

Consumer Credit Risk Measurement: Challenges for the Paraguayan Banking System

By

Bruno Gomez

B.A. Business Administration
National University of Asunción, 2012

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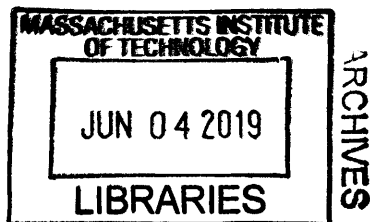
Certified by: _____

Deborah J. Lucas
Director, MIT Golub Center for Finance and Policy
Thesis Supervisor

Signature redacted

Accepted by: _____

Jacob Cohen
Senior Associate Dean for Undergraduate & Master's Program
MIT Sloan School of Management



Consumer Credit Risk Measurement: Challenges for the Paraguayan Banking System

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Bruno Gomez

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ABSTRACT

Credit risk is often a critical risk in the financial sector. Therefore, how a financial institution manages its credit risk is an important determinant of profitability and solvency. In this regard, the identification and measurement of credit risk is the first component of efficient risk management. Correct and timely credit ratings are important for risk management systems, and for informing regulators about financial system risks.

Credit risk is the main risk faced by the Paraguayan financial sector. Effectively managing it requires banking supervisión and regulation in line with international best practices. As a step in that direction, this research assesses the Paraguayan banking regulation of credit risk and compares it to the principles and the best practices about credit risk management issued by the Basel Committee. I propose principles to guide the implementation of statistical models for better measurement of credit risk in Paraguayan financial institutions.

Thesis Supervisor: Deborah J. Lucas

Title: Director, MIT Golub Center for Finance and Policy

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INTRODUCTION

The rapidly changing financial world and the crisis of the 90s triggered the revision of the 1988 Capital Accord (Basel I). Its main limitation is its insensitivity to changes in risk, and that it ignores an essential dimension of risk: that the probability of default by bank borrowers varies with their credit quality. Under Basel I, banks can assume that all of its borrowers have the same probability of default.

Consequently, the Basel Committee presented a New Capital Accord in 2004 (Basel II). This new agreement establishes general guidelines that allow monitoring closely and effectively the risk profile of banks and is based on three pillars: minimum capital requirements, bank supervision and market discipline.

The stability of the financial system depends heavily on the decisions of debtors regarding payment of the obligations they have acquired from banking institutions. These decisions affect banks because the increase in default levels imply increases in provisions and decreases in interest income. This results in the reduction in profits and solvency of financial institutions, which, decreases its ability to absorb unexpected losses and could eventually lead to its bankruptcy.

The vulnerability of the financial system is directly correlated with the probability of default of credit debtors. Therefore it is important to evaluate and measure credit risk using statistical models to identify the determinants that debtors may default on any of its loans.

Basel II introduces the concept of system rating, which includes all methods, processes, controls and data collection system and information technology required for credit risk assessment and measurement, estimation of the default probability and losses (Basel Committee on Banking Supervision, 2004).

Already in the 1990s, portfolio models for measuring credit risk were gaining popularity. These models allow analysts to obtain rigorous estimates of expected or unexpected losses and thus determine the needs of provisions and capital required by banks to address these potential losses.

This work focuses on answering the question: *“Is it possible to determine the probability of default and the expected loss of consumer loan portfolio of banks in Paraguay by financial and statistical models, and therefore measure more effectively the credit risk of bank portfolios?”*. To help to answer this question, this paper has the following objectives:

Overall objective

- a) Conduct a study on a theoretical level of the Paraguayan legal framework governing credit risk management, and compare it with the recommended practices proposed by the Basel Committee.
- b) Propose the implementation of financial and statistical models to measure more effectively credit risk in consumer portfolios of Paraguayan financial institutions.

Specific objectives

- a) Conduct an analysis of the Paraguayan legal framework in order to identify weaknesses in the regulation related to management of credit risk of customers grouped as consumer loan (Consumer Loan).
- b) Determine the probability of default and the expected loss of a sample of 10,000 customers, which are part of a consumer portfolio of a financial institution in Paraguay, by using the binary logic regression model.
- c) Identify the most significant variables of the model used and identify its impact and predictability of default of the studied sample.
- d) Compare the expected loss model obtained with the specific provision that the financial institution cover the potential loss of clients which are part of the studied sample.

1. Theoretical Framework Credit Risk

1.1. Definition of Credit Risk

Credit risk is the likelihood that, at a payment due date, a debtor cannot pay, partly or wholly, its obligation to a lender due to insufficient assets, illiquidity or some other reason.

Lending may involve a number of risks to income and assets of a financial institution. Therefore, it is important to know all the risks embedded in the loan portfolio and estimate its potential impact on the institution.

The objective of administration of credit risk is to maximize the risk-adjusted rate of return, keeping exposure to credit risk within acceptable limits. Therefore, effective credit risk management is a critical component of a comprehensive approach to risk management and is essential for long-term success of any banking or financial institution¹.

The essence of the activity of financial institutions is taking risks. The risk is an inevitable component in their operations. Therefore, they should be aware of the need to identify, measure, monitor and control credit risk and determine whether their capital is adequate for this risk. Credit risk also involves other risks such as default risk and market risk, liquidity risk and risk of insolvency.

As it was mentioned, the credit risk assessment is based on the likelihood that the borrower fails to comply with its obligations. Economic cycles are an important factor in the occurrence of default, as default is often reduced during periods of economic expansion and increased in periods of economic contraction. Also, the particular circumstances of each debtor may affect its ability to pay. Specific credit risk is often characterized through the assignment of a rating. This measure is useful to classify debtors according to their credit risk².

Credit risk management has both qualitative and quantitative aspects. Technological advances have led and facilitated the quantitative valuation of credit risk. Information systems play an important role in conducting of analysis and in the new methodologies for the treatment of debts.

New information and communication technologies provide data for internal credit risk models used to determine the expected loss of a loan portfolio, and allow those models to be more effective, more accurate, and to get more consistent predictions.

1.2. What is a credit score?³

The risk rating is a summary indicator based on qualitative and quantitative criteria that analysts apply to evaluate loan applicants and borrowers.

"It's an updated opinion on the overall financial capacity (credit quality) of an issuer to meet its financial obligations. This review focuses on the ability and willingness of the issuer to meet its financial debts at the time they have to pay them back." (Arana, Jose Jaime," Determinants Credit Ratings "- 1999).

1.3. Credit Risk Elements⁴

Credit risk can be analyzed in three basic dimensions (Galicia, 2003):

- a) Exposure: The uncertainty regarding future amounts at risk. The credit must be repaid in accordance with established payment dates and thus will be possible to know in advance the remaining balance at a certain date.
- b) Recovery: originated when credit was defaulted. It is uncertain, since it depends among other things on the type of guarantee that has been received and their status at time of default. The existence of a guarantee minimizes credit risk when it can be sold quickly easily for a value to cover the amount owed. In the case of guarantees, there is also uncertainty because it is a transfer of risk in case of default of the guaranteed, and it could happen that the guarantor also fail at the same time and as a result have a joint probability of default.
- c) Default risk: There is some discretion in what types of contractual violations are classified as defaults. Banking institutions generally establish grace periods before they can declare a default. The events that cause credit risks are default and the deterioration of the borrower's creditworthiness, credit thus migrates to a lower rating category. The probability of default is an important element in evaluating credit risk and its meaning most commonly used is the failure to pay an overdue debt.

1.4. Definition of default or failure to pay a debt⁵

Not all defaults entail a loss. Simple delays caused by small liquidity mismatches or operational failures of debtors usually are resolved with a full payment. Whether a default event entails a significant probably of loss depends on the type of credit and may change depending on economic circumstances. A company that falls into default because it has entered into a formal process of suspension of payment is different from a company that does not pay for a temporary lack of liquidity, for example, because of the default of one of its customers who subsequently regularized their situation.

The Committee on Banking Supervision proposed a definition of default: "It is considered that a default has occurred with respect to a particular debtor when one or more of the following events have occurred:

- It is determined that it is unlikely that the debtor complies fully with the obligations (principal, interest or fees).
- A loss that changes the credit risk associated with any payment obligation, such as an established provision or renegotiation of the financial terms involving forgiveness or new postponement of the pending debt, interest or fees.
- The debtor was delayed more than ninety days in any of its loan obligations.
- The debtor has applied for bankruptcy or similar protection from creditors. "

"In the context of the credit models, there are different definitions of default, including:

- a) Stop paying interest and/or principal of a debt for a specified period.
- b) Any of the following events: a debt restructuring, a provision for a specific portfolio or decrease in credit rating.
- c) The situation in which the value of a company's assets is less than their debts.
- d) Bankruptcy "⁶.

From the above definitions, the most widely used credit risk measurement is the first one; a default occurs when the borrower fails to pay interest and/or capital.

2. International Standards of Banking Regulation and Supervision.

2.1. Basel Committee on Banking Supervision⁷

The Basel Committee history begins in 1974. It was created by the governors of the central banks of the G10 countries. Currently, representatives from the monetary authorities of Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, Netherlands, Spain, Sweden, Switzerland, United Kingdom and USA participate on the meetings of the Committee which take place in the Bank for International Settlements in Basel, Switzerland, four times a year.

The Basel Committee on Banking Supervision Basel is an organization that provides guidance on global financial regulation. Their recommendations reflected in the Basel Accords are not mandatory compliances. However, they serve as a guide for the authorities of each country.

The objective of the Basel Committee is to strengthen, in general, banking systems. To achieve this goal, standards are promoted on various topics such as money laundering, good corporate governance, management credit risk, internal control, among others. In other words, the purpose of this forum is the development and convergence of financial supervision globally.

2.2. Basel I ⁸

Basel I is the first of the agreements issued by the Basel Committee and was published in 1988. It was based on several recommendations or suggestions in order to set a limit on the issuance of credits that a financial institution can grant based on the equity it has. It was established that the minimum capital must be at least 8% of their risk-weighted assets (credit, market and exchange rate added).

The most important banking recommendation made was to limit the leverage or the multiplicative effect of investments of financial institutions to 12.5 times the value of own resources in their balance sheets. This limit was important at that time, because financial institutions have historically been highly levered, raising funds from people and granting loans without taking into account risk parameters in case of insolvency of a person or a company.

The definition of regulatory capital that was established divided it into two categories called Tier I and Tier II, depending on whether they met certain requirements in terms of capacity to absorb losses as well as its permanence and protection from bankruptcy. The main risk addressed is credit risk, which is calculated by grouping risk exposures into 5 categories according to counterparty and assigning a different "weight" to each category (0%, 10%, 20%, 50%, 100%), the sum of the risk-weighted form risk assets.

2.2.1. Tier 1 (Main Capital)⁹

Tier 1 or *core capital* is a ratio used to measure the strength of a bank. It is composed of core capital, consisting primarily of common shares. It may also include perpetual preferred and other bank resources.

The Tier 1 capital ratio is therefore the relationship between the Tier 1 capital of a bank and all its risk-weighted assets. This ratio provides a basic measure of the strength of banks.

Therefore, the formula for calculating the Tier 1 is as follows:

Tier 1 = Equity / risk-weighted assets

2.2.2. Tier 2 (Capital Supplementary)¹⁰

The Tier 2 capital ratio is also called the supplementary capital ratio. Tier 2 capital is composed of the elements that absorb losses when the entity is not viable, such as undisclosed reserves, subordinated term debts, and hybrid financial products

The first Basel Capital Accord has played a major role in strengthening banking systems. The impact of the agreement, and the degree of homogeneity achieved in regulating the solvency requirements has been extraordinary. More than 130 countries have adopted it.

However, since Basel I contained certain limitations in its definition, in June 2004, it was replaced by Basel II.

2.3. Basel II ¹¹

The New Capital Accord (Basel II) 2004 requires banks to take additional steps to maintain solvency and market discipline. The latter means that financial institutions should be transparent in reporting on the risk level of their operations.

The purpose of Basel II, initially published in June 2004, is the creation of an international standard as a reference for banking regulators, in order to establish capital requirements necessary to ensure the protection of the institutions against financial operational risks.

Basel II's new set of recommendations are based on three pillars.

2.3.1. Pillar I: calculation of minimum capital requirements

This constitutes the core of the agreement and includes a number of developments with respect to Basel I: it takes into account the individual creditworthiness of borrowers (using internal or external ratings) and adds capital requirements for operational risk.

Basel I standard requires equity higher than 8% of risk-weighted assets, considering: (credit risk+trading risk +exchange rate risk), while Basel II considers: (credit risk+market risk+exchange rate risk+operational risk).

Credit risk is calculated through three fundamental components:

- PD (Probability of Default)
- LGD (Loss Given Default), also known as "severity" indicating the severity of the loss
- EAD (Exposure At Default)

Given the existence of banks with different levels of sophistication, the agreement proposes different methods for calculating credit risk. In the standard method, the PD and LGD are implicitly calculated through credit ratings published by specialized companies (rating agencies). Instead, the most sophisticated banks can, under a number of conditions, opt for the advanced internal ratings method, which allows them to use their own mechanisms for risk assessment to make their own estimates. An alternative intermediate method allows banks to estimate the PD, the most basic parameter, and then use LGD values precalculated by the regulator.

To date, many banks in various countries managed their credit risk based on expected losses, which determine their level of provisions against defaults. Trading risk and exchange rate risk are still calculated according to Basel I.

Operational risk is calculated as a percentage of revenue. There are 3 alternative methods that can be used depending on the degree of sophistication of the bank.

Finally, the definition of regulatory capital remains similar to Basel I.

It should be noted that an objection to this risk calculation is that the the aggravating/mitigating effects of the concentration/risk diversification (structure of probabilistic correlation between different exposures) is ignored. This is one of the main differences between regulatory capital and economic capital.

2.3.2. Pillar II: the process of supervising the management of equity

National supervisory authorities are able to increase the level of prudence required of banks under their jurisdiction. They must also validate the statistical methods used to calculate the parameters required in the first pillar that determine the adequacy of levels of own funds to deal with an economic crisis. They can force banks to increase them depending on the results.

Further it requires that senior managers of banks are actively involved in risk control and planning future capital needs. This self-assessment of capital requirements should be discussed between senior managers and banking supervisors. As banks are free to choose the methodology for self-evaluation, other risks not contemplated in the regulatory calculation can be included, such as the risk of concentration and/or diversification, liquidity risk, reputation risk, etc.

2.3.3. Pillar III: market discipline

The agreement established standards of transparency and demands regular publication of information about its exposure to various risks and adequacy of its own funds. The objective is:

1. The generalization of good banking practices and its international homogenization.
2. Reconciliation of financial and accounting point of views and risk management on the basis of information accumulated by the financial institutions.
3. Financial transparency through the homogenization of risk reports published by banks.

Initially, the information should include:

- Description of risk management: objectives, policies, structure, organization, scope, coverage policies and risk mitigation.
- Technical aspects of the calculation of capital: differences in financial and regulatory consolidation.
- Description of capital management.
- Detailed composition of regulatory capital elements.
- Capital requirements for each risk, indicating the calculation method used.

The initial requirement is to be published at least annually, although it is expected that the frequency will be higher (at least summary) and its contents will be adding minimum information required by the market at all times.

2.3. Basel III ¹²

Most recently, Basel III was published in 2010. Its most important aspect is controlling systemic risk. To this end, it refers to the constant preservation of reserves, both in recession and economic expansion.

Basel III reform responds to the 2008 financial crisis. Inflated asset values on the balance sheets of banks (and also outside them, as in the case of derivatives), and the simultaneous fall in the level and quality of own funds kept for risk losses, pushed Banks towards insolvency. Also many institutions did not have sufficient reserves to face their liquidity needs. Furthermore, the banking system did not have the capital to absorb losses affecting structured securitization products and the re-intermediation of some off-balance sheet exposures that banks had to assume.

At the height of the crisis, there was uncertainty about whether individual Banks were solvent. That uncertainty gave risk to systemic risk. Banks' interdependence could cause the insolvency of one institution to spill over and cause the insolvency other banks. This generated a widespread crisis of confidence. Given the central role of the financial system i in the real economy, the international nature of financial institutions, and losses that would be borne by governments through rescue plans with public funds, coordinated intervention by international regulators was considered legitimate.

Unlike Basel I and Basel II, which both focused primarily on the level of reserves that banks must hold for bank losses, Basel III focuses primarily on the risk of "bank runs." That risk gives rise to different levels of required capital for different types of bank deposits and other loans. Basel III is therefore not a substitute for Basel I and Basel II; rather it complements them.

2.4. Principles for Effective Banking Supervision of Basel Committee¹³

The Core Principles for Effective Banking Supervision (Core Principles) are the minimum standards for proper prudential regulation and supervision of banks and banking systems. Since its publication in 1997 by the Committee on Banking Supervision (the Committee), the Basic Principles have served countries as a benchmark for assessing the quality of their supervisory systems and identify the measures necessary to achieve comparable levels of quality of supervisory practices. The Basic Principles are also used by International Monetary Fund (IMF) and the World Bank in its Program Financial Sector Assessment Program (FSAP) to test the effectiveness of the systems and practices of banking supervision in different countries.

The Committee last reviewed the Core Principles in October 2006 in collaboration with supervisors worldwide. In its October 2010 entitled, "The response of the Basel Committee to the financial crisis: report to the G20," the Committee announced its plans to revise the Basic Principles as part of its continuing efforts to strengthen the practices of global banking supervision.

In March 2011, the Committee instructed the revision and updating of the Core Principles. Specifically, the review should take into account the most significant developments in global financial markets and the regulatory environment since October 2006. The revised Core Principles still offer a comprehensive standard for the regulation, supervision, good governance and risk management in the banking sector.

The Basic Principles provide a framework of minimum standards for adequate supervision that is considered universally applicable. Basic Principles consist of 29 precepts necessary for the effectiveness of the financial system. These principles are grouped into two broad categories: the first (Principles 1 to 13) focuses on the powers, authority and functions of supervisors, while the second (Principles 14-29) governs prudential regulations and requirements to be met by banks.

With regard to credit risk, principles 17 and 18 of this document states:

2.4.1. Principle 17: Credit risk

The supervisor must determine that banks have adequate credit risk management process that takes into account their appetite for risk, its risk profile and macroeconomic and market situation. This includes prudent policies and processes to identify, quantify, evaluate, monitor, report and

control or mitigate credit risk (including credit risk counterparty) at the right time. The entire life cycle of credit is contemplated, including the granting of credit, credit assessment and ongoing management of the loan and investment portfolios.

The first essential criterion of Principle 17 states that "The law, regulation or the supervisor require that the bank has adequate credit risk management processes that offer a comprehensive view of exposure to that risk throughout the bank. The supervisor determines that these processes are in line with the risk appetite, risk profile, systemic importance and soundness of bank capital, taking into account the macroeconomic situation and market and result in a prudent criteria the grant, evaluation, management and monitoring of credit. "

The third essential criteria of Principle 17 states that "The supervisor requires, and regularly determines that such policies and processes create an appropriate risk management environment subject to appropriate controls, which means: [...]

[...] b) criteria and well defined policies and procedures for approving new exposures (including prudent rules for granting loans), as well as to renovate and refinance loans, and to identify the relevant authority to give approval based on the volume and complexity of the exposures;

c) effective policies and processes for managing credit, including ongoing analysis of the ability and willingness of the borrower to repay its debt on the agreed terms (including a review of the performance of the underlying assets in case of securitization exposures); monitoring of documentation, legal covenants, contractual requirements, collateral and other forms of credit risk coverage; and a suitable system rating or classification of assets. [...]"

2.4.2. Principle 18: Non-performing assets, provisions and reserves

The supervisor determines that banks have adequate policies and processes for early identification and management of problem assets and maintaining adequate provisions and reserves.

The fourth essential criterion of Principle 18 states that "The supervisor determines that banks have policies and processes to ensure that provisions and write-offs are timely and reflect realistic expectations of repayment and recovery, taking into account the macroeconomic situation and markets. "

Similarly, the fifth essential criterion of Principle 18 states that "The supervisor determines that banks have adequate policies and processes and organizational resources for the early identification of problem assets, continuous monitoring of doubtful assets and collecting performing loans. For portfolios credit positions with homogeneous characteristics, positions are classified when credit remain unpaid trough a minimum of days (for example, 30, 60 or 90 days). The supervisor checks the treatment banks give to assets to detect any significant non-compliance of the criteria for classification and provisioning (for example, by restructuring, refinancing or reclassification of loans). "

2.5. Principles of Credit Risk Management Basel Committee¹⁴

In July 1999, the Basel Committee published a document entitled Principles of Credit Risk Management containing 16 principles that guide financial supervisors to assess the effectiveness of the credit risk management in banks. Healthy practices defined in this document are specifically related to the following areas: (i) establish an appropriate environment for credit risk; (ii) operate under a sound process to grant credit; (iii) maintain adequate process to manage, measure and monitor credits; and (iv) ensuring adequate credit risk controls. The document also mentions that although the specific practices of credit risk management may vary among banks, depending on the nature and complexity of their credit activities, a complete credit risk management program must include these four areas.

The area relating to maintaining adequate process to manage, measure and monitor credit states that:

Principle 8: Banks should have a system for continuous administration of their various credit risk portfolios.

Principle 9: Banks should have a system to monitor the condition of individual credits, including determining compliance of provisions and reserves.

Principle 10: Banks should develop and use systems of internal risk assessment to manage credit risk. The classification system should be consistent with the nature, size and complexity of the bank's activities.

Principle 11: Banks must have information systems and analytical techniques to enable management to measure the inherent credit risk in all activities on and off the balance sheet. The management information system should provide adequate information on the composition of the loan portfolio, including identification of risk concentrations.

Principle 12: Banks should have a system to monitor the composition and overall quality of the loan portfolio.

Principle 13: Banks should take into account possible future changes in economic when assessing individual loans and loan portfolios conditions, and should assess their exposures to credit risk low pressure conditions.

2.6. Guidance on credit risk and accounting for expected credit losses¹⁵

The purpose of this document is to establish supervisory guidance on good practice credit risk associated with the implementation and ongoing application of accounting frameworks for expected credit losses (ECL).

In June 2006, the Committee on Banking Supervision ("the Committee") published its guidelines *Sound credit risk assessment and valuation for loans* on how to use data and common processes for the purpose of credit risk assessment, accounting and capital adequacy, as well as highlighting concepts related to provisions that are consistent in prudential and accounting frameworks. This document replaces the 2006 Committee's guidelines.

Point 32 of this document states that "the process of identifying credit risk should ensure that the factors that impact on changes in credit risk and estimates of ECL are properly identified periodically. In addition, consideration of inherent credit risk to new products and activities should be a key process of risk identification and assessment and calculation of the ECL element."

3. Legal Framework in the Paraguayan financial system

3.1 Regulatory Framework of Credit Risk in Paraguay

In Paraguay, Law N°. 489 of 1995 "ORGANIC LAW OF PARAGUAYAN CENTRAL BANK " and Law N° 861 of 1996 "General Banking, Financial and Other Credit Institutions" define the fundamental objectives of the Central Bank of Paraguay related to the promotion of efficiency and stability of the domestic financial system.

Law N° 489/95 in its Article N° 31 states that it corresponds exclusively to the Central Bank of Paraguay, through the Superintendency of Banks, monitor compliance with tax laws by banks, financial and other credit institutions and adopt standards to organize and monitor: a) banks, financial and other foreign credit institutions, public or private, national or operating in the country [...]"

In this context, the Superintendency of Banks (SB) is responsible for overseeing the banking system to preserve stability, security and confidence, and the protection of depositors and customers. Resolutions and circulars issued by the Superintendency of Banks are mandatory for the banking sector. The SB is also a regulator of the Paraguayan banking system.

In that sense, to maintain properly credit risk assessment, the SIB issued in 2007, Resolution N° 1 - Act N° 60 called "Asset Classification Standards, Credit Risks, Provisions and Accrued Interest". This document contains specific policies and procedures that determine the criteria and the way in which financial institutions must evaluate, qualify, monitor and cover their credit risk.

3.2. Classification Asset standards, Credit Risks, Provisions and Accrued Interest (Resolution N° 1 - Act N° 60 of 2007)¹⁶

3.2.1. Area of application

This standard defines that credit institutions that make up the financial system subject to the Law N° 861/96 "General Banking, Financial and Other Credit Institutions" shall meet the following criteria, in order to:

- a. Maintain at all times classified assets and risks that are assumed in cash and contingent credit operations;
- b. Make provisions that cover the expected losses of its assets and operations contingent losses; a,
- c. not record as earnings interest gains and additional fees earned with transactions on which there are reasonable doubts about their recovery.

3.2.2. Credit arrangements

This standard also defines the different types of credits to be classified considering the following definitions:

- a) Large debtors: are companies of any type, economic units or individuals who maintain a productive, commercial or service business and maintain balances equal to or greater amounts to two percent (2%) of the minimum capital required by banks. Large debtors are also those whose balances exceed in the financial system, four percent (4%) of the legally minimum capital required of banks, respectively. These percentages have been amended by Resolution N° 37 - Act N° 72 of 2011. The legally required minimum capital shall be determined annually by the SIB in accordance with what it is established in Law N° 861/96.
- b) Small and Medium Debtors: are companies of any type, economic units or individuals who maintain a productive, commercial or service business and maintain balances for amounts lower than the percentage to be considered a large debtor.
- c) Consumer loan debtor: those individuals who have received consumer loans or housing loans, as defined in this standard and not in another category definition.
- d) Microcredits. They are defined as such loans to individuals or legal entities for the financing of small-scale activities production, marketing and services, whose primary source of repayment is the proceeds of sales or revenues generated by these activities properly verified by the financial institution, the amount does not exceed twenty-five times (25) paraguayan minimum monthly wage (25 multiplied by \$400 aprox).

3.2.3. Credit Ratings

According to this standard of SB, there are 6 risk ratings (1 to 6) for loans granted under the different credit portfolios previously defined (paragraph 3.2.2).

Loans grouped as large debtors can be classified considering two aspects: a) qualitative (debtor's ability to pay); and, b) quantitative (behavior of debt payment). However, other loans granted as Small and Medium Debtors, Consumer Loan Debtors and Microcredits can only be classified considering the quantitative aspect (behavior of debt payment), which means that, they can only be reclassified to a lower category when they fail to pay interest and/or the capital of a debt for a period determined as defined in Exhibit N° 1 to Exhibit 3 (shown at the end of the paper).

3.2.4. Variables used in measuring credit risk of large debtors

The rule issued by the SB determines that the basic factors for classifying large debtors are, first, the payment capacity of the debtor and, secondly, the behavior observed in the debt payment.

Additionally, as a relevant factor will be considered moral suitability demonstrated by shareholders and company executives analyzed in developing their businesses, previous experience in the industry, ability to deal with contingency situations, national conditions and international economic sector in which it operates, reasonableness of projected financial and

economic flows, and the required documentation.

a) Ability to pay the debtor.

Assessment of the risks taken by large debtors includes the analysis of its financial, economic and financial situation. It also includes the appreciation of their business (production, market, management and shareholders) and must be based primarily on the ability of the borrower to generate sufficient operating cash flows for the recovery of resources provided within the agreed deadlines. This concept cover aspects like the analyzing the client's financial statements, the characteristics of its business, the level of indebtedness, the application of credit funds target and the sustained identifying sources of repayment.

It was also considered for analysis if the loans were granted to finance operating capital or to finance fixed investment business, services, manufacturing or primary production.

The assessor should take special care to appreciate the changes, regarding the date on which the credit is requested, which may have affected the equity, financial and economic situation of the debtor and that are affecting their ability to pay. The assessor must analyze the causes of these changes and determine the level of risk they pose to the credit institution.

The evaluation should include an analysis of sensitivity of credit risks to exchange rate fluctuations that could adversely affect both the ability of payments and cash flows. In this context, for large borrowers the evaluator will pay particular attention to the capacity to generate cash flows in the currency in which the loan was granted.

b) Behavior of borrowers observed in debt payment.

Payment obligations, both to a particular bank and to other creditors, should be evaluated independently of what is indicated by the borrower's financial statements. The information used to assess this is available on the Central Credit Risks, the Paraguayan credit registry.

In this regard, it is considered that the client has satisfied its obligations when there is no record of default.

3.2.5. Variables used in measuring credit risk of Small and Medium Debtors, Consumer Loan Debtor and Microcredits

The Resolution N° 1 - Act N° 60 of 2007 mentions that debtors grouped as Small and Medium Debtors, Consumer Loan Debtor and Microcredits will be classified only according to their payment behavior, in terms of not debt payment observed according to the days of delay as indicated in Exhibits 2 and 3.

In all cases, regardless of the default, the lack of documentation required by regulation implies that the debtor must be classified at least in category 3.

Moreover, in the case of Small and Medium Debtors, they are subject to a classification in category 4 when customers have declared bankruptcy.

3.2.6. Provision regime

The Resolution N° 37 – Act N° 72 of 2011 determines that for the purpose of provisions creation, default is determined as of the first day of debt delinquency. Moreover, Resolution N° 37 - Act N° 72 amending certain articles of Resolution N° 1 - Act N° 2007, incorporated categories 1a (delay from 1 day to 30 days) and 1b (delay from 31 days to 60 days).

In all types of credit, loans with a ratings different from 1 are those who has 60 days or more of unpaid debts, which are considered as non-performing loans. Following this definition, any debtor with a ratings different from 1 is classified as in default.

Provisions to cover risks of loss of the loan portfolio for large debtors, medium and small debtors; consumer loans and microcredits, must be constituted by an amount equal to the estimated amounts of unrecoverable debt, made with extremely prudent criteria.

Resolution N° 37 - Act N° 72 of 2011 specifies that provisions should be on the balance of total debt (principal plus interest accrued to the date of classification), according to the classification categories in the following table:

Category	Percentage
1a	0,5%
1b	1,5%
2	5% *
3	25%
4	50%
5	75%
6	100%

3.2.7. Suspension of Interest Accrual

Paragraph 38 of Resolution N° 1 - Act N° 60 of 2007 stipulates that credit institutions must avoid recording as profits all accrued interest and other charges on those credit transactions that are in one or more of the following situations:

- a) loans payable in one installment of principal and interest: the suspension will be made if the customer fails to pay its debt until the last day of the contractually agreed maturity. Therefore, it has 1 day of delay in payment of its financial debt.
- b) Credits payable in many installments: Banks must avoid recording as profits all accrued interest from the time that any of installments remains unpaid for more than 60 days.
- c) Loans classified in category 3 or higher by the SB or for the financial institution. [...]

3.3. Basic Standards for Credit Risk Management and methodology of calculating general provisions.

Resolution N° 1 - Act N° 74 of 2008 and its amending Resolution N° 16 - Act N° 78 of 2010, contains the same principles of credit risk management recommended by the Basel Committee in 1999. These principles relate to good practices based on areas: (i) establish an appropriate environment for credit risk; (ii) operate under a sound process to grant credit; (iii) maintain adequate process to manage, measure and monitor credit; and (iv) ensuring adequate credit risk controls.

This regulation of the SB defines that the calculation methodology for the establishment of additional general provisions (up to 2%) applied to the entire loan portfolio of each financial institution if financial institutions do not comply with the principles of credit risk management observed by supervisors during the on site evaluation of the financial institutions.

3.4. Renewed loans, refinanced and restructured

3.4.1. Resolution No. 1 - Act No. 60 of 2007¹⁶

Resolution N° 1 - Act N° 60 of 2007 mentions that only if clients pay, with their own financial resources, the accrued interest and other fees of the debt, banks can stop recording the days of non-payment. In other words, if clients received finance from the bank to pay the accrued interest, other fees and/or the principal of the debt, banks have to continue recording the days of non-payment to determine the category of the client.

Refinancings and restructurings may improve a credit rating, provided that the debtor has paid the accrued interest due and repaid 10% of the original principal balance.

In any case, in order to improve its classification, the debtor must submit satisfactory restructuring plans, including plans for productive, commercial, organizational and managerial reorganization, being the refinancing or restructuring subject to a new credit assessment to consider the feasibility of borrower's business and its ability to pay debt, considering the operating cash flow it generates.

3.4.2. Resolution N° 13 – Act N° 28 of 2014¹⁷

In 2014, the SB issued the Resolution N° 13 – Act N° 28 which supplements the one described above (in 3.4.1). This Resolution details the rules to be followed for the treatment of renewed, refinanced and restructured credits applied to all different clients (large debtors, small and medium debtors, Consumer loan debtor and microcredits), which are mentioned below:

3.4.2.1. Renewal

Before 60 days of non-payment, a debt is called “Renewal”. To renew a debt, clients have to pay, with its own financial resources, the accrued interest and other fees of the debt which is going to be renewed. If a client does not pay the accrued interest and other fees, banks cannot stop

recording the days of non-payment. In other words, if clients received financing from a bank to pay the accrued interest, other fees and/or the principal of the debt, banks have to continue recording the days of non-payment to determine the category of the client.

3.4.2.2. Refinancing

After 60 days of non-payment, a debt is called “Refinancing”. To refinance a debt, clients have to pay, with its own financial recourses, the accrued interest, other fees, and additionally 10% of the principal balance of the debt which is going to be refinanced. If a client does not pay the accrued interest, other fees and 10% of the principal balance, banks cannot stop recording the days of non-payment. In other words, if clients received financing from a bank to pay the accrued interest, other fees and/or the principal of the debt, banks have to continue recording the days of non-payment to determine the category of the client.

3.4.2.3. Restructuring

After 60 days of non-payment, a debt is called “Restructuring”. To restructure a debt, clients have to pay, with its own financial recourses, the accrued interest, other fees, and additionally 10% of the principal balance of the debt which is going to be restructured. If a client does not pay the accrued interest, other fees and 10% of the principal balance, banks cannot stop recording the days of non-payment. In other words, if clients received financing from a bank to pay the accrued interest, other fees and/or the principal of the debt, banks have to continue recording the days of non-payment to determine the category of the client.

The difference between Refinancing and Restructuring is that a debt which was restructured has a high probability of default comparing to refinancing debt. A client with restructuring debt is unable to pay its debt because it has severe economic and financial weakness. On the other hand, a client with refinancing debt has a transitional economic and financial weakness.

All credits which are going to be restructured, renewed and refinanced have to be assessed taking into account appropriate recovery plans, including productive, commercial, organizational plans. Also, credit analysis made by banks have to show that clients will improve the economic and financial weaknesses after the renegotiation of credits. In other words, after a credit is renegotiated, a client will produce again enough operating cash flow to pay its debt at the agreed time.

4. Statistical data of Paraguayan financial system

The Paraguayan financial system is dominated by commercial banks. In the last Financial Stability Report issued in November 2018 by the Central Bank of Paraguay, it is stated that the consolidated assets of Banks and other Financial Institutions (considering data from September 2018) total 54% of GDP (Paraguayan GDP is USD 30,000 millon). Loans are the largest category (66.8% of total assets). See details in Exhibit N° 4

Loans granted in domestic currency represent 53% of total credit and loans in foreign currency represent 47% of total credit loans (Exhibit N° 5 and 6).

The average non-performing loans ratio of all financial and banking institutions in Paraguay was 3% in September 2018. In local currency, the average non-performing ratio was 3.9%; in foreign currency it was 2.1% in September 2018 (Exhibit N° 8).

According to the Statistical Bulletin published in December 2018 by the Superintendency of Banks of the Central Bank of Paraguay. Total consumer credit portfolio represents 13% of the total portfolio of the Paraguayan financial system as shown in the following table:

Total Credit Loans and Consumer Loans (In USD)

	Total Credit Loan	Consumer loans	%
Banks	14,183,773,170	1,787,131,510	13%
Financial Institutions	848,686,150	189,359,108	22%
Total	15,032,459,321	1,976,490,618	13%

The exchange rate used G / USD = 5960.54

The Financial Stability Report published in November 2018 indicates that consumer credits recorded the second highest non-performing ratio, reaching 5.8% in September 2018, although below the ratio in the same month last year (6, 8%). A consumer loan related sector is retail trade, which has a non-performing ratio that fell in annual terms from 5.6% to 4.5% (Exhibit N° 9).

In the same report it is mentioned that the total renegotiated (restructured, renewed and refinanced credits combined) portfolio represented 15.5% of the total portfolio of the financial and banking system in September 2018. The renewed portfolio represented 77.6% of 2018 September total renegotiated portfolio, the restructured portfolio was 16.3 %, the refinanced portfolio was 3.7%. Renegotiated portfolio has been increasing since the last IEF (data to March 2018), the renewed portfolio being the most influenced this increase (Exhibit N° 10).

As for the coverage of credit risk, non-performing loans has remained fully covered since the last report. In this regard, total accumulated provisions in September 2018 represents 105.4% of non-performing loans (108.8% last March Report) and 2.3% of the total laon portfolio system. In turn, the specific provisions constitute 68.9% of total loans and the generic provisions 31.1% in September 2018.

5. Report of the 2010 Evaluation of the Financial Stability System in Paraguay¹⁸.

The Core Principles for Effective Banking Supervision developed by the Basel Committee, referred to in section 2.4 are used by the International Monetary Fund (IMF) and the World Bank in its Financial Sector Assessment Program (FSAP) to test the effectiveness of systems and practices of banking supervision in different countries.

Assessments under the FSAP have to assess the stability of the financial system as a whole. They have been established to help countries identify and correct deficiencies in its financial sector, thereby strengthening their resilience to macroeconomic shocks and contagion. Assessments under the FSAP do not cover risks that are specific to each institution.

In this context, the evaluation of the stability of the Paraguayan financial sector was conducted in November 2010 by a joint mission of the IMF and the World Bank in the framework of the Financial Sector Assessment Program (FSAP). The initial FSAP was conducted in 2005. Some of the results of the 2010 study were as follows:

a) Regulation and supervision of banks in Paraguay have made great strides in many areas since the last Financial Sector Assessment Program (FSAP). It is being implemented with a risk-based supervisory approach and they are strengthening various prudential standards, including those relating to risk management, licensing to operate, the eligibility criteria and capacity for members of the Executive Board and senior management of banks. These developments have resulted in greater compliance with international standards and a significant improvement in the soundness of the financial sector, which have also contributed to the favorable macroeconomic conditions.

b) However, regulatory restrictions imposed by the Banking Law and the Organic Law of the Central Bank has limited the possibility of the Central Bank of Paraguay (BCP) to achieve major progress towards an effective framework for risk-based supervision. In view of the growing dynamism of the Paraguayan economy and its financial sector, lawmakers should find a solution to correct this situation. They should restructure the legal framework for laws establishing general principles and requirements, leaving the responsibility to establish the specific requirements and technical details in the hands of BCP.

Finally, the mission has strongly recommended the following:

a) The adoption of measures to moderate credit growth and induce financial institutions to establish reserves to protect themselves and their customers in the event of a sudden reversal in the economic conditions. In that sense, the tightening of monetary policy should be accelerated, and regulations should be adopted without delay to harmonize the definition of bank capital with international standards and ensure adequate provisioning. The mission has supported plans of the authorities to institute a system of prospective provisioning.

b) Improving the treatment of provisioning for refinanced and restructured loans. Paraguay could improve the regulatory treatment of credits classified as renewed, refinanced and restructured (RRR). Under the renewed title, banks report revolving credit operations and which are mainly long-term loans. They are reported as short-term operations, which has a significant impact on risk assessment. Under the name refinanced and restructured loans, banks report loans to borrowers whose credit quality has deteriorated. This can lead to underestimates of the required provisioning. Regulations related to the RRR credits should be strengthened and streamlined.

Institutions should be required to adequately identify the conditions and the credit quality of individual transactions, and should apply stricter loan classification and stricter criteria to allowance for bad debt . For example, the release of provisions corresponding to a refinanced loan should only occur gradually and once there is evidence that customer's creditworthiness has improved.

6. Credit Risk Measurement Problem

6.1. Description of the problem

Resolution N° 1 - Act N° 60, issued in 2007 by the Central Bank of Paraguay (set out in section 3.2.5 of this document) mentions that credits grouped as small and medium debtors, consumer loan debtors and microcredits can only be reclassified when those debtors do not pay their debts under the terms established in this regulation. In other words, they cannot be reclassified taking into account their capacity to pay the principal balance, even when the analysis shows that they have serious economic and financial weaknesses.

Additionally, Resolution N° 13 – Act N° 28 of 2014 and Resolution N° 1 – N° 60 Acta of 2007 (expressed in paragraphs 3.4.1 and 3.4.2 of this document) mention that the only condition for renewal of debts of all kind of credits (large debtors, small and medium debtors, consumer loan debtors and microcredits) is that customers of the financial institution have to pay all accrued interest and other fees. The renewal of debt allows banks to maintain classify bad clients as “1” which is the best category. In this sense, the main weakness of the Paraguayan credit regulation is that it does not allow bank supervisors or even to the own banks to reclassify or lower the category of bad clients when there is evidence that clients have persistent economic and financial weakness to pay the principal balance of the debts that are constantly being renewed. Those clients maintain persistent economic and financial weakness even after they have been renegotiated.

In addition to what was mentioned, Paraguayan credit regulation does not put any limit to the renewal of credit of bad clients (clients who cannot pay the principal balance because of the persistent economic and financial weakness). So, in the Paraguayan banking sector is a common practice to ask bad clients to pay the accrued interest and other fees in order to renew constantly their credits to avoid reaching 60 days past due. As being said already, this mechanism of constantly renewing bad credit allows banks to maintain bad clients with the best category which is “1” (meaning zero probability of default). Banks do not want their clients to reach 60 days of non-payment because after 60 days their credits must:

- a) be classified in category 2 and higher,
- b) made the required provision for bad loan,
- c) be considered as non-performing loans,
- d) be part of the calculation of non-performing loan ratio of the financial institution,
- c) due accrued interest generated by these loans cannot be recognized as profits by financial institutions as mentioned in section 3.2.7 of this document.

Additionally, Paraguayan credit regulations does not ask banks to disclose, in their financial statements, which proportion or percentage of renewal credits are considered bad clients with permanent financial weaknesses from those who are still considered good clients with just

temporary financial weaknesses. So, nowadays, it is not possible to identify which clients are unable to pay the principal balance at the agreed time.

The problem described above does not help to correctly measure credit risk of clients and to estimate the probability of default of clients. So, banks do not underestimate the allowance for bad debt to recognize the potential loss of those bad credits.

To sum up, the Paraguayan credit regulatory weaknesses cause: a) banks to renew bad debts constant and unlimitedly over time; b) lack of differentiation between bad from good credits in the financial statement; c) the inability to assign a lower category to customers who have serious economic-financial deficiencies or lack of ability to pay the principal balance; and d) underestimation of allowance for bad debt. In other words, these situations produce asset overvaluation, undervaluation of allowance against credits with high probability of default, overvaluation of regulatory capital, overvaluation of profits and weakness in the disclosure of quality of credit portfolio of the financial institution.

These weaknesses of the Paraguayan credit regulation were already pointed out by the IMF and the World Bank in the framework of the Financial Sector Assessment Program (FSAP) conducted in 2010 which was described in point 5 of this paper. They recommended to strengthen and simplify regulations related to RRR loans by requiring institutions to identify properly the conditions and the credit quality of individual clients, and apply stricter criteria for classification of loan and stricter criteria for making allowance for bad debts.

Additionally, the Resolution N° 1 - Act N° 74 of 2008 and its amending Resolution N° 16 - Act N° 78 of 2010 (discussed in Section 3.3), which are based on the Basel Committee principles of risk management (mentioned in paragraph 2.5 of this paper), defines the framework to be used by bank supervisors to assess and determine banks level of compliance with the best practices and principles related to credit risk management. Therefore, if during the on-situ supervision of a bank, bank supervisors determine that banks do not comply or do not have good credit risk management practices, the SB may request banks to make additional generic allowance for that debt (up to 2%) calculated on the whole loan portfolio of the bank. But nevertheless, if banks are asked to make this maximum 2% percentage of generic allowance for bad debt (2%) over the total portfolio, this may not be enough to cover all the required client specific allowance for bad credits.

International best practices of banking regulation and supervision issued by the Basel Committee (mentioned in paragraphs 2.4, 2.5 and 2.6 of this document) mention that the banking supervisors must:

a) determine that banks have adequate management credit risk processes and prudent policies to identify, quantify, evaluate, monitor, report and control or mitigate credit risk at the right time.

b) issue legislation to require that the bank has adequate risk management processes of credit that offer a comprehensive view of exposure to that risk throughout the bank. The supervisor determines that these processes result in a prudent criteria for granting, evaluation, management and monitoring of credit.

c) require, and regularly determine, that these policies and processes create a good environment for risk management subject to appropriate controls, which means having well-defined criteria and

policies and processes for approving new exposures (including prudent rules granting loans), as well as to renovate and refinance existing exposures.

c) require banks to have effective policies and processes for managing credit that allow continuous credit analysis of the ability and willingness of the borrower to repay its debt on the agreed terms, track documentation, and appropriate system rating or classification of assets.

d) determine that banks have adequate policies and processes for early identification and management of problem assets and maintaining adequate provisions and reserves.

e) determine that banks have adequate policies and processes to ensure that provisions and write-offs are timely and reflect realistic repayment and recovery expectations.

d) determine that banks have adequate policies and processes and organizational resources for the early identification of problem assets, continuous monitoring of doubtful assets and collection of overdue loans. The supervisor checks the treatment banks give assets and loans to detect any significant non-compliance of the criteria for classification and provisioning (for example, by restructuring, refinancing or reclassification of loans).

6.2. Proposed solution

To overcome the regulatory weaknesses, the Central Bank of Paraguay should make the necessary adjustment to the regulatory credit framework and start promoting the implementation of credit risk models based on statistical methods to better determine the probability of default and the expected loss of the entire portfolio of small and medium debtors, consumer loans and microcredits.

The implementation of any statistical model requires that banks record and collect data and information on their clients over an extended period of time, like the data described in the section 8.4 of this document. For that to occur, the Central Bank of Paraguay would have to adjust the regulatory framework for credit risk to ask banks to collect those data.

The objective of measuring credit risk is to identify the determinants of credit risk of the portfolio of each institution, in order to better manage and reduce potential losses. There are multiple models for measuring credit risk, but this research will focus on the binary logistic regression model to calculate the probability of default and the expected loss of a sample of 10,000 customers of the consumer portfolio a Paraguayan financial institution and then compare the result with the specific provisions that the financial institution has made to cover the potential loss of credit of those 10,000 customers.

7. Measuring credit risk

7.1. Importance of Credit Risk Measurement¹⁹

Credit risk is the main risk in the financial sector. Therefore, how a financial institution chooses and manages its credit risk is an important determinant of profitability and stability.

Identification of credit risk ratings is the first component of an efficient risk management framework. Therefore, financial institutions must have a system of credit risk management that produces an accurate and timely categorization of clients.

The rating system of a financial institution should reflect the complexity of its lending activities and their overall level of risk. Therefore, larger institutions must have a sophisticated rating system, with multiple categories that adequately reflect the risk differences across borrowers.

Efficient systems of credit risk rating, to facilitate informed decision-making, also promote the safety and soundness of the financial institution.

Rating systems estimate credit risk and differentiate individual transactions and credit groups based on risk. This allows management of the financial institution and supervisors to track changes and trends in risk level.

7.2. Desirable characteristics of a rating system for credit risk¹⁹

There is no single risk rating system applicable to all financial credit institutions. However, any system should have certain characteristics or fulfill certain functions, which are mentioned below:

- > To be the basis for estimating, monitoring and reporting of credit risk.
- > Support the decision-making process of senior management.
- > Be integrated into the overall management of portfolio risk;
- > Be approved by senior management, who must also delegating clear responsibilities for risk rating process and receive sufficient information to monitor their implementation.
- > Rate all exposures to credit risk.
- > Assign grades that reflect the risks that represent both the expected performance of the borrower, and the structure of the transaction.
- > Be dynamic, change the rating when the risk changes.
- > Subject ratings to independent validation (in addition to that provided by the supervisory authorities).
- > Determine, through retrospective analysis, if the assumptions underlying rating definitions of financial institutions are valid, meaning if they anticipate the results correctly.
- > Document accurately the ratings in the credit file.

It is noteworthy that in addition to increasing the number of rating definitions, some banks have introduced dual rating systems. These systems assign a rating to the credit quality of the borrower and one to each outstanding credit. The credit rating considers the protection afforded by collateral and other elements in the structuring of loans plus the credit quality of the borrower.

Dual rating systems arose because one grade was not enough to support all functions requiring a credit risk rating.

7. 3. Concept and design of a system for measuring credit risk²⁰

The credit risk measurement takes place in financial institutions through a system that can be more or less complex depending on the needs and goals of the organization.

The purpose of a system for measuring credit risk is to provide directly or indirectly, one or more exact or approximate measures that allow banks to quantify the credit risk of loans they have exposure to.

In this regard, the Committee on Banking Supervision states that: "in general, a model credit risk encompasses all policies, procedures and practices used by financial institutions to estimate the distribution function of financial assets exposed to credit risk. "

A system for measuring credit risk should include all strategies, policies, standards, procedures, rules, methods and models, as well as all tangible, intangible and human elements related in some way to all of them, the financial institution used to obtaining one or more measures to quantify credit risk which is exposed in the course of business.

The methods comprise the tools the bank uses in measuring credit risk, constituting a systematic procedure to be executed in an orderly and subsequent to that end. Furthermore, models are theoretical schemes expressed mathematically and are used to represent in simplified form the credit risk or one of its variables.

The design of a measurement system of credit risk requires taking a series of decisions on the elements that compose it and which are largely dependent on the results provided by the same.

7.4. Importance of Central Risk Information Systems in the Implementation of Credit Risk Models²²

Recently, in connection with the developments in Basel II, given the greater ability to quantify credit risk (generalization of concepts and methodology, technological innovation ...) and the need for the supervisor to validate future minimum internal models by financial institutions and estimates of capital requirements that they obtain, the Central Credit Information Systems are emerging as a key source of information for modeling (calculation and validation) of the probability of default (PD) of borrowers, as a favorable framework for monitoring loss given default (LGD) and as a certain baseline on which to validate estimates provided by the financial institutions regarding the value of the exposure at default (EAD) (...).

Clearly, therefore, the potential of Central Credit Information Systems and how they can contribute in a significant way in this new and crucial task involved the implementation of Basel II. (...) supervisors have a unique opportunity, with a relatively small, modular and adapt these instruments so that they can serve to facilitate the transition to Basel II with rigorous cost and orderly manner. To make use of the possibilities (...) it is necessary that the Central Credit

Information Systems contain minimal information available. First, it is necessary to establish that, for the calculation of the minimum requirements of each entity according to Basel II, the supervisor needs to have in his possession a set of minimum essential information (...), the value of the PD, LGD, the EAD, maturity, existing guarantees and the level of provisions are the fundamental elements that establish the starting point for extensive usage assumes that can have.

8. Statistical Models Measuring Credit Risk

There are several models, both quantitative and qualitative, that have been proposed to evaluate credit risk. In practice, entities often employ more than one of these models.

The choice of which model to use depends on the type of operation. The model of binary logistic regression is the statistical model proposed by this research to determine the probability of default and the expected loss of the portfolio of consumer loans of financial institutions in Paraguay.

I chose to use a regression model because it helps to evaluate what variables can be used to predict the probability of default of clients in a consumer portfolio.

8.1. Development methodology of probability of default and expected loss models²⁰

The process of developing statistical models consists of four steps:

a) Determination of the target variable. The aim of statistical models is to predict the behavior of the target variable, depending on the values adopted by another set of variables that could be called predictive variables. In the case of the default probability models the target variable is always the default probability defined as a probability that a given operation or customer enters default for the next twelve months.

b) Construction and analysis of candidate variables. Start by separating data that may make economic sense discarding those which, by their nature, are not related to the target variable that can give us information about their future behavior. In the case of individuals, for example, variables that may be observed are: solvency, assets, repayment ability, age, marital status, number of children, profession, appearance or not in the files of negative impacts, both internal to the bank and external account balances, account number and movement, profitability, etc.

c) Selection of predictor variables. Include the variables that have predictive power for indicating the operations or customers which have high probability of default of those that do not, but always do this by using statistical methods, never random or based on subjective criteria, and proceed to a selection of these variables. The goal is to stay with the smallest possible number of variables containing the greatest explanatory response to the target variable.

d) Selection of the modeling technique and model building. The statistical model can use a single technique or a combination of them. Once it is developed, it is applied to the sample to compare

the model predictions with results actually observed, thus measuring their predictive power. Finally, a series of checks are performed:

- The model is validated by applying it to another sample of the same portfolio.
- It is calibrated and the model is seasoned including samples corresponding to different time windows for calculating a probability of default adjusted to the business cycle.
- Basel II regulations cites the Bank's obligation to conduct a stress test in order to evaluate the effect of macroeconomic conditions on its regulatory capital requirements under the IRB approach.

8.2. Logistic Regression Model²¹

Logistic regression (RL) is a technique that involves the following basic elements:

8.2.1. Dependent or target variable:

It is the variable (qualitative) whose values define each of the groups (in this case default or non-default). When the target variable takes only two values, it is said to be binomial response variable and the values assumed arbitrarily can denote 0 and 1. If 3 or more values are assumed, is said to be multinomial response variables.

8.2.2. Explanatory or predictor variables:

Are the (qualitative or numerical) variables used to classify the item in any of the groups (default or not).

8.2.3. Logistic function:

The logistic function (when the response variable is binomial) has the structure:

$$p_i = 1 / [1 + e^{(-B_0 - B_1x_1 - B_2x_2 - B_3x_3 + \dots)}]$$

Where B_1, B_2, \dots are constants that are estimated in the known models, x_1, x_2, \dots are predictor variables and p_i is the probability that the response variable to assume the value of 1 (meaning that the probability that the response variable assumes the value of $0 = 1 - p_i$).

Binary Logistic Regression (BLR) is a tool that estimates an odds ratio (the probability that something is true divided by the probability that it is false) is that can be used to infer maximum likelihood estimators. Overall, logistic regression is appropriate when the response variable Y is dichotomous, that is, when there are only two possible answers. In this case, default or non-default.

8.3. Definition of variables for Binary Logistic Regression Model

These are some of the variables that can be used to build a logistic regression model for default in Paraguay:

- Sex (male and female): F or M.
- Internal Rate: is the internal ratings assigned by the financial institution after performing financial analysis and guarantees.
- Banking Superintendency rating: refers to the rating given by the financial supervision according to the height of overdue financial obligations.
- Days of non-payment: Days past due of each client, it is worth clarifying to take into account all products, i.e., considering the client holistically even if the bank holds only one defaulted product.
- New or Renegotiated: whether obligations are new or have been renewed or restructured for some reason.
- Maturity: refers to the time until the loan comes due.
- Guarantees: this includes collateral such as real or personal property that is pledged
- Age of the client if natural persons; for legal persons the age of the company.
- Segment: Corresponds to customer segment within total portfolio.
- Assets: The value of customer assets on its balance sheet.
- Average Amount of loans: Average loan granted to each client in the bank.
- Total Risk: Corresponds to the total exposure approved for the client in each financial institution
- Exposure available: The approved credit that is available but not currently used by a customer.
- Risk products: Number of current credit obligations to the bank.
- Earnings: profits or salaries that customers receive monthly
- Number of Children
- Marital Status: single, divorced, etc.
- City: where the customer lives
- BR: Bank Branch

9. Logistic regression model applied to a consumer loan of a Paraguayan financial institution.

The goal is to build a model capable of describing the effect of changes in explanatory variables on the probability that Y default (probability of default or event of interest we call success $Y = 1$).

9.1. Sample studied

The sample is composed of 10,000 customers (7,000 customers in non-default and 3,000 customers in default) of the consumer portfolio of a Paraguayan financial institution (the name of the financial institution evaluated is omitted for confidentiality reasons). Customers in default are those with greater than 60 days of non-payment.

I have built a simplified model which considers the following variables to determine whether they explain the probability of default:

- Tloan = Type of Loan
- NP = N° of Payments
- CBR = Central Bank Rating
- AG = Age
- SX = Sex
- MS = Marital Status
- BR = Bank Branch
- BIR = Bank Internal Rating

The variables used are a subset of the above list because of limited data availability.

9.2. Model Results

9.2.1. Model Validation

The model's predictive ability is summarized by the following results:

- The 97.78% of customers are correctly classified. The cutoff that was used is 0.5, meaning that if the probability is higher than that cutoff, clients will be classified as being defaulted.
- The significance of the statistical or p-value is less than 0.05, which determines that at least one of the predictors considered serve to explain the behavior of the target variable with a alpha level of 5%.
- Of the 3,000 customers who are predicted to go into default, 2,855 customers effectively entered into default. However, 145 customers did not enter into default and therefore are misclassified.
- Of the 7,000 customers who did not enter into default, the model predicted that 6,923 customers actually did not enter into default, and 77 clients entered into default, so they are misclassified.

It is important to mention that this simple model only consider data of one month, which is Dec. 2018.

Classification Table

	Suc-Obs	Fail-Obs	Clients
Suc-Pred	2855	77	2932
Fail-Pred	145	6923	7068
Clients	3000	7000	10000

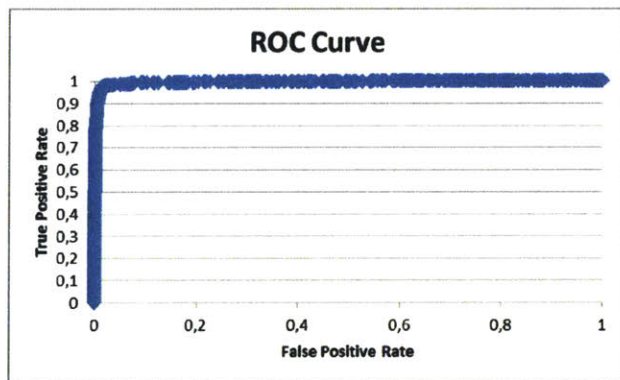
Accuracy 95,17% 98,90% 97,78%

Cutoff 0,5

9.2.2. ROC curve

The model also presents a good ROC curve which is the graph that shows the performance of a classification model in all classification thresholds.

Furthermore, it has been also evidenced that the model has an AUC (area under the ROC curve) of 1.0, which indicates that the predictions are 100% accurate.



9.2.3. Explanatory Variables

Considering the level of significance of less than 0.05, the variables that have more statistical significance in the model made that affect the likelihood that a customer fails to pay its debts are: TLoan, FR, CBR, AG, BIR.

	<i>coeff b</i>	<i>s.e.</i>	<i>Wald</i>	<i>p-value</i>	<i>exp(b)</i>	<i>lower</i>	<i>upper</i>
Intercept	-27,7222398	1,64156177	285,195173	0,000000	9,1282E-13		
Tloan	-0,48095308	0,08011347	36,0407901	0,000000	0,61819392	0,52836254	0,7232983
FR	-0,26424817	0,06845345	14,9016152	0,000113	0,76778298	0,67138371	0,87802354
CBR	2,48377566	0,12665924	384,548362	0,000000	11,9864357	9,35141907	15,36394
AG	0,76571956	0,04245539	325,292315	0,000000	2,15054127	1,97883547	2,33714617
BIR	1,75973673	0,16245018	117,342414	0,000000	5,81090734	4,22635632	7,98954031

9.2.4. Probability of Default

The default probability is determined by the following model:

$P(x = 1 \text{ "Default"}) =$

$$\frac{1}{1 + \text{EXP}(-27.72223976 - 0.480953084 \cdot x_1 - 0.264248168 \cdot x_2 - 2.483775656 \cdot x_3 - 0.76571956 \cdot x_4 - 1.75973673 \cdot x_5)}$$

Where B_1, B_2, \dots are the coefficients determined by the model, x_1, x_2, \dots are predictor variables and P is the probability that the response variable to assume the value of 1 (Default), (Non-default equals to 0 = 1 - P).

9.2.5. Determining the expected loss of the evaluated sample

PD (Probability of Default): Using the formula above is calculated probabilities of default of each of the 10,000 customers in the evaluated sample.

EAD (Exposure at Default): It was used the outstanding amounts due for each customer in the evaluated sample.

LGD (Loss Given Default): Considering that the consumer loan portfolio of banks generally do not have guarantees that mitigate the credit risk loss, a recovery rate (TR) of 10% is assumed, so

$\text{LGD} = 1 - \text{TR} = 90\%$.

Consequently, the expected loss of the sample tested is \$3,294,955. The provision that the evaluated Banking Institution already have for the costumers of the tested sample is \$2,673,421. The difference between them is USD 621.534. This amount represents the additional provision that the financial institution should make to cover the expected loss of the costumers included in the evaluated sample if my assumption about LGD is accurate.

CONCLUSION

In comparison to international best practices, I have shown that the Paraguayan regulatory framework for credit risk management has some weaknesses that should be corrected over time.

International best practices of credit risk management establish that banking regulations and supervisors should encourage financial institutions to have sound and prudent practices for credit risk. Experience shows that a major cause of bank failures is poor credit quality and deficiencies in assessment practices and credit risk calculation. If not identified and recognized at the right time, credit risk problems may be exacerbated and prolonged. Similarly, if the policies and procedures for credit risk are inadequate, it may take recognition and calculation of increased credit risk, which affects the adequacy of bank capital and hinders the proper evaluation and control of the bank's exposure to credit risk.

To overcome the regulatory weaknesses, the Central Bank of Paraguay should consider using credit risk models based on statistical methods, like the logit regression models, to determine the probability of default and the expected loss of the entire portfolio of small and medium debtors, consumer loans and microcredits.

As shown in this research, the applied logit regression model proved to be a useful tool to determine the main variables that influence the probability of default of consumer clients and to determine the expected loss of the portfolio.

Finally, the implementation of any statistical model requires that banks record and collect extensive data and information on their clients for a long period of time, like the data describe in the section 8.4 of this document. To make that feasible, the Central Bank of Paraguay would have to change the regulatory framework for credit risk to ask banks to collect those data.

EXHIBITS

Exhibit N° 1: Credit ratings Large Debtors and Medium and Small Debtors (Resolution N° 37 - Act N° 72 of 2011)

CATEGORY	DAYS OF NON-PAYMENT
1	Balance of loans overdue 60 days
2	Balance of loans overdue more than 60 and up to 90 days
3	Balance of loans overdue more than 90 and up to 150 days
4	Balance of loans overdue more than 150 and up to 180 days
5	Balance of loans overdue more than 180 and up to 270 days
6	Balance of loans overdue more than 270 days

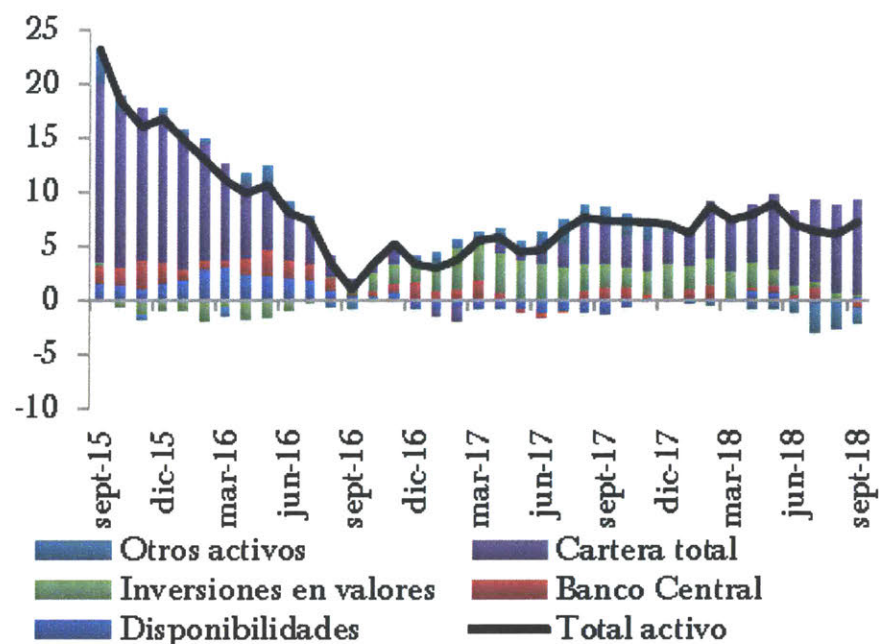
Exhibit N° 2: Consumer Loan Debtor (Consumer Credit and Housing)

CAT	DAYS OF NON-PAYMENT
1	Balance of loans overdue 60 days
2	Balance of loans overdue more than 60 and up to 90 days
3	Balance of loans overdue more than 90 and up to 150 days
4	Balance of loans overdue more than 150 and up to 180 days
5	Balance of loans overdue more than 180 and up to 270 days
6	Balance of loans overdue more than 270 days

Exhibit N° 3: Credit Rating for Microcredits (Resolution N° 37 – N° 72 Acta 2011)

CAT	DAYS OF NON-PAYMENT
1	Balance of loans overdue 60 days
2	Balance of loans overdue more than 60 and up to 90 days
3	Balance of loans overdue more than 90 and up to 120 days
4	Balance of loans overdue more than 120 and up to 150 days
5	Balance of loans overdue more than 150 and up to 180 days
6	Balance of loans overdue more than 180 days

Exhibit N° 4: Asset of the Banking System

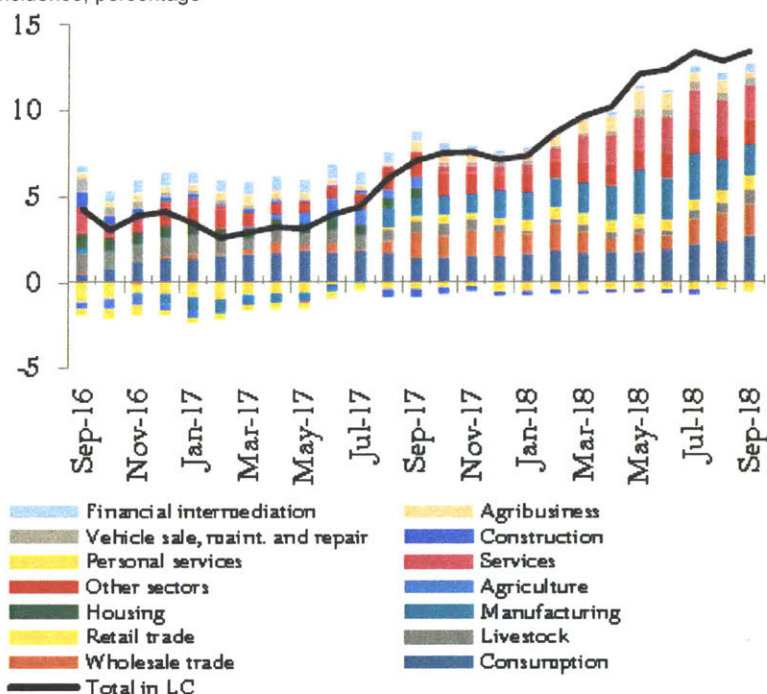


Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

Translation: a) Otros activos = Other Assets; b) Inversiones en Valores = Investments; c) Disponibilidades = Cash and Equivalents; d) Cartera Total = Total Credit Portfolio; e) Banco Central = Central Bank; f) Total activo = Total Assets.

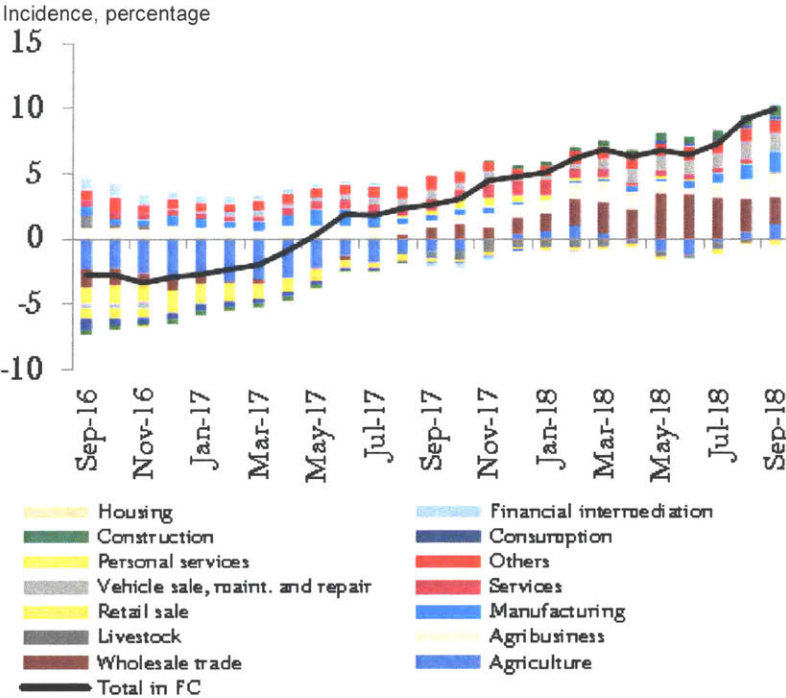
Exhibit N° 5: Loans in Local Currency

Incidence, percentage



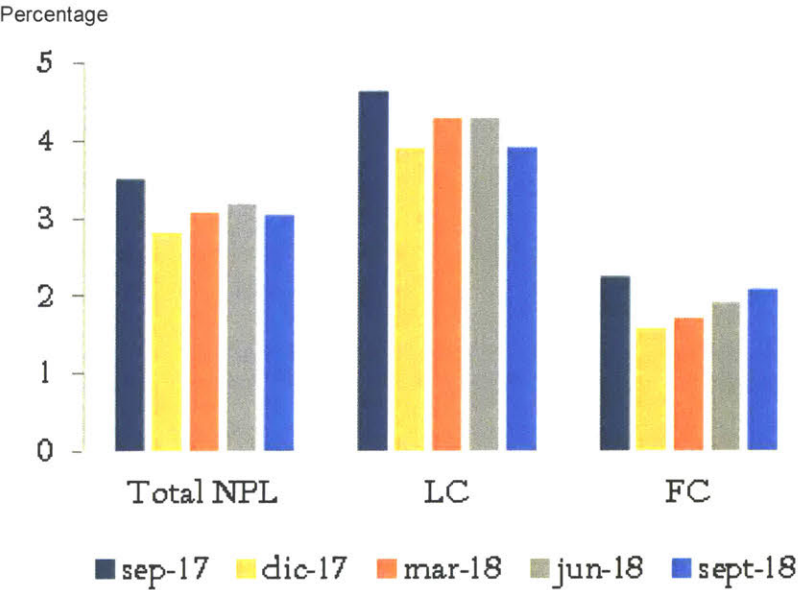
Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

Exhibit N° 7: Loans in foreign currency



Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

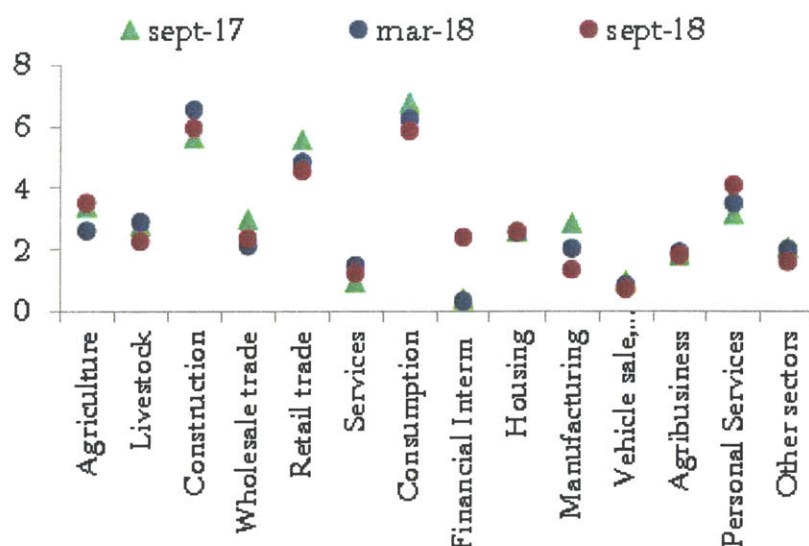
Exhibit N° 8: Non-performing loans



Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

Exhibit N° 8: Non-performing loans by Sectors

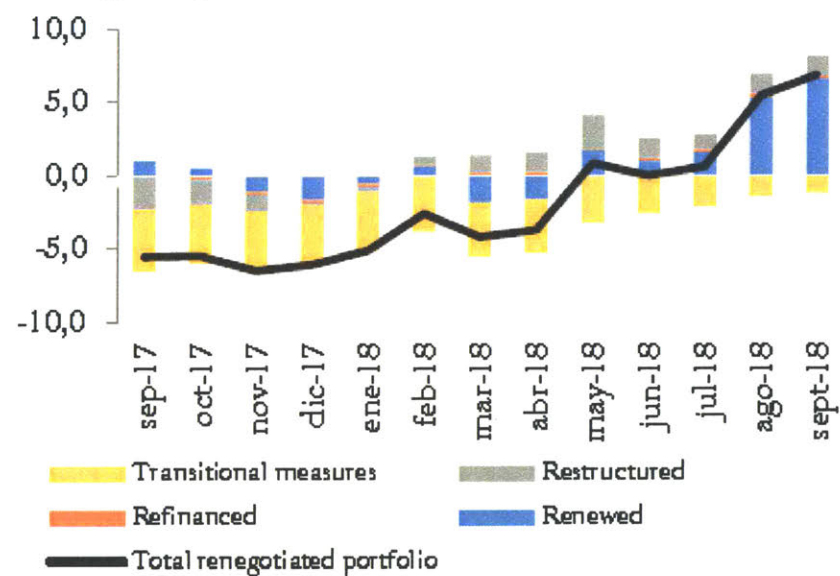
Percentage



Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

Exhibit N° 9: Renegotiated portfolio

Incidence, percentage



Source: Financial Stability Report - Central Bank of Paraguay (November 2018)

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