

Keywords: bank supervision; simulation portfolio approach; systemic risk; bank system.
JEL Classification: G15; G21.

[*] Professor, George Washington University – Finance Department.
[**] Economist, International Monetary Fund, and associate professor at the Fluminense Federal University. This work was completed while he was a Doctoral Student at the George Washington University.
[***] Research Department, Central Bank of Brazil. E-mail: benjamin.tabak@bcb.gov.br

1. Introduction

In light of the enormous potential economic impact of bank failures, measurement and management of bank risks is a topic of overriding importance. Forward looking risk assessment methodologies are highly valuable, since they help to identify and assess proactive measures that can be adopted to manage banks' risks before they materialize. Ideally, all of the major risks faced by banks (market, credit, liquidity, and so forth) would be integrated into a single risk measure. However, current practice calls for evaluating market risk and credit risk separately and then add them together (e.g. Basel Accord, 1998, 1996 and 2001). It is no easy task to combine such risk measurements into a single aggregate measurement of portfolio risk (Jarrow and Turnbull, 2000 and Barnhill and Maxwell, 2002). The absence of aggregate portfolio risk measurements makes it more difficult to define capital requirements, measurements of capital at risk, hedging strategies, etc. For example, Barnhill and Gleason (2002) showed that the Basel capital requirements seem to be very high for low risk banks that operate in developed countries, while they are frequently very low for banks operating in more volatile environments, such as emerging countries.

This article uses an integrated market and credit risk methodology, along with the portfolio simulation approach – PSA – to assess credit worthiness of 6 hypothetical Brazilian banks. This approach has already demonstrated that it is capable of producing reasonable results, such as in the case of South African banks (Barnhill, Papapanagiotou and Schumacher (2003)), Japanese banks (Barnhill, Papapanagiotou, and Souto (2004)) and credit transition probabilities for two major Brazilian banks (Barnhill, Souto, and Tabak (2003)).

There are several advantages in utilizing PSA, including its capacity to deal simultaneously with interest rates, exchange rates and credit risk for bank asset and liability portfolios, distributed among various sectors of the economy, regions of the country, maturities and currencies. One constraint found in the PSA methodology is that it requires a large quantity of data in order to calibrate the model.

In this study, we have utilized the Central Bank of Brazil database along with BankScope data in order to simulate returns on net worth, returns on assets and capital ratios for a group of six hypothetical banks. Aside from asset and liability distribution and operational information, the data also encompass the distribution of loans according to credit quality[1]. At the same time, a database was created with the characteristics of the 543 publicly traded Brazilian companies for which it was possible to obtain ratings. This data made it possible to estimate capital structure, systemic risk and non-systemic risk for companies according to the credit worthiness.

One important feature that needed to be captured in our simulations relates to the fact that Brazilian banks charge high interest rate spreads (resulting in an average of 51% for corporate loans and 85% for personal loans). We were unable to obtain specific information on a bank-by-bank basis with respect to these spreads. However, we propose a methodology to estimate interest rates for Brazilian banks, for varying levels of credit quality, in such a way that they will reflect the historical levels of default and net interest margin.

Aside from their high rates of interest, Brazilian banks also have a significant fraction of their assets as non-interest earning assets as well as heavy operational expenses. Our results indicate that these two characteristics may be related: at the time of this study, we conjecture that the banks could have been charging higher interest to offset these inefficiencies. In those scenarios in which banks charge (and pay) more moderate interest rate spreads, the simulated capital ratio is clearly lower.

The remainder of the article is organized as follows: section 2 reviews literature correlating credit and market risk; section 3 describes the conceptual approach - PSA - to evaluate integrated credit and market risks; in section 4, we describe how we model Brazilian banks and the macroeconomic environment in which they operate; section 5 presents and discusses the results of the simulation; finally, section 6 contains the conclusions drawn in this study.

2. Modeling credit and market risk and correlated credits

The major frameworks for pricing instruments subject to credit risk are the structural approach and the reduced-form approach. The first approach was developed by Black and Scholes (1973) and Merton (1974) who developed a theoretical formula for evaluating options under a no-arbitrage condition. They argued that all corporate

[1] Brazilian banks use a rating methodology that begins with AA, the highest level of loan quality, followed by the categories A, B, C, D, E, F, G and H, as the credit quality deteriorates. Basically, categories G and H represent loans in arrears.

liabilities could be seen as combinations of options. The reduced-form methodology was introduced by Jarrow and Turnbull (1995) with the objective of avoiding the difficulties inherent to the analysis of contingent assets, such as the absence of observable data on the value of the companies.

The KMV models, *CreditMetrics* and *CreditRisk+* are currently utilized in credit risk management. While the structural form approach is at the roots of the *CreditMetrics* and KMV systems, an actuarial approach of security mortality underlies *CreditRisk+*. In KMV, a company enters bankruptcy when its value drops below a certain threshold. This has an important advantage - it implicitly incorporates market information on the probabilities of default, by utilizing the market value of the stocks as an approximation for the value of the company. Unfortunately, some of the variables used in the KMV (for example, the value of the company) are not directly observable. Furthermore, interest rates are deterministic, a fact that limits the utility of the model when it is used in the analysis of interest sensitive instruments (Jarrow and Turnbull, 2000).

The *CreditMetrics* (J.P. Morgan and Reuters, 1996) offers a methodological alternative based on the probability of a security migrating from one credit category to another over a specific time horizon. This method is based on historical probabilities of transition and assumes that all companies with a certain level of credit quality have the same probability of default. Alternatively, *CreditRisk+* (CSFP) derives the distribution of losses of a fixed income portfolio under an environment in which the risk of default is not related to the capital structure of the companies. Taken together, these two methodologies are quite useful but they have the same limitations as the KMV - they ignore market risk and are unable to cope with non-linear products such as options (Crouhy et. al., 2000).

Other models, such as the *CreditPortfolioView* (Wilson, 1997a, 1997b), condition the probability of default to macroeconomic variables, such as unemployment and interest rates, in a multi-period framework. This methodology has the disadvantage of being based on *ad hoc* matrix transition adjustment procedures, thus casting doubts as to whether it produces a better performance than the simpler Bayesian model (Crouhy et. al., 2000).

There is ample evidence that both interest rate and credit risks must be estimated together, so as to be able to accurately price fixed income portfolios and to provide venues for hedging. Based on the 1995 Federal Reserve study that concluded that none of the bank failures that occurred in the United States could be attributed to interest rate risk, Jarrow and Deventer (1998) compared the Fabozzi approach for fixed income analysis with the high risk debt model.[2] The authors compared the performance of a hedging strategy using the two methodologies and found that the Fabozzi method eliminates approximately 40% of the risk of the hedged portfolio, in contrast to just 20% when the Merton model is used. In spite of the improved performance, the Fabozzi approach eliminates less than half of the risk, leaving an important fraction of the risk unhedged.

Longstaff and Schwartz (1995) corrected various problems of fixed income evaluation methods. They derived analytical formulas for debt with fixed and floating interest rate risk. One of the traditional limitations to the Black-Scholes-Merton approach is that the companies only enter a situation of default when they have exhausted their assets, implying lower credit spreads than currently in effect (e.g. Franks and Touros, 1989), Black and Cox (1976) generate credit spreads that are more consistent with those observed, but they also assume constant interest rates and absolute allocation priority in the case of default. Among others, Franks and Touros (1989, 1994) demonstrate that this is not the case when the companies are going through periods of financial stress.

Longstaff and Schwartz expanded the literature focusing on evaluating corporate securities with interest rate and default rate risk, allowing for the possibility of default occurring before asset depletion, with complex capital structures, multiple debt issuance and deviations from the rules of absolute priority. The authors found strong evidence that interest rates are negatively correlated with credit spreads and that this correlation has a significant impact on the properties of spreads - the spreads implicit in the model are consistent with most of the properties of those observed. In this way, this approach is able to explain why securities with similar credit qualities, but originating in different industries or sectors, can have significant differences in their spreads. The properties of

[2] Fabozzi and Fabozzi (1989) focus on interest rate levels, duration and convexity and ignore credit risk when they evaluate securities and risk.

the securities in the speculative category are quite different from those of less risky securities.

Davis and Lischka (1999) utilize a two dimensional trinomial graded method in order to evaluate convertible securities with interest rate and credit risks. They utilize three sources of uncertainty - the price of the stock, the interest rate and the credit spread. The probability of default for the next period is given by the survival rate. For purposes of simplicity and in order to avoid computational problems, market professionals and researchers have traditionally analyzed models with a maximum of two stochastic variables. In this way, Davis and Lischka consider different scenarios with a limited number of stochastic variables. In the first case, only the price of the stock is considered as stochastic, while the survival rate and the interest rate are deterministic functions of time. Then, the stocks and the short-term rate are assumed to be stochastic, while the survival rate is deterministic. Finally, all of the variables are modeled stochastically. This method results in values that are consistent with those observed in market data and can be calibrated to replicate the initial interest rate structure, but cannot be extended to include more stochastic risk factors.

One of the oldest examples of the reduced-form approach is the Jarrow and Turnbull (1995) model. In this model, the companies received a rating according to the credit class and default is modeled as a point process. Bankruptcy is exogenous and is not related to the company's assets. The advantage is that exogenous hypotheses are imposed only on observable variables. Jarrow, Lando and Turnbull (1997) extended this formulation in a model in which bankruptcy is characterized by a Markov process of finite states in the credit rating of companies. This model uses historical transition probabilities and is able to cope with different debt seniorities through the use of a wide range of recovery rates in the event of default. The process of bankruptcy of the company is assumed independently of the forward risk-free interest rate structure.

Consistent with other authors, Jarrow and Turnbull (2000) recognize that there is considerable empirical evidence that credit spread variations are negatively correlated to changes in risk-free interest rates (i.e. Duffee, 1997 or Das and Tufano, 1996). In various scenarios, they derive analytical solutions for the value of securities with credit and market risk. First, for when recovery rates are assumed to be proportional to the value of the instrument prior to default (see Duffie and Singleton, 1997). Second, under a scenario where the securities holders claim accrued interest (accumulated and unpaid) plus the face value of the securities (a highly popular hypothesis among those utilizing this method).

Barnhill and Maxwell (2002) extended the diffusion models developed by Merton (1974) and Longstaff and Schwartz (1995) to include credit and market risk. The authors propose a simulation approach that deals with the limitations of both the structural and the reduced-form approaches, specifically in the sense of coping with various correlated variables. They used a simulation approach in order to simultaneously model the correlated evolution of security credit quality, as well as the future environment (interest rate risk, interest rate spread risk and exchange rate risk) in which fixed income instruments will be evaluated. The authors state that the four sources of risk are important, with credit risk being more significant for the non-investment category of securities (speculative). This model produced reasonable transition matrices, security prices and portfolio risk measures. Given the large number of stochastic variables modeled and considering the complexity of their interrelations, there is no single analytical solution.

Bank portfolios are normally composed of large quantities of corporate and personal loans along with credits granted to the government that can be partially modeled as a security portfolio. In light of the discussion above, it is evident that both credit and market risks impact the value of bank portfolios. However, integration of these risk factors represents a significant challenge. With appropriate models, we hope to achieve more precise measurements of value and value-at-risk, since these are very important for investor portfolio managers and regulators.

3. The conceptual approach to bank risk evaluation

Given the correlated nature of market and credit risk (see Fridson et al. 1997), as discussed in the previous section, the importance of a methodology that integrates market and credit risk is evident. In approaching the problem of measuring risk, Barnhill and Maxwell (2000) developed a methodology based on diffusions in order to evaluate the Value-at-Risk (VAR) of a fixed income securities portfolio with correlated interest rates, interest rate spread, exchange rates and credit risk. Barnhill, Papapanagiotou and Schumacher (2003) extended the model to incorporate evaluation of financial institution assets and liabilities for South African banks, and Barnhill, Papapanagiotou and Souto (2004) used the same methodology in order to estimate potential losses given defaults in the Japanese financial system. Barnhill and Gleason (2002) and Barnhill and Handorf (2002) apply the PSA and compare simulated capital requirements with those demanded by the new Basel Accord. These studies demonstrated that appropriate calibration of the PSA model produces:

1. a simulated financial environment with parameters for the environmental variables within reasonable value intervals;

2. credit transition probabilities similar to those reported in historical transition probabilities;

3. simulated security prices, with credit risk near the risk levels observed on the market;

4. simulated value at risk measurements for security portfolios with values highly similar to the historical values for value at risk;

5. bank capital requirements estimates that are generally lower than the Basel capital requirements for banks operating in developing countries and higher for banks operating in emerging countries.

In general, both the future financial environment in which the assets will be evaluated and the credit rating of the specific loans are simulated. The financial environment can be represented by any number of correlated random variables. Evolution of the market value of the company's equity, its debt ratio and its credit rating are simulated in the context of the financial environment created. The structure of the methodology is to select a period of time in which the stochastic variables can vary as correlated random processes. The specific returns of the companies (differently from the aggregate indices, such as the index of an economic sector or of the real estate sector) and rates of recovery in the event of default are assumed not to be correlated among themselves or with other random variables. For each simulation, a new financial environment (correlated interest rate forward structures, exchange rate, stock market returns, real estate sector index returns), along with specific debt ratios of the companies, credit ratings and recovery rates in the event of default are generated. This information makes it possible for the correlated values of the financial assets (including stocks and investments in the real estate sector) to be estimated and, following a large number of simulations, to construct the portfolio's value distribution.

4. Simulating Brazilian banks

4.1 Modeling the macroeconomic environment in which Brazilian banks operate

In the proposed simulation model, a point of central importance is to characterize the financial and macroeconomic environment in which the banks operate. As discussed in section 3, the variables that define the macroeconomic scenario are updated according to correlated stochastic processes, utilizing the Monte Carlo simulation. Consequently, one must specify as reasonably as possible the initial conditions from which the simulated stochastic processes will evolve.

For the purpose of this analysis, several variables were selected that, in our opinion, will have a specific influence on the simulated banks' portfolio. These variables are[3]: short-term domestic interest rates (Central Bank benchmark rate), short-term USA interest rate (three-month American treasury rate), exchange rate R$/US$ – bid), domestic inflation, oil (Brent-type crude), broad market index of Brazil (Ibovespa), twelve Brazilian sectoral indices[4] (banks, basic industry, beverages, chemicals, general industry, metal, mining, oil, paper, wireless telecommunications, textiles, tobacco and utilities) and seasonally adjusted unemployment rates, broken down by geographic region[5] (Brazil, Belo Horizonte, Porto Alegre, Recife, Rio de Janeiro, Salvador, São Paulo).

The volatilities and correlations for the variables cited above were assumed to follow an IGARCH process as defined by the Exponentially Weighted Moving Averages (EWMA). The initial volatilities and correlations were estimated for the first six months of 2000. The results of EWMA volatilities and correlations on July 25, 2002 are presented in tables 1 and 2.

---

[3] The short-term Brazilian interest rate (daily), the rate of exchange (daily), inflation (monthly) and gold (daily) were obtained on the basis of Central Bank of Brazil data. The market indices (daily) and stock indices (daily) were obtained from the *DataStream*. The seasonally adjusted unemployment rate was obtained from the Brazilian Institute of Geography and Statistics (IBGE). We obtained the daily time series for United States short-term interest rates on the web site of the Federal Reserve Bank of St. Louis. Daily Brent-type crude oil data were downloaded from the International Petroleum Exchange (and converted into US dollars per barrel).

[4] The definition of the sectors can be found in the *DataStream*.

[5] The correlation between unemployment rates and other variables will be particularly important to the simulation of the values of consumer loans (individuals).

The Brazilian government interest rate is quite volatile - annualized standard deviation of 3.29%. Exchange rate volatility is also high, 15.85%, and the period in question does not include changes in the exchange market during the pre-electoral period (August/September 2002). Stock market indices have also been highly volatile, in the range of approximately 22%-49%, and are compatible with other emerging markets.

In terms of correlations, we observed an expected negative relation between domestic interest rates and market indices (-0.063 between the BR interest rate and Ibovespa). However, the magnitude of the correlation is not as strong as in other markets. The domestic interest rate is correlated to the rate of exchange (0.028), though the correlation is not strong. This suggests that, in the period in question, the rate of interest tends to increase (decrease), when the real depreciates (appreciates) in relation to the American dollar.

4.2 Estimating betas for a set of Brazilian companies

We utilized the one factor CAPM model[6] in order to evaluate market risk of corporate loans held in the banks' portfolio. To do this, one must appropriately estimate the specific and systemic risk of Brazilian companies. Estimation of the beta of Brazilian companies is made more difficult by the fact that some of them are not frequently traded. Since some stocks do not have liquidity, price series are artificially rigid and this can reduce the estimated betas, yielding erroneous empirical evidence.

Based on the use of the twelve sectoral stock market indices for Brazil (banks, basic industry, beverages, chemicals, general industry, metal, mining, oil, paper, wireless telecommunications, textiles, tobacco and utilities), betas for 543 companies were estimated according to their respective industrial sectors[7]. Data on price indices and stocks were gathered from *DataStream*. We assumed that the credit risk profile of the companies used will be representative of the borrowers of credits in the banks' portfolios.

[6] We opted for the one factor CAPM model due to its simplicity and intuition in the risk-return ratio. Multiple factor models can also be used.

[7] Estimating betas through the use of sectoral indices instead of market indices makes it possible to perceive the benefits of diversification, since banks lend to different sectors of the economy.

Initial estimates based on daily data resulted in a large number of betas close to zero. To get around this problem, several attempts were made to estimate the betas using: (i) monthly observations; (ii) the Scholes-Williams (1977) approach; and (iii) non-leveraged betas such as that defined in the expression below:

$$\beta_U = \frac{\beta_L}{1+(1-\tau_c)\frac{D}{S}}, \qquad (1)$$

in which β_U is the non-leveraged beta, β_L is the leveraged beta, τ_C is the tax rate, D represents the market value of the debt and S is the market value of the equity.

Monthly observations produced estimates that were more consistent with the betas, when one considers the financial characteristics of the Brazilian companies (we obtained values in the range of 0.032 to 1.497). The final results for the betas, specific risk of the companies and their respective ratings are presented in table 3.

Table 3 also presents information on the debt/company value ratio for each credit category. This information was developed initially by calculating the debt/company value ratio of all of the publicly traded companies in Brazil followed by an analysis of the distribution of these ratios by credit rating[8]. As a further refinement of the calibration of this model, a series of simulations was developed to identify the target, the upper and lower limits of the debt/company value ratios. Both registered declines in the values observed for the debt/value ratios for each credit category and produced credit transition probabilities similar to those observed in the period of 2000 to 2001 and 2001 to 2002. The target was considered as being the current (and planned) value of the debt/company value ratio. The upper and lower limits are presented in table 3 and represent the debt ratios based upon which the companies would shift to a higher/lower credit rating. Consequently, for example, in the case of level B companies, they would drop to category C when their debt ratios increased to more than 0.90. These results are

[8] The banks supplied the information on the ratings of companies directly to the Central Bank of Brazil. For reasons of confidentiality, these data can not be presented. The information on the debt/company value ratio was obtained from *Economática*.

consistent with the theory: credit risk rating deteriorates when the systematic and nonsystematic risk components increased and when the debt/value ratio increases.

4.3 Distribution of loan quality

Loans to individuals and corporate entities represent a major share of Brazilian bank assets[9]. Consequently, when we model a bank portfolio, the first step must be a definition of the distribution of the loan portfolio.

To simplify this, we modeled loans to individuals exactly in the same way we modeled corporate loans[10]. We show that this hypothesis is quite reasonable and we produce a simulated credit transition matrix that is quite close to the historical series estimated by the Central Bank of Brazil Risk Bureau.

It is important to mention that the Central Bank of Brazil utilizes a credit risk scale different from that used by Moody's or Standard & Poor's. Credit ratings in Brazil are divided into the following categories ranging from high-quality credits down to lower credit quality categories: AA, A, B, C, D, E, F, G and H. Categories AA and A correspond to investment grade, while categories G and H represent loans in default.

Tables 4 and 5 show the aggregate distribution of loans to corporate entities among the different industrial sectors and broken down by credit risk for six hypothetical banks.

4.4 Credit transition matrix

Once the betas were estimated and distributed according to the credit categories, we estimated the transition probability matrix. For each simulation, we estimated market index returns, assuming prices to follow a geometric Brownian motion and estimated new equity values based on the Capital Asset Pricing Model (CAPM). These returns are then utilized to estimate the distribution of future values of equity and debt/value ratios. The debt/value ratios are then transformed into credit ratings, according to the calibrations presented in table 3[11]. Finally, a distributional analysis is

---

[9] In some cases, more than 56% of total assets.

[10] In the context of the simulation, the value of each corporate loan is calculated discounting future cash flows with simulated interest rates corresponding to the simulated credit rating of each corporate client. In the event of default, payment of the loan is given by the net recovery value of transaction costs.

[11] This methodology assumes a deterministic relation between the proportion of debt of a company and its rating which, in an environment of contingent claims, is equivalent to assuming that the volatility of the company's value is constant.

used to generate transition probabilities to each credit rating. We present the results of this analysis in table 6, along with the historical transition probabilities matrix (estimated by the Risk Bureau and presented in table 7). As is shown, the two transition probabilities matrices are quite similar. For example, in table 8, the median absolute difference between the two transition matrices is 0.0002, while the maximum absolute difference never exceeds 0.1060, and the simulated default rates for each credit risk category are similar to those historically reported. This is an important result in the analysis, since it supports our belief that the simulations will produce reasonable estimates for banks' capital ratios.

4.5 Balance Sheet

In table 9, we present a simplified version of the six banks analyzed in this article. These banks have one common characteristic: a significant fraction of their non-interest earning assets which is a factor that, obviously, can erode banking efficiency. However, the banks are highly heterogeneous with regard to the distribution of their assets. We present the average, minimum and maximum values.

4.6 Structure of asset and liability maturities

We were unable to obtain more detailed information on the maturity of bank assets and liabilities. Nonetheless, we obtained information for bank 4, which was then utilized as the standard for the remaining banks simulated in this study. For this bank, mostly all liabilities and assets are short-term (one-year maturity or less).

4.7 Interest rate spreads

In December 2002, the benchmark interest rate (Selic) was 24%[12] per year. At the same time, the average yields for corporate and personal loans were approximately 51% and 85%, respectively. Even considering default rates on personal and corporate loans, spreads were very large.

Ideally, we would have good estimates of the spreads that each bank charges for each credit category. Unfortunately, we have been unable to obtain precise data on banking spreads. For this reason, we estimated the interest rate spreads for the different credit categories using information on banks' net interest margin. In the first place, we estimated average losses in each credit category as a product of the historical default rate and of the rate of losses given default. For example, for class AA corporate loans, the default rate in one year is 0.68%, with an assumed loss rate of 85% or, in other words, banks have been highly successful in recovering 15% of the value of the loans, resulting in an average loss on defaults of 0.58% (0.68% times 0.85). To the average loss given defaults, we then add spread that is proportional to stylized spread profiles observed in United States banking industry, across different risk categories[13]. For the AA category, the additional risk spread measured by the United States spread would be 0.0013x. For category A, the additional risk spread would be 0.005x, etc., with knowledge of the percentage of loans in each rating category. With this, one can resolve the value of x, which produces an average rate of 51% for corporate loans and 85% for individual loans. This additional spread is 5.01% in the case of category AA corporate loans. The total interest spread will then be the sum of two components 0.58 + 0.01 = 5.59% for AA loans. This procedure produced the distribution of banking spreads presented in table 10. It is important to stress that, though this procedure is somewhat arbitrary, it did produce interest rate spreads for the various credit categories that are quite close to those observed in Brazilian banks, according to data released by the Off-Site Supervision and Information Management Department, at the Brazilian Central Bank.

Finally, we had the interest rate margins for each bank drawn from *BankScope*. Consequently, a final adjustment was made for each bank so that the market spreads would produce net interest rate margins consistent with those reported by *BankScope*.

5. Simulation results

In order to investigate future profitability, risk and capital adequacy of the six banks simulated in this study, we constructed two major scenarios in which we assume that the banks operate: (i) in a scenario of high interest rates, in which banks charge interest rates as estimated in the previous section; and (ii) in a scenario of low interest rates in which banks charge (and pay) 60% of the rates in the high interest scenario. Capital ratios are simulated over a one–year horizon. The results of this simulation are presented in table 10.

---

[12] Inflation in the same period of time was approximately 10%. Consequently real interest rates were close to 14%.
[13] For example, we assume that United States banks would charge an average of 0.13%, comparable to category AA, 0.50% for level A and so forth (table 9).

5.1 Bank profitability in a scenario of high interest rates

PSA makes it possible to simulate the distribution of returns on assets and equity (ROA and ROE, respectively) given the hypotheses regarding the volatility of the macroeconomic and financial environment, credit quality of the bank portfolios, etc.. An important question is just how reliable and useful are these estimates of profitability. To examine this question, we would like to study whether the simulated averages and standard deviations of the returns explain the historical averages and standard deviations for the same six banks. The historical returns of these banks were calculated for the period extending from 1998 to 2002.

Table 11 presents the degree of adjustment of the regressions to ROE and ROA. The average historical returns are compared to the simulated returns. We use the simulated returns as an explanatory variable for the historical returns. The null hypothesis consists in that the returns simulated by the PSA model can explain the historical returns. With this, the following regressions were made:

$$mean\_historical\_ROE = \alpha + \beta mean\_simulated\_ROE + \varepsilon \qquad (2)$$

$$mean\_historical\_ROA = \alpha + \beta mean\_simulated\_ROA + \varepsilon \qquad (3)$$

$$std\_historical\_ROE = \alpha + \beta std\_simulated\_ROE + \varepsilon \qquad (4)$$

$$std\_historical\_ROA = \alpha + \beta std\_simulated\_ROA + \varepsilon \qquad (5)$$

in which *std* refers to the standard deviation, *mean*, to the average, and *historical* and *simulated* refer to the historical and simulated values, respectively.

Table 11 presents adjusted R^2 for these regressions, which result in a measurement of the degree of adjustment of the regressions. The adjusted R^2 are high for both regressions, ROE and ROA, for means and standard deviations. The simulated ROE and ROA are not biased if one is unable to reject the hypothesis that $\alpha = 0$ e $\beta = 1$ is true. Wald's statistics in the last column suggest that this hypothesis is not true only for the regression to the ROA mean. However when all the observations are utilized, increasing the degree of freedom of the regressions, we cannot reject this hypothesis.

If we utilize all of the observations (24 observations), the beta coefficient is 0.97 with an adjusted R^2 of 81.13%. These results suggest that the means and standard deviations of the simulated ROE and ROA are quite close to the historically observed values, illustrating that the PSA performs quite well in replicating real observed data. When we consider this result, we must remember that the six banks have a wide variety of asset and liability structures, distributions of credit quality and historical profitability.

5.2 Bank risk and capital adequacy in a scenario of high interest rates

Table 12 presents an analysis of the one-year ahead distribution of simulated capital ratios for the two alternative scenarios. In the high interest rate scenario, the average simulated capital ratio is consistently above the initial values. This should not come as a surprise, considering the values of interest rate spreads in Brazil and the quality of the credit portfolios of these banks. We also noted that the standard deviation of the simulated proportions of capital varied greatly: from 0.008 for banks 2 and 3 to 0.023 for banks 6. These variations reflect the asset and liability structures of the banks as well as the quality of the credits in question. In general, we found that when sovereign risk is not considered, the six banks have low probability of default in the scenario of high interest rates. More specifically, none of these banks have simulated capital below 2% at a 99% confidence level. Only two banks have capital below 3% at the 99% confidence level. This analysis suggests that the simulated banks are generally well-capitalized.

One important characteristic of this methodology is that it generates quantitative measurements of risk for each bank on a consistent basis (i.e., the same hypotheses in relation to the economic and financial environment, consistent treatment of correlated market and credit risk, consistent treatment of the effects of portfolio diversification, consistent treatment of credit risk, and so forth). Consequently, the relative risk and capital adequacy of the banks can be evaluated directly from the quantitative results of the simulation. It is also important to observe that the analysis was carried out through the use of data systematically collected by the Credit Risk Bureau and other public sources. Therefore, there is no reason why this process should not be automated and applied to all Brazilian banks with the frequency considered most useful. Once again, this type of analysis is sensitive to alterations in the financial environment and to volatility, changes in bank assets and liabilities (for example, exchange exposure, interest rate exposure), changes in the diversification or concentration of portfolios and changes in the quality of credits.

6. Conclusions

This article presents a simulation methodology - the portfolio simulation approach (PSA) - that makes it possible to model integrated market and credit risk in bank assets and liabilities. Our argument is that this methodology has several advantages in relation to theoretical models (for example, the possibility of modeling bank portfolios) and to ad hoc methodologies, such as that of the Basel Accord (1988, 1996, 2001) (for example, the role of integrated market and credit risk). We argue that this simulation methodology has significant capacity for analyzing credit risk. For example, the simulated credit transition matrix is quite close to that estimated by the Risk Bureau. Furthermore, the simulated bank returns are unbiased predictors of historical returns (both averages and standard deviations).

Our simulations indicate that interest rate spreads in Brazil more than offset typical losses in credit portfolios. Consequently, Brazilian banks in general are highly profitable and have low probability of default, despite the fact that significant resources are invested in assets that do not generate income.

It is our belief that such a forward looking methodology as PSA, taken along with systematically collected databases, makes it possible for indirect supervision to perform quantitative risk evaluations consistent with bank profitability and risk and capital adequacy for all banks. We believe that these opportunities would be available to those countries that opt to systematically collect the data required for this type of analysis.

References

Barnhill, T., Papapanagiotou, P., Souto, M., 2004. "Preemptive Strategies for the Assessment and Management of Financial System Risk Levels: an Application to Japan with Implications for Emerging Economies", Review of Pacific Basin Financial Markets and Policies, forthcoming.

Barnhill, T., Papapanagiotou, P., Schumacher, L., 2003. "Measuring Integrated Market and Credit Risk in Bank Portfolios: an Application to a Set of Hypothetical Banks Operating in South Africa", Journal of Financial Markets, Institutions, and Instruments, forthcoming.

Barnhill, T. and G. Kopits, 2003, "Assessing Fiscal Sustainability Under Uncertainty". IMF Working Paper WP/03/79.

Barnhill, T., M. Souto, and B. Tabak, 2003, "Modeling Business Loan Credit Risk in Brazil", Financial Stability Report 2 (1), 159-174.

Barnhill, T., Gleason K., 2002. "The New Basel Capital Accord: The Crucial Importance of a Conceptual Framework", Working Paper, George Washington University.

Barnhill, T., Maxwell, W., 2002. "Modeling correlated interest rate, exchange rate, and credit risk in fixed income portfolios". Journal of Banking and Finance 26, 347-374.

Basel Committee on Banking Supervision, 1988. International Convergence of Capital Measurement and Capital Standards, Bank for International Settlements, July, Basel, Switzerland.

Basel Committee on Banking Supervision, 1996. Amendment to the Capital Accord to Incorporate Market Risks, Bank for International Settlements, January, Basel, Switzerland.

Basel Committee on Banking Supervision, 2001. The New Basel Capital Accord, Bank for International Settlements, January, Basel, Switzerland.

Black, F. and Cox, J., 1976. "Valuing corporate securities: some effects of bond indenture provisions", Journal of Finance, no. 31, pp. 351-367.

Black, F., Scholes, M., 1973. "The pricing of options and corporate liabilities". Journal of Political Economy 81, 637-659.

Crouhy, M., Galai D. and Mark, R., 2000. "A comparative analysis of credit risk models", Journal of Banking and Finance, no. 24, pp. 59-117.

Das, S.R. and Tufano, P., 1996. "Pricing credit sensitive debt when interest rates, credit ratings and credit spreads are stochastic", Journal of Financial Engineering, no. 5, pp. 493-526.

Davis, M. and Lischka, F., 1999. "Convertible bonds with market and credit risk", Tokio-Mitsubishi International PLC working paper.

Duffie, G.R., 1997. “The relationship between Treasury yields and corporate bond yield spreads”, Journal of Finance, no. 53, pp. 2225-2241.

Duffie, D. and Singleton, K., 1997. “An econometric model of the term structure of interest rate swap yields”, Journal of Finance, no. 52, pp. 1287-1321.

Fabozzi, F. and Fabozzi, T., 1989. Bond Markets, Analysis and Strategies, Prentice Hall

Franks, J.R. and Touros, W., 1989. “An empirical investigation of US firms in reorganization”, Journal of Finance, no. 44, pp. 747-769.

Franks, J.R. and Touros, W., 1994. “A comparison of financial recontracting in distressed exchanges and Chapter 11 reorganizations”, Journal of Financial Economics, no. 27, pp. 315-354.

Fridson, M., Garman, C., Wu, S., 1997. “Real interest rates and the default rates on high-yield bonds”. Journal of Fixed Income 7, 27-34.

Jarrow, R.A. and Turnbull, S.M., 1995. “The pricing and hedging of options on financial securities subject to credit risk”, Journal of Finance, no. 50, pp. 53-85.

Jarrow, R.A. and Turnbull, S.M., 2000. “The intersection of market and credit risk”, Journal of Banking and Finance, no. 24, pp. 271-229.

Jarrow, R.A., Lando, D. and Turnbull, S.M., 1997. “A Markov model for the term structure of credit risk spreads”, Review of Financial Studies, no. 10, pp. 481-523.

J. P. Morgan and Reuters, 1996, Risk Metrics™ - Technical Document, New York, Fourth Edition.

Longstaff, F.A. and Schwartz, E.S., 1995. "A simple approach to valuing risky fixed and floating rate debt", Journal of Finance, no. 50, pp. 789-819.

Merton, R., 1974. “On the pricing of corporate debt: the risk structure of interest rates”. Journal of Finance 29, 449-470.

Rochet, J.-C., and Tirole, J., 1996. “Inter-bank Lending and Systemic Risk”. Journal of Money, Credit, and Banking 28 (4). 733-762.

Scholes, M., and J. Williams, 1977. “Estimating Betas from Nonsynchronous Data”, Journal of Financial Economics 5, 309-327.

Wilson, T., 1997a. Portfolio Credit Risk I. Risk 10(9), September

Wilson, T., 1997b. Portfolio Credit Risk II. Risk 10(9), October

Table 1 - EWMA Volatilities

BRrate	3.29%	Beverage	31.10%	Tobac	48.57%
USrate	0.18%	Chemicals	30.69%	Utility	33.90%
FXrate	15.85%	GenInd	22.09%	URBH	20.02%
BR c.p.i.	2.47%	Metal	30.48%	URPA	23.10%
Oil	26.51%	Mining	23.51%	URRE	22.49%
Gold	24.51%	OilSec	49.20%	URRJ	22.00%
Ibovespa	39.11%	Paper	30.61%	URSA	16.69%
Banks	37.42%	TlWire	34.12%	URSP	16.78%
BasicInd	26.03%	Text	40.42%	URBR	11.19%

Volatilities for a set of Brazilian financial and macroeconomic variables were estimated via exponentially weighted moving average (RiskMetricsTM) methodology, as of 07/25/2002. The values are annualized and presented in percentages. BR rate is the Brazilian short-term interest rate (Brazilian Central Bank referential interest rate), US rate is the 3-Month U.S. Treasury Constant Maturity Rate, FX rate is the foreign exchange rate (Brazilian currency, R$, over US$), BR c.p.i. is the Brazilian consumer price index, oil represents the Brent crude oil as quoted in the International Petroleum Exchange, Ibovespa is the Brazilian broad market index, which is followed by Brazilian equity market indices by sectors (as defined in DataStream): Banks, BasicInd (Basic Industry), Beverage, Chemicals, GenInd (General Industry), Metal, Mining, Oil_Sec (Oil Equity Sector), Paper, Telewire (Telecommunications Wireless), Textile, Tobacco, and Utility. URBH, URPA, URRE, URRJ, URSA, URSP, are the seasonally adjusted unemployment rates for the cities of Belo Horizonte, Porto Alegre, Recife, Rio de Janeiro, and São Paulo respectively and URBR is the seasonally adjusted unemployment rate for Brazil.

Table 2a. EWMA correlations

Table 2a

	BRrate	USrate	FXrate	Brcpi	Oil	Gold	Ibov	Banks	BasInd	Bev	Chem	GenInd	Metal	Mining
BRrate	1	-0.064	0.028	-0.036	0.017	-0.063	-0.095	-0.091	-0.132	0.051	-0.080	-0.080	-0.122	0.075
USrate		1	-0.042	0.046	0.002	-0.165	0.079	-0.037	0.086	0.010	0.053	0.166	0.157	-0.089
FXrate			1	-0.035	0.050	0.541	-0.336	-0.508	-0.041	-0.201	-0.229	-0.258	-0.106	-0.027
Brcpi				1	-0.108	-0.058	-0.172	0.039	0.006	-0.030	-0.366	-0.093	0.102	-0.021
Oil					1	-0.023	0.360	0.274	0.240	0.165	0.363	0.225	0.200	0.049
Gold						1	-0.640	-0.462	-0.278	-0.395	-0.255	-0.284	-0.347	0.009
Ibov							1	0.745	0.673	0.602	0.449	0.564	0.684	0.171
Banks								1	0.418	0.634	0.386	0.463	0.420	0.170
BasInd									1	0.581	0.313	0.665	0.934	0.259
Bev										1	0.166	0.315	0.490	0.041
Chem											1	0.420	0.256	0.478
GenInd												1	0.670	0.332
Metal													1	0.196
Mining														1
OilSec														
Paper														
TIWire														
Text														
Tobac														
Utility														
URBH														
URPA														
URRE														
URRJ														
URSA														
URSP														
URBR														

Table 2b. EWMA correlations

Table 2b

	OilSec	Paper	TlWire	Text	Tobac	Utility	URBH	URPA	URRE	URRJ	URSA	URSP	URBR
BRrate	0.009	-0.002	-0.181	-0.008	-0.058	-0.086	0.279	-0.087	-0.024	0.215	-0.197	0.106	0.007
USrate	-0.038	-0.070	-0.039	0.124	-0.368	0.027	0.123	0.079	-0.133	0.303	-0.002	0.101	0.230
FXrate	-0.129	0.099	-0.237	-0.145	-0.333	-0.319	0.457	-0.364	-0.098	0.153	-0.169	0.111	-0.075
Brcpi	-0.093	-0.044	-0.141	-0.128	-0.064	0.048	-0.013	0.105	0.223	0.110	-0.085	-0.072	-0.060
Oil	0.486	0.224	0.249	-0.060	0.172	0.308	0.283	-0.141	-0.040	-0.036	-0.221	-0.086	-0.120
Gold	-0.302	-0.058	-0.599	-0.425	-0.176	-0.644	0.487	-0.401	-0.097	0.077	-0.135	0.132	-0.067
Ibov	0.763	0.435	0.857	0.377	0.323	0.930	0.065	-0.100	-0.123	0.199	-0.169	0.069	-0.054
Banks	0.550	0.267	0.527	0.282	0.507	0.647	-0.195	0.132	0.082	0.087	0.030	-0.135	-0.083
BasInd	0.624	0.812	0.544	0.442	0.233	0.610	0.295	-0.414	-0.178	0.256	-0.210	0.321	0.102
Bev	0.610	0.560	0.449	0.132	0.359	0.503	0.067	-0.118	-0.193	0.020	-0.085	-0.145	-0.273
Chem	0.438	0.227	0.266	-0.089	0.397	0.353	0.050	-0.299	0.240	0.070	-0.020	0.056	-0.040
GenInd	0.492	0.435	0.397	0.436	0.343	0.585	-0.116	0.198	-0.127	0.121	-0.018	-0.153	-0.157
Metal	0.523	0.555	0.580	0.455	0.154	0.647	-0.129	0.042	-0.256	0.134	-0.044	0.193	0.186
Mining	0.279	0.249	0.035	0.098	0.190	0.128	0.427	-0.557	0.015	0.200	-0.251	0.294	-0.001
OilSec	1	0.588	0.502	0.138	0.217	0.687	-0.020	0.068	0.008	-0.017	-0.104	0.217	0.178
Paper		1	0.317	0.302	0.275	0.355	0.514	-0.581	-0.102	0.261	-0.213	0.263	-0.016
TlWire			1	0.356	0.317	0.833	-0.291	0.226	-0.027	0.037	-0.168	-0.045	-0.126
Text				1	0.000	0.353	0.180	-0.086	-0.089	0.091	-0.346	0.015	-0.058
Tobac					1	0.315	0.246	-0.201	-0.264	0.090	-0.064	0.122	-0.063
Utility						1	-0.197	0.118	-0.251	-0.045	-0.035	-0.093	-0.119
URBH							1	-0.261	0.052	0.255	-0.399	0.246	0.251
URPA								1	-0.032	0.090	0.122	-0.234	0.092
URRE									1	-0.098	-0.297	0.005	0.086
URRJ										1	0.084	0.583	0.717
URSA											1	0.000	0.164
URSP												1	0.866
URBR													1

Table 3.

	AA	A	B	C	D	E	F	G + H
Debt ratios								
Lower bound	-	0.51	0.67	0.78	0.79	0.80	0.85	0.96
Target	0.38	0.61	0.82	0.84	0.88	0.89	0.89	0.96
Upper bound	0.53	0.78	0.90	0.92	0.93	0.93	0.95	0.96
Beta	0.67	0.85	1.00	1.10	1.20	1.30	1.36	-
Firm-specific risk	0.38	0.55	0.69	0.71	0.77	0.78	0.72	-

Table 4 – Distribution of business loans by industry sector

	Mean	Minimum	Maximum
Ibovespa	0.0552	0.0070	0.0890
Aerospace	0.0017	0.0000	0.0075
Basic ind.	0.3415	0.2936	0.4264
Chemicals	0.0416	0.0004	0.0600
Cyc. serv.	0.2734	0.2322	0.3347
Food prd	0.0809	0.0043	0.1073
Food ret	0.0520	0.0149	0.1622
Forestry	0.0160	0.0000	0.0282
Paper	0.0047	0.0000	0.0086
Mining	0.0067	0.0014	0.0125
Oil & Gas	0.0254	0.0000	0.1232
Financial	0.0120	0.0013	0.0298
Utility	0.0888	0.0418	0.1770

Table 5 – Distribution of business loans by credit quality

	AA	A	B	C	D	E	F	G + H
Mean	0.2691	0.3403	0.1793	0.1286	0.0362	0.0149	0.0088	0.0227
Minimum	0.0002	0.2351	0.0797	0.0499	0.0190	0.0007	0.0036	0.0019
Maximum	0.4158	0.5108	0.2550	0.2293	0.0616	0.0350	0.0150	0.0365

Table 6 – Estimated transition matrix, for Brazilian companies, using the PSA approach

	AA	A	B	C	D	E	F	G+H
AA	90.35%	9.65%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
A	11.40%	79.63%	8.93%	0.05%	0.00%	0.00%	0.00%	0.00%
B	0.40%	4.95%	75.33%	10.00%	3.10%	1.55%	3.45%	1.23%
C	0.15%	2.70%	12.60%	68.63%	4.88%	2.23%	5.48%	3.35%
D	0.03%	0.70%	4.45%	1.48%	61.48%	4.88%	8.85%	18.15%
E	0.00%	0.58%	3.78%	1.25%	0.85%	56.18%	10.48%	26.90%
F	0.00%	0.23%	2.33%	1.23%	0.75%	7.30%	60.38%	27.80%

Table 7 – Brazilian credit risk bureau's transition matrix (Adjusted for repayments, for two banks and weighted averaged between the periods of June 2000 to June 2001, and June 2001 to June 2002).

	AA	A	B	C	D	E	F	G+H
AA	90.08%	6.43%	2.05%	0.53%	0.18%	0.03%	0.03%	0.68%
A	11.90%	69.03%	10.15%	4.73%	2.13%	0.30%	0.43%	1.40%
B	3.28%	11.03%	71.88%	9.23%	2.00%	0.48%	0.55%	1.63%
C	3.28%	4.18%	15.25%	67.35%	4.65%	0.90%	1.33%	3.08%
D	1.08%	1.85%	4.00%	5.13%	60.20%	3.90%	5.43%	18.43%
E	0.13%	7.75%	0.53%	0.83%	4.05%	55.80%	4.03%	26.83%
F	0.78%	0.60%	1.15%	2.25%	3.10%	7.60%	56.80%	27.63%

Table 8 – Difference between simulated and historical transition matrices.

	AA	A	B	C	D	E	F	G+H
AA	0.27%	3.23%	-2.05%	-0.53%	-0.18%	-0.03%	-0.03%	-0.68%
A	-0.50%	10.60%	-1.23%	-4.68%	-2.13%	-0.30%	-0.43%	-1.40%
B	-2.88%	-6.08%	3.45%	0.78%	1.10%	1.08%	2.90%	-0.40%
C	-3.13%	-1.48%	-2.65%	1.28%	0.23%	1.33%	4.15%	0.28%
D	-1.05%	-1.15%	0.45%	-3.65%	1.28%	0.98%	3.43%	-0.28%
E	-0.13%	-7.18%	3.25%	0.43%	-3.20%	0.37%	6.45%	0.08%
F	-0.78%	-0.38%	1.18%	-1.03%	-2.35%	-0.30%	3.58%	0.18%

Table 9. Descriptive Statistics

	Mean	Min.	Max.
Liabilities			
Domestic funding	0.5694	0.5168	0.6194
Foreign funding	0.1047	0.0708	0.1768
Non-interest liability	0.0659	0.0264	0.0809
Capital and reserves	0.1185	0.0440	0.2362
Debt	0.1414	0.0383	0.2219
Total liabilities	100.00%	100.00%	100.00%
Assets			
Money	0.0336	0.0003	0.0705
Risk-free loans	0.2556	0.0226	0.5229
Business loans	0.1859	0.0002	0.3494
Consumer loans	0.1959	0.0001	0.5630
Foreign loans	0.0745	0.0000	0.1721
Equity investments	0.0096	0.0000	0.0183
Real estate investments	0.0118	0.0102	0.0146
Other assets (Non-interest)	0.2330	0.1353	0.3251
Total assets	100.00%	100.00%	100.00%
Capital ratio	0.1185	0.0440	0.2362
Operating expense ratio	-0.013	-0.020	-0.007
Tax rate	0.3400	0.3400	0.3400

Table 10a – Interest rate spreads for business' loans (High interest rate scenario)

Credit risk categories	Default rate	Loss rate	Loss rate spread	U.S. risk spread profile	Assumed risk (scaled by U.S.)	Assumed risk spread (total)
AA	0.68%	0.85	0.58%	0.13%	5.01%	5.59%
A	1.40%	0.85	1.19%	0.50%	20.04%	21.23%
B	1.63%	0.85	1.39%	0.75%	30.06%	31.45%
C	3.08%	0.85	2.62%	1.00%	40.08%	42.70%
D	18.43%	0.85	15.67%	1.50%	60.12%	75.79%
E	26.83%	0.85	22.81%	2.00%	80.16%	102.97%
F	27.63%	0.85	23.49%	2.50%	100.20%	123.69%
G + H	100.00%	0.85	85.00%	3.00%	120.24%	205.24%

Table 10b – Interest rate spreads for consumers' loans (High interest rate scenario)

Credit risk categories	Default rate	Loss rate	Loss rate spread	U.S. Risk spread profile	Assumed risk (scaled by U.S.)	Assumed risk spread (Total)
AA	0.68%	0.85	0.58%	0.13%	7.69%	8.27%
A	1.40%	0.85	1.19%	0.50%	30.76%	31.95%
B	1.63%	0.85	1.39%	0.75%	46.15%	47.53%
C	3.08%	0.85	2.62%	1.00%	61.53%	64.15%
D	18.43%	0.85	15.67%	1.50%	92.29%	107.96%
E	26.83%	0.85	22.81%	2.00%	123.06%	145.86%
F	27.63%	0.85	23.49%	2.50%	153.82%	177.31%
G + H	100.00%	0.85	85.00%	3.00%	184.58%	269.58%

Table 11 – Goodness of fit for ROE and ROA and unbiased tests

	Coefficient	Adjusted R2	Wald Statistic
Panel A: ROE Regressions			
		41.66%	0.09
Mean	0.87***		
Standard Error	(0.41)		
t Statistic	[2.14]		
Standard Deviation	1.19**	69.38%	0.7
Standard Error	0.34		
t Statistic	[3.51]		
Panel b : ROA Regressions			
Mean	1.49*	97.07%	18.10*
Standard Error	(0.12)		
t Statistic	[12.90]		
Standard Deviation	1.19***	49.47%	0.23
Standard Error	(0.49)		
t Statistic	[2.43]		
Panel c: Pool			
ROE	1.004*	63.17%	0.1294
Standard Error	(0.23)		
t Statistic	[4.46]		
ROE	1.31*	85.17%	3.71
Standard Error	(0.23)		
t Statistic	[8.01]		
All	0.97*	81.13%	0.22
Standard Error	(0.10)		
t Statistic	[9.99]		

*,** and *** correspond to the levels of significance of 1.5 and 10% repectively.

Table 12. Distribution of simulated capital ratios for the two alternative scenarios

Bank	1	1	2	2	3	3
Int. rate	High	Low	High	Low	High	Low
Mean	0.256	0.237	0.056	0.028	0.139	0.124
Std. dev.	0.011	0.013	0.008	0.012	0.008	0.009
Max	0.288	0.271	0.071	0.047	0.160	0.145
Min	0.189	0.156	-0.005	-0.049	0.097	0.072
VaR						
99%	0.227	0.196	0.028	-0.013	0.118	0.096
98%	0.231	0.203	0.033	-0.007	0.119	0.098
97%	0.233	0.206	0.037	-0.002	0.122	0.103
96%	0.235	0.209	0.039	0.001	0.123	0.104
95%	0.236	0.211	0.040	0.004	0.124	0.106
94%	0.237	0.213	0.041	0.006	0.125	0.107
93%	0.239	0.216	0.043	0.008	0.126	0.109
92%	0.240	0.217	0.044	0.010	0.127	0.111
91%	0.241	0.219	0.044	0.011	0.128	0.112
90%	0.242	0.220	0.045	0.012	0.128	0.113
75%	0.249	0.231	0.052	0.024	0.134	0.119
50%	0.256	0.238	0.057	0.032	0.140	0.125
25%	0.263	0.245	0.061	0.036	0.145	0.130
1%	0.278	0.260	0.067	0.043	0.153	0.138

Table 12b

Bank	4	4	5	5	6	6
Int. rate	High	Low	High	Low	High	Low
Mean	0.104	0.085	0.075	0.060	0.120	0.105
Std. dev.	0.010	0.012	0.014	0.017	0.023	0.026
Max	0.124	0.108	0.111	0.100	0.177	0.165
Min	0.042	0.012	0.010	-0.012	-0.007	-0.034
VaR						
99%	0.071	0.044	0.029	0.008	0.055	0.031
98%	0.077	0.050	0.039	0.019	0.063	0.039
97%	0.083	0.055	0.043	0.023	0.069	0.046
96%	0.085	0.058	0.045	0.026	0.074	0.051
95%	0.087	0.060	0.048	0.028	0.077	0.055
94%	0.088	0.062	0.050	0.031	0.081	0.059
93%	0.089	0.064	0.052	0.033	0.084	0.062
92%	0.090	0.065	0.054	0.035	0.086	0.064
91%	0.091	0.067	0.056	0.036	0.088	0.066
90%	0.091	0.068	0.056	0.037	0.090	0.068
75%	0.099	0.080	0.068	0.049	0.106	0.091
50%	0.105	0.088	0.077	0.063	0.122	0.109
25%	0.110	0.094	0.085	0.073	0.136	0.123
1%	0.119	0.103	0.099	0.088	0.162	0.150

Banco Central do Brasil

Trabalhos para Discussão

Os Trabalhos para Discussão podem ser acessados na internet, no formato PDF, no endereço: http://www.bc.gov.br

Working Paper Series

Working Papers in PDF format can be downloaded from: http://www.bc.gov.br

1	**Implementing Inflation Targeting in Brazil** *Joel Bogdanski, Alexandre Antonio Tombini and Sérgio Ribeiro da Costa Werlang*	Jul/2000
2	**Política Monetária e Supervisão do Sistema Financeiro Nacional no Banco Central do Brasil** *Eduardo Lundberg*	Jul/2000
	Monetary Policy and Banking Supervision Functions on the Central Bank *Eduardo Lundberg*	Jul/2000
3	**Private Sector Participation: a Theoretical Justification of the Brazilian Position** *Sérgio Ribeiro da Costa Werlang*	Jul/2000
4	**An Information Theory Approach to the Aggregation of Log-Linear Models** *Pedro H. Albuquerque*	Jul/2000
5	**The Pass-Through from Depreciation to Inflation: a Panel Study** *Ilan Goldfajn and Sérgio Ribeiro da Costa Werlang*	Jul/2000
6	**Optimal Interest Rate Rules in Inflation Targeting Frameworks** *José Alvaro Rodrigues Neto, Fabio Araújo and Marta Baltar J. Moreira*	Jul/2000
7	**Leading Indicators of Inflation for Brazil** *Marcelle Chauvet*	Sep/2000
8	**The Correlation Matrix of the Brazilian Central Bank's Standard Model for Interest Rate Market Risk** *José Alvaro Rodrigues Neto*	Sep/2000
9	**Estimating Exchange Market Pressure and Intervention Activity** *Emanuel-Werner Kohlscheen*	Nov/2000
10	**Análise do Financiamento Externo a uma Pequena Economia Aplicação da Teoria do Prêmio Monetário ao Caso Brasileiro: 1991–1998** *Carlos Hamilton Vasconcelos Araújo e Renato Galvão Flôres Júnior*	Mar/2001
11	**A Note on the Efficient Estimation of Inflation in Brazil** *Michael F. Bryan and Stephen G. Cecchetti*	Mar/2001
12	**A Test of Competition in Brazilian Banking** *Márcio I. Nakane*	Mar/2001

13	**Modelos de Previsão de Insolvência Bancária no Brasil** *Marcio Magalhães Janot*	Mar/2001
14	**Evaluating Core Inflation Measures for Brazil** *Francisco Marcos Rodrigues Figueiredo*	Mar/2001
15	**Is It Worth Tracking Dollar/Real Implied Volatility?** *Sandro Canesso de Andrade and Benjamin Miranda Tabak*	Mar/2001
16	**Avaliação das Projeções do Modelo Estrutural do Banco Central do Brasil para a Taxa de Variação do IPCA** *Sergio Afonso Lago Alves*	Mar/2001
	Evaluation of the Central Bank of Brazil Structural Model's Inflation Forecasts in an Inflation Targeting Framework *Sergio Afonso Lago Alves*	Jul/2001
17	**Estimando o Produto Potencial Brasileiro: uma Abordagem de Função de Produção** *Tito Nícias Teixeira da Silva Filho*	Abr/2001
	Estimating Brazilian Potential Output: a Production Function Approach *Tito Nícias Teixeira da Silva Filho*	Aug/2002
18	**A Simple Model for Inflation Targeting in Brazil** *Paulo Springer de Freitas and Marcelo Kfoury Muinhos*	Apr/2001
19	**Uncovered Interest Parity with Fundamentals: a Brazilian Exchange Rate Forecast Model** *Marcelo Kfoury Muinhos, Paulo Springer de Freitas and Fabio Araújo*	May/2001
20	**Credit Channel without the LM Curve** *Victorio Y. T. Chu and Márcio I. Nakane*	May/2001
21	**Os Impactos Econômicos da CPMF: Teoria e Evidência** *Pedro H. Albuquerque*	Jun/2001
22	**Decentralized Portfolio Management** *Paulo Coutinho and Benjamin Miranda Tabak*	Jun/2001
23	**Os Efeitos da CPMF sobre a Intermediação Financeira** *Sérgio Mikio Koyama e Márcio I. Nakane*	Jul/2001
24	**Inflation Targeting in Brazil: Shocks, Backward-Looking Prices, and IMF Conditionality** *Joel Bogdanski, Paulo Springer de Freitas, Ilan Goldfajn and Alexandre Antonio Tombini*	Aug/2001
25	**Inflation Targeting in Brazil: Reviewing Two Years of Monetary Policy 1999/00** *Pedro Fachada*	Aug/2001
26	**Inflation Targeting in an Open Financially Integrated Emerging Economy: the Case of Brazil** *Marcelo Kfoury Muinhos*	Aug/2001
27	**Complementaridade e Fungibilidade dos Fluxos de Capitais Internacionais** *Carlos Hamilton Vasconcelos Araújo e Renato Galvão Flôres Júnior*	Set/2001

28	**Regras Monetárias e Dinâmica Macroeconômica no Brasil: uma Abordagem de Expectativas Racionais** *Marco Antonio Bonomo e Ricardo D. Brito*	Nov/2001
29	**Using a Money Demand Model to Evaluate Monetary Policies in Brazil** *Pedro H. Albuquerque and Solange Gouvêa*	Nov/2001
30	**Testing the Expectations Hypothesis in the Brazilian Term Structure of Interest Rates** *Benjamin Miranda Tabak and Sandro Canesso de Andrade*	Nov/2001
31	**Algumas Considerações sobre a Sazonalidade no IPCA** *Francisco Marcos R. Figueiredo e Roberta Blass Staub*	Nov/2001
32	**Crises Cambiais e Ataques Especulativos no Brasil** *Mauro Costa Miranda*	Nov/2001
33	**Monetary Policy and Inflation in Brazil (1975-2000): a VAR Estimation** *André Minella*	Nov/2001
34	**Constrained Discretion and Collective Action Problems: Reflections on the Resolution of International Financial Crises** *Arminio Fraga and Daniel Luiz Gleizer*	Nov/2001
35	**Uma Definição Operacional de Estabilidade de Preços** *Tito Nícias Teixeira da Silva Filho*	Dez/2001
36	**Can Emerging Markets Float? Should They Inflation Target?** *Barry Eichengreen*	Feb/2002
37	**Monetary Policy in Brazil: Remarks on the Inflation Targeting Regime, Public Debt Management and Open Market Operations** *Luiz Fernando Figueiredo, Pedro Fachada and Sérgio Goldenstein*	Mar/2002
38	**Volatilidade Implícita e Antecipação de Eventos de *Stress*: um Teste para o Mercado Brasileiro** *Frederico Pechir Gomes*	Mar/2002
39	**Opções sobre Dólar Comercial e Expectativas a Respeito do Comportamento da Taxa de Câmbio** *Paulo Castor de Castro*	Mar/2002
40	**Speculative Attacks on Debts, Dollarization and Optimum Currency Areas** *Aloisio Araujo and Márcia Leon*	Apr/2002
41	**Mudanças de Regime no Câmbio Brasileiro** *Carlos Hamilton V. Araújo e Getúlio B. da Silveira Filho*	Jun/2002
42	**Modelo Estrutural com Setor Externo: Endogenização do Prêmio de Risco e do Câmbio** *Marcelo Kfoury Muinhos, Sérgio Afonso Lago Alves e Gil Riella*	Jun/2002
43	**The Effects of the Brazilian ADRs Program on Domestic Market Efficiency** *Benjamin Miranda Tabak and Eduardo José Araújo Lima*	Jun/2002

44	**Estrutura Competitiva, Produtividade Industrial e Liberação Comercial no Brasil** *Pedro Cavalcanti Ferreira e Osmani Teixeira de Carvalho Guillén*	Jun/2002
45	**Optimal Monetary Policy, Gains from Commitment, and Inflation Persistence** *André Minella*	Aug/2002
46	**The Determinants of Bank Interest Spread in Brazil** *Tarsila Segalla Afanasieff, Priscilla Maria Villa Lhacer and Márcio I. Nakane*	Aug/2002
47	**Indicadores Derivados de Agregados Monetários** *Fernando de Aquino Fonseca Neto e José Albuquerque Júnior*	Set/2002
48	**Should Government Smooth Exchange Rate Risk?** *Ilan Goldfajn and Marcos Antonio Silveira*	Sep/2002
49	**Desenvolvimento do Sistema Financeiro e Crescimento Econômico no Brasil: Evidências de Causalidade** *Orlando Carneiro de Matos*	Set/2002
50	**Macroeconomic Coordination and Inflation Targeting in a Two-Country Model** *Eui Jung Chang, Marcelo Kfoury Muinhos and Joanílio Rodolpho Teixeira*	Sep/2002
51	**Credit Channel with Sovereign Credit Risk: an Empirical Test** *Victorio Yi Tson Chu*	Sep/2002
52	**Generalized Hyperbolic Distributions and Brazilian Data** *José Fajardo and Aquiles Farias*	Sep/2002
53	**Inflation Targeting in Brazil: Lessons and Challenges** *André Minella, Paulo Springer de Freitas, Ilan Goldfajn and Marcelo Kfoury Muinhos*	Nov/2002
54	**Stock Returns and Volatility** *Benjamin Miranda Tabak and Solange Maria Guerra*	Nov/2002
55	**Componentes de Curto e Longo Prazo das Taxas de Juros no Brasil** *Carlos Hamilton Vasconcelos Araújo e Osmani Teixeira de Carvalho de Guillén*	Nov/2002
56	**Causality and Cointegration in Stock Markets: the Case of Latin America** *Benjamin Miranda Tabak and Eduardo José Araújo Lima*	Dec/2002
57	**As Leis de Falência: uma Abordagem Econômica** *Aloisio Araujo*	Dez/2002
58	**The Random Walk Hypothesis and the Behavior of Foreign Capital Portfolio Flows: the Brazilian Stock Market Case** *Benjamin Miranda Tabak*	Dec/2002
59	**Os Preços Administrados e a Inflação no Brasil** *Francisco Marcos R. Figueiredo e Thaís Porto Ferreira*	Dez/2002
60	**Delegated Portfolio Management** *Paulo Coutinho and Benjamin Miranda Tabak*	Dec/2002

76	**Inflation Targeting in Emerging Market Economies** *Arminio Fraga, Ilan Goldfajn and André Minella*	Jun/2003
77	**Inflation Targeting in Brazil: Constructing Credibility under Exchange Rate Volatility** *André Minella, Paulo Springer de Freitas, Ilan Goldfajn and Marcelo Kfoury Muinhos*	Jul/2003
78	**Contornando os Pressupostos de Black & Scholes: Aplicação do Modelo de Precificação de Opções de Duan no Mercado Brasileiro** *Gustavo Silva Araújo, Claudio Henrique da Silveira Barbedo, Antonio Carlos Figueiredo, Eduardo Facó Lemgruber*	Out/2003
79	**Inclusão do Decaimento Temporal na Metodologia Delta-Gama para o Cálculo do VaR de Carteiras Compradas em Opções no Brasil** *Claudio Henrique da Silveira Barbedo, Gustavo Silva Araújo, Eduardo Facó Lemgruber*	Out/2003
80	**Diferenças e Semelhanças entre Países da América Latina: uma Análise de *Markov Switching* para os Ciclos Econômicos de Brasil e Argentina** *Arnildo da Silva Correa*	Out/2003
81	**Bank Competition, Agency Costs and the Performance of the Monetary Policy** *Leonardo Soriano de Alencar and Márcio I. Nakane*	Jan/2004
82	**Carteiras de Opções: Avaliação de Metodologias de Exigência de Capital no Mercado Brasileiro** *Cláudio Henrique da Silveira Barbedo e Gustavo Silva Araújo*	Mar/2004
83	**Does Inflation Targeting Reduce Inflation? An Analysis for the OECD Industrial Countries** *Thomas Y. Wu*	May/2004
84	**Speculative Attacks on Debts and Optimum Currency Area: a Welfare Analysis** *Aloisio Araujo and Marcia Leon*	May/2004
85	**Risk Premia for Emerging Markets Bonds: Evidence from Brazilian Government Debt, 1996-2002** *André Soares Loureiro and Fernando de Holanda Barbosa*	May/2004
86	**Identificação do Fator Estocástico de Descontos e Algumas Implicações sobre Testes de Modelos de Consumo** *Fabio Araujo e João Victor Issler*	Maio/2004
87	**Mercado de Crédito: uma Análise Econométrica dos Volumes de Crédito Total e Habitacional no Brasil** *Ana Carla Abrão Costa*	Dez/2004
88	**Ciclos Internacionais de Negócios: uma Análise de Mudança de Regime Markoviano para Brasil, Argentina e Estados Unidos** *Arnildo da Silva Correa e Ronald Otto Hillbrecht*	Dez/2004
89	**O Mercado de *Hedge* Cambial no Brasil: Reação das Instituições Financeiras a Intervenções do Banco Central** *Fernando N. de Oliveira*	Dez/2004

90	**Bank Privatization and Productivity: Evidence for Brazil** *Márcio I. Nakane and Daniela B. Weintraub*	Dec/2004
91	**Credit Risk Measurement and the Regulation of Bank Capital and Provision Requirements in Brazil – A Corporate Analysis** *Ricardo Schechtman, Valéria Salomão Garcia, Sergio Mikio Koyama and Guilherme Cronemberger Parente*	Dec/2004
92	**Steady-State Analysis of an Open Economy General Equilibrium Model for Brazil** *Mirta Noemi Sataka Bugarin, Roberto de Goes Ellery Jr., Victor Gomes Silva, Marcelo Kfoury Muinhos*	Apr/2005
93	**Avaliação de Modelos de Cálculo de Exigência de Capital para Risco Cambial** *Claudio H. da S. Barbedo, Gustavo S. Araújo, João Maurício S. Moreira e Ricardo S. Maia Clemente*	Abr/2005
94	**Simulação Histórica Filtrada: Incorporação da Volatilidade ao Modelo Histórico de Cálculo de Risco para Ativos Não-Lineares** *Claudio Henrique da Silveira Barbedo, Gustavo Silva Araújo e Eduardo Facó Lemgruber*	Abr/2005
95	**Comment on Market Discipline and Monetary Policy by Carl Walsh** *Maurício S. Bugarin and Fábia A. de Carvalho*	Apr/2005
96	**O que É Estratégia: uma Abordagem Multiparadigmática para a Disciplina** *Anthero de Moraes Meirelles*	Ago/2005
97	**Finance and the Business Cycle: a Kalman Filter Approach with Markov Switching** *Ryan A. Compton and Jose Ricardo da Costa e Silva*	Aug/2005
98	**Capital Flows Cycle: Stylized Facts and Empirical Evidences for Emerging Market Economies** *Helio Mori e Marcelo Kfoury Muinhos*	Aug/2005
99	**Adequação das Medidas de Valor em Risco na Formulação da Exigência de Capital para Estratégias de Opções no Mercado Brasileiro** *Gustavo Silva Araújo, Claudio Henrique da Silveira Barbedo,e Eduardo Facó Lemgruber*	Set/2005
100	**Targets and Inflation Dynamics** *Sergio A. L. Alves and Waldyr D. Areosa*	Oct/2005
101	**Comparing Equilibrium Real Interest Rates: Different Approaches to Measure Brazilian Rates** *Marcelo Kfoury Muinhos and Márcio I. Nakane*	Mar/2006
102	**Judicial Risk and Credit Market Performance: Micro Evidence from Brazilian Payroll Loans** *Ana Carla A. Costa and João M. P. de Mello*	Apr/2006
103	**The Effect of Adverse Supply Shocks on Monetary Policy and Output** *Maria da Glória D. S. Araújo, Mirta Bugarin, Marcelo Kfoury Muinhos and Jose Ricardo C. Silva*	Apr/2006

104	**Extração de Informação de Opções Cambiais no Brasil** *Eui Jung Chang e Benjamin Miranda Tabak*		Abr/2006
105	**Representing Roomate's Preferences with Symmetric Utilities** *José Alvaro Rodrigues-Neto*		Apr/2006
106	**Testing Nonlinearities Between Brazilian Exchange Rates and Inflation Volatilities** *Cristiane R. Albuquerque and Marcelo Portugal*		May/2006
107	**Demand for Bank Services and Market Power in Brazilian Banking** *Márcio I. Nakane, Leonardo S. Alencar and Fabio Kanczuk*		Jun/2006
108	**O Efeito da Consignação em Folha nas Taxas de Juros dos Empréstimos Pessoais** *Eduardo A. S. Rodrigues, Victorio Chu, Leonardo S. Alencar e Tony Takeda*		Jun/2006
109	**The Recent Brazilian Disinflation Process and Costs** *Alexandre A. Tombini and Sergio A. Lago Alves*		Jun/2006
110	**Fatores de Risco e o *Spread* Bancário no Brasil** *Fernando G. Bignotto e Eduardo Augusto de Souza Rodrigues*		Jul/2006
111	**Avaliação de Modelos de Exigência de Capital para Risco de Mercado do Cupom Cambial** *Alan Cosme Rodrigues da Silva, João Maurício de Souza Moreira e Myrian Beatriz Eiras das Neves*		Jul/2006
112	**Interdependence and Contagion: an Analysis of Information Transmission in Latin America's Stock Markets** *Angelo Marsiglia Fasolo*		Jul/2006
113	**Investigação da Memória de Longo Prazo da Taxa de Câmbio no Brasil** *Sergio Rubens Stancato de Souza, Benjamin Miranda Tabak e Daniel O. Cajueiro*		Ago/2006
114	**The Inequality Channel of Monetary Transmission** *Marta Areosa and Waldyr Areosa*		Aug/2006
115	**Myopic Loss Aversion and House-Money Effect Overseas: an experimental approach** *José L. B. Fernandes, Juan Ignacio Peña and Benjamin M. Tabak*		Sep/2006
116	**Out-Of-The-Money Monte Carlo Simulation Option Pricing: the join use of Importance Sampling and Descriptive Sampling** *Jaqueline Terra Moura Marins, Eduardo Saliby and Joséte Florencio do Santos*		Sep/2006