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STRESS TESTING: ASSESSING POSSIBLE IMPACTS OF COVID-19 PANDEMIA ON THE CREDIT DEFAULT IN PORTUGAL

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Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

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by

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Dissertation presented as partial requirement for obtaining the Master's degree in Statistics and Information Management , with a specialization in Risk Analysis and Management

Advisor: Professor Carlos Rafael Santos Branco

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DEDICATION

To my babies boys,

Artur and Francisco.

To my husband Tomé,

For unconditional support and dedication.

And God!

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ABSTRACT

The current health crisis is shaking the economic and financial world and Portugal was no exception. The present dissertation main goal is to assess the credit risk impact by the current situation due to COVID-19 pandemic in Portugal.

The key objective is to evaluate credit inherent risk, in order to be able to intervene in advance and to mitigate possible risks, as well as predict likely defaults.

In order to predict possible serious effects in terms of credit default having, the present dissertation has as its object the study of the impact of macroeconomic variables and their influence on credit default. An exploratory quantitative approach was used in the empirical study, complemented with a qualitative approach, focused fundamentally on the description of the results obtained with the SPSS software.

Linear regression models were tested, which were defined as independent variable o credit default. As dependent variables the indicators of credit risk management; UR, LR, LMC, LCC, LBC, EUR, GDP, PSI, DIG, CPI, ER and CP. Among all these indicators of credit risk management used, the ones that had the greatest impact were the LR, LMC, UR, GDP, CPI and CP have more significant effect. However, the variable CP does not suggest the existence of a direct and reliable relationship between the independent variable, but recent studies refer to it as one of the most important to be considered.

As noted in world history, the impacts of financial disasters, reinforce the need for systematic analysis and effective financial stability instruments. In order to forecast those situations, stress testing will be used to predict possible scenarios of induced financial crisis by the current healthy crisis, such as credit risk, in specific. To be able to foresee, a country macroeconomic analysis is needed, by merging several credit components, as established by the Basel agreements. The data herein as reference has taken from *Banco de Portugal, INE, Stooq and oecd*, since the 2003 to 2020, in order to be provisions regarding economic.

KEYWORDS

Credit Default, Stress Test; Scenario; Credit Risk; COVID-19

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LIST OF ABBREVIATIONS AND ACRONYMS

BCBS - Basel Committee on Banking Supervision

BCP – Banco Comercial Português

BPI – Banco Português de Investimento

BST – Banco Santander Totta

CGD – Caixa Geral de Depósitos

EBA – European Banking Authority

EAD – Exposure at Default

ECB - European Central Bank

EL – Expected Loss.

ES – Expected Shortfall

ICAAP - Internal capital adequacy assessment process

ICCMCS – International Covergence of Capital Measurement and Capital Standards

ILAAP - Internal Liquidity Adequacy Assessment Process

IRB – Internal Rating Based.

LGD – Loss given Default

M – Maturity

NAO - National Audit Office

PD – Probability of Default

p-value – *Probability Value*

SPSS – *Statistical Package of Social Science*

SREP – Supervisory Review and Evaluation Process

VaR – Value at Risk

1. INTRODUCTION

1.1. BACKGROUND

The main objective in this investigation was the choice of a theme that beyond relevant, were current: default credit in banks the present situation regarding coronavirus in our society.

Banks have the main goal of maximizing profits of its activity, which entails a rigorous evaluation and management risks incurred. It is absolutely necessary to understand the extent which default influences the financial structure.

Stress tests should be part of the institutions corporate culture and its results should impact risk management and strategic business decision making. Financial institutions should have a stress testing program able to provide risk identification and control, able to give complementary risk perspective in hand with other institutions inside tools and offer capital and liquidity management improvements as well. Stress tests must be flexible enough, covering a wide range of perspectives and techniques. Test variables should be evaluated regularly and independently (Supervision, May 2009).

The international financial crisis in 2007/2008 making a set of imbalances more visible came in the financial system. The financial risks taken by the institutions are extremely high, due to the lack of knowledge, with low levels of capitalization and a low liquidity. After few years of the crisis, there was a written legislation whose main objective was to increase the resilience of the financial system. In the Portuguese banking system, it was created a new regulatory requirement by supervision of institutions. The main objective was to build a higher capital and liquidity levels than those observed in the period before the international financial crisis.

The COVID-19 pandemic brought many measures, such as social lockdown, which ended up having significant economic consequences. Overall, many companies and individuals affected by the crisis may face low liquidity, as well as difficulties to meet its financial obligations, among others. Thus, financial institutions may therefore face credit issues, payment and obligations delays, which can lead to a large number of defaults.

The impact caused by COVID-19 pandemic will be felt on several fronts. It should be necessary to evaluate the strategies to be implemented and check the economic outcomes from them, even also assess health protection from the most vulnerable ones and general population as well.

The pandemic creates a situation uncertainty exacerbated, in particularly challenging for financial stability, at national and international levels, considering the scale of the shock that originates on the economy, assessed by its abrupt nature, its intensity and scope and also by its persistence. In contrast to the previous international financial crisis, this shock is exogenous to the financial sector and it is not directly related to the previous accumulation of macroeconomic and financial imbalances. (Portugal, Relatório de Estabilidade Financeira, June 2020)

The biggest discussion society is now facing the paradigm between protecting vulnerable groups, by blocking people and goods free movement, or economic activities full restart, increasing the risk of infection spread. Assessing a rapid economy reopening can lead to a greater number of infections, thus overwhelming the healthcare system, rendering to countless deaths, as well as consumer confidence will drop and portions of the economy will be shut down even with or without a government decree.

On the other hand, lockdowns are also a major public health concern as unemployment, loss of income, closed schools and less demand for medical attention can lead to long-term mental and physical health consequences, which may ultimately lead to increased mortality, as research suggest.

Government actions include other sets of measures such as social distancing, (add here other measures previously mentioned) financial stimulus and economy reboot plans of the based on the specific compensation of each country. The measures indicated by the government go through three distinct phases: first is to flatten the dissemination curve; the second, to fight the virus collectively, preserve public health and gradually reopen economy and society sectors; and third, to prepare the country for the future. However, it is mandatory to evaluate the impact on the economy, and on credit lines during this confinement period, and possible adverse scenarios that arise from it. Urgent issues include the path of shocks and recovery, whether economies will be able to return to production levels and pre-shock growth rates pre-pandemic and whether there will be any structural legacy of the coronavirus crisis.

As we are dealing with an entirely new situation, the properties of the virus are not fully understood and they can change, the role of asymptomatic patients is still imperfect; the true infection and immunity rates are unknown; the political responses are inaccurate and late and there will be errors; companies and families are uncertain with the future. Perhaps the only certainty is that any definitive prediction attempt will fail. However, analyzing multiple scenarios still adds value in this limited visibility environment.

The COVID-19 pandemic has brought us a new viral strain - SARS-CoV-2, a new situation never experienced and its economic impact is still unknown. There is a great uncertainty and political change is happening surprising fast. Contrary to normal times when the government wants to encourage economic growth and preserve employment, today governments themselves are deliberating recessions to save life and containment measures are crushing the economy. Provisional GDP calculations are constantly changing and declining at disastrous speeds. Governments and central banks are responding to this virus in order to protect lives, but without predicting the future impacts on the economy. There is a big political and economic upheaval, and through scenario analysis we can try to look for measures to mitigate a possible economic depression.

1.1.1. Problem Justification

The main reason of this study is the addition of literature on stress tests in the financial sector, to study an adverse scenario and macroeconomic variables, in Portugal. Assessing possible breaches of credit risk default in the banking sector is influencing the entire economy and a way to prevent a charge-off. Thus, it allows credit quality evaluation and to calculate possible losses, as a measure to intervene in order to prevent large losses.

1.1.2. Problem

In the next chapter there will be a review explaining the entire stress test program to be developed. The main considerations are as follows:

I. **Program of stress test**: Set of processes, with methodologies, documentation and regulation in which its main objective is to identify potential system vulnerabilities;

II. **Stress Test:** Prospective assessment exercise with a specific purpose that assesses the adverse events and circumstances, potential impacts on a specific portfolio;

III. **Sensitivity analysis**: Stress test methodology that allows us to evaluate the resulting impact from parameter, liquidity or portfolio value changes;

IV. **Scenarios analysis:** Stress test methodology that allows assessing, over a given time period, the impact resulting from simultaneous and coherent variations in a set of parameters relevant to liquidity or the portfolio value.

This type of testing arises from the need for a prospective view of credit losses when exposed to adverse scenarios. Thus, it shows up the need to create and develop contingency and risk mitigation plans in stressful conditions, and so revealing the main issue, raised up by this research, that consists of review the macroeconomic factors that may affect credit risk, from the epidemiological crisis of COVID-19, in Portuguese society. In addition, the results should be used to identify, measure, evaluate, monitor and mitigate of the society's risks:

i. Review of risk appetite levels;

ii. Review of policies, strategies and limits established for risk and capital management purposes;

iii. Capital adequacy assessment;

iv. Attain a stress test based on scenarios provided by the Regulator.

1.1.3. Objectives

1.1.4. Main objective

The main objective of the study is to identify the main macroeconomic factors that may affect credit risk.

1.1.5. Specific objectives

In order to achieve the general objective, the specific objectives are as follows:

I. Literature review regarding credit risk, stress tests and known macroeconomic factors;

II. Propose a model for default rates;

III. Test the model;

IV. Evaluate the results.

1.1.6. Study relevance and importance

Present study may contribute to policies and market in order to prevent an attainable crisis, identifying the main factors of default at the macroeconomic level.

2. LITERATURE REVIEW

2.1. SECTION I REGULATION, CREDIT RISK AND MACROECONOMIC COMPONENTS

2.1.1. Framework history and regulation - Basel Committee on Banking Supervision

There are same important crisis in our history. The first one is Great Depression of 1929. The second one is Subprime Crisis, when in September 2008, US authorities decided not to save investment bank Lehman Brothers, witnessing further deterioration economic activity and the financial system. In 2008 was marked by the crisis in the international financial markets and by the economic slowdown global level, translating into a particularly adverse framework for the performance of the activity of banks.

According to the International Monetary Fund the high leverage, levels insufficient capital and inadequate contingency plans were factors that contributed to serious financial problems.

The global proportions that the financial crisis had assumed, the European Development Fund and European Central Bank began to exercise more actively their role as the highest financial supervisory authority, promoting measures to contain the negative effects and reserve the recessive scenario created in order to prevent this crisis from assuming systemic proportions.

In the 1970s, there was great instability in the international markets, therefore the G10[1] Central Banks established a Basel Committee on Banking Supervision (BCBS). This was a worldwide forum for discussion and cooperation on prudential banking regulation. The main goal was to harmonize the banking supervision standards for regulatory capital assessment.

Currently BCBS consists of 19 nations, 32 economies, known as the G20[2]. Its main purpose is to create standard rules for all international economies belonging to the group, nevertheless each country ends up regulating according to its principles. The Basel accords aim to reduce the likelihood of systematic risk, with a focus on liquidity, creating defense mechanisms against possible financial crises. (Vasconcelos, Peres M., & Cristóvão, 2017)

There are 3 Basel Accord in existence: Basel I, Basel II and Basel III agreements. Basel I approved a set of regulatory proposals for the world banking sector in 1988, the International Convergence of Capital Measurement and Capital Standards (ICCMCS). The agreement made it possible to measure the requirement capital to cover additional credit risks in the financial system and to minimize the bankruptcy risk. From this agreement highlights the establishment of minimum regulatory capital requirements to ensure the solvency of financial institutions and the system robustness promotion,

[1] The GAB was formed in 1962, when the governments of eight IMF members—Belgium, Canada, France, Italy, Japan, the Netherlands, the United Kingdom, and the United States—and the central banks of Germany and Sweden, agreed to make resources available to the IMF.

[2] The G20 members are Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Republic of Korea, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States and the European Union (EU)

through the creation of a unified standard for all international banks, thus reducing the competitive imbalance between institutions. (Vasconcelos, Peres M., & Cristóvão, 2017)

The progress made with Basel I in regulatory framework was undeniable. However, in view of the shortcomings in the previous accord, regarding to capital arbitrage[3] the new Basel Accord, known as Basel II, was published in 2004. It defined how to apply the new capital requirements, which is more sensitive to credit and market risks. Under the New Accord, credit risk measurement approaches are classified into two types: standardized and based on Internal Rating Based (IRB). The introduction of IRB methodologies, internal ratings, are the main innovation of this accord, aiming to make capital requirements more dynamic and sensitive to risk. Furthermore, to improve credit risk management, Basel II introduces the operational risk as a major minimum capital requirement risk component (Vasconcelos, Peres M., & Cristóvão, 2017).

BCBS agreement is structured on three pillars:

Pillar I: determination of minimum capital requirements: topics related to the determination of minimum regulatory capital requirements to cover credit, market and operational risks are addressed. With the implementation of this pillar, it is expected that banking institutions will be able to use their own methodologies and more sensitive risk, ultimately, they can benefit from lower risks than those using standard methodologies.

Pillar II: supervisory review: qualitative supervision will be carried out by regulatory entities off internal control of bank risk, requiring from banking authorities' strategies to maintain suitable levels of capital. In addition to the reinforcement of the external supervision, Pillar II seeks to establish a set of internal risk management procedures, so that financial entities could be able the capital's suitability and sufficiency. This set of procedures was called the Internal Capital Adequacy Assessment Process (ICAAP), which includes stress tests, which should be carried out with the proper frequency.

Pillar III: market discipline: new conditions for public disclosure of financial reports with information about risks, with the purpose of improving banking risk management.

The Basel III: Agreement is a response to the main vulnerabilities presented by the banking sector during the 2008 financial crisis. The Basel Committee introduces a series of changes related to Basel II, with emphasis on the capital structure of financial institutions, expansion of banks' resilience and strength.

In this agreement, a series of studies about the causes and impacts of the crisis began:

- Identifies the main flaws in the regulatory models in force in the Basel II agreement.
- Reshapes the operational framework in order to improve the ability of financial institutions to absorb shocks provided by the financial system or some sector of the economy.
- Reduces the risk of contagion in the financial sector.

[3] Arbitrage is the purchase and sale of an asset in order to profit from a difference in the asset's price between markets. It is a trade that profits by exploiting the price differences of identical or similar financial instruments in different markets or in different forms.

After the crisis in 2009, the Basel Committee made a set of measures requiring banks to integrate market risk calculations based on VaR models and accompanied by "rigorous and extensive" stress tests.

In May 2009, the Basel Committee published the final version of its recommendations on stress testing practices and how stress testing should be supervised by regulators (Supervision, May 2009). The recommendations emphasize the importance of stress testing in determining how much capital is needed to absorb losses (regulatory capital).

These recommendations highlighted the importance of top management and the involvement of the board. Bearing in mind that top management and the board of directors must be involved in the establishment of stress test objectives, scenarios definition, the discussion of the stress tests results and the evaluation of potential actions as well as decision making. He says that the banks that went well in the mid-2007 financial crisis were those in which senior management as a whole was actively interested in the development and operation of stress tests, contributing these results for the strategic decision making. The stress test must be carried out in all areas of the bank as a hole.

The Basel recommendations state that many of the scenarios chosen before 2007 were based on historical data and therefore less severe than what actually happened. Specific recommendations for the banks are:

I. The stress test must be an integral part of the bank's culture and risk management, and so, it must affect decision making;
II. The bank must have a stress test program that involves the promotion and the identification of risk control, which improves the company's management on capital and liquidity as well as internal and external communication;
III. It must be taken into account the standpoint of the entire organization and cover a variety of perspectives and techniques;
IV. Policies and procedures must be placed into paper by the bank;
V. Flexible infrastructure to accommodate changes in stress tests;
VI. Individual components must be frequently evaluated;
VII. Cover risks to areas of negotiation - in order to provide a complete risk image of the entire company;
VIII. The stress tests must cover a variety of prospective scenarios and must consider interactions in the system and its feedback effect;
IX. To include a series of losses, taking into account that its reputation must be maintained among the shareholders;
X. Consider simultaneous market pressures and active asset financing;
XI. To be effective in risk mitigation techniques;
XII. They must include complex and personalized products;
XIII. They must cover risks of pipelines and warehouses;
XIV. Improve stress testing methodologies to capture the effect of international risk;
XV. Evaluate the vulnerabilities of the assets classes.

The recommendations for top management or senior bank managers are as follows:

I. They must regularly evaluate the stress test program;

II. Take corrective measures;

III. Assess the severity of the scenarios, sensitivity to portfolios or parameters;

IV. Internal capital assessment and liquidity risk;

V. Implement stress exercises in common base scenarios;

VI. Identify systematic vulnerabilities.

2.1.2. Credit Risk

The main activity of banks is the granting of credit, to finance consumption or investment by the population. The bank credit is a relevant instrument for leveraging economies, critical to possible new productive combinations, and these will be at the basis of the economies dynamics. There are internal studies of banks in order to predict situations of default. Basel I came to define what credit risk was, defining the probabilities of default. BCBS defined credit risk operations, which include guarantees and investments in bank securities.

> *"Banking credit is a right that the Bank acquires, throughout an initial cash delivery (real or potential) to a customer, to receive from that customer the amount due, on future dates, one or more cash installments whose total value is equal to the initial delivery plus the price fixed for that service (interest and commissions). (APB, 2020)*

According to Taborda et al. (2004), cited by (Veloso, 2016), when we refer to bank credit, we must take into account the following six elements:

Purpose: "what will be acquired with the amount provided by the bank and its use" (Nunes, 2009 - quoted by (Veloso, 2016);

Term: according to Taborda et al. (2004), referenced by (Veloso, 2016), can be classified as:

- Short term: maturity <1 year;
- Medium term: 1 year <maturity <5 years;
- Long term: maturity> 5 years.

Price: interest and commissions. Among other variables, the greater the risk involved in the operation, the higher the price to be charged (Veloso, 2016);

Amount: determined according to the clients' needs and the value of the asset to be acquired (Nunes, 2009 - cited by (Veloso, 2016);

Potential **loss** resulting from the credit operation (Veloso, 2016);

Guarantees: they are a way of compensating the creditor for a possible loss in the business or one (Amaral et al. (1997), cited by (Veloso, 2016).

The definition of credit risk also includes other definitions, as mentioned (Veloso, 2016):

Counterparty Risk - understood as the possibility of non-compliance, by a certain counterparty, with obligations related to the settlement of transactions that involve the trading of financial assets, including those related to the settlement of derivative financial instruments;

Country Risk - understood as the possibility of losses associated with non-compliance with financial obligations under the terms agreed upon by a policyholder or counterpart located outside the country, as a result of actions taken by the government of the country where the policyholder or counterparty is located, and the risk of transfer , understood as the possibility of the occurrence of obstacles in the currency conversion of the amounts received;

Commitment risk - understood as the possibility of disbursements to honor sureties, guarantees, co-obligations, credit commitments or other operations of a similar nature;

Intervener risk - understood as the possibility of losses associated with to the non-compliance with financial obligations under the terms agreed by an intermediary or convention of credit operations;

Concentration risk - understood as the possibility of credit losses resulting from significant exposures to a counterparty, a risk factor or to groups of related counterparties through common characteristics.

2.1.3. Credit Risk Components

The Basel II agreement came to provide guidelines for measuring capital risk, using internal parameters.

The minimum requirements for calculating credit risk capital (IRB Approach) are the following:

Default Probability (PD), percentage that corresponds to the long-term expectation of default rates, with a time horizon of 1 (one) year for borrowers of a certain level of credit risk or homogeneous group of risk;

Exposure at Default (EAD), corresponds to the value of the institution's exposure, whether effective or contingent, to the borrower or counterparty at the time of the event of default, gross of provisions and possible partial reductions at loss;

Loss Given Default (LGD), corresponds to the percentage, in relation to the observed EAD parameter, of the economic loss resulting from the split, considering all relevant factors, including discounts granted for credit recovery and all direct and indirect costs associated with charging the use;

Effective Maturity Term (M), corresponds to the remaining term of the operation weighted by the cash flows for each future period.

Financial institutions, to quantify credit risk, are authorized to use one of three approaches or methodologies: standard methodology, Internal Rating Based (IRB) Foundation methodology (or simple internal method) and IRB Advanced (or internal methods advanced). (Pereira, 2019)

In the standard methodology, the risk weights vary according to the rating given by the rating agencies certified by the supervisory authorities. These ratings vary with the degree of compliance of the debtor and by its nature, namely international organization, institution, sovereigns, companies or real estate. (Pereira, 2019)

In the IRB methodology, the bank uses internal credit risk estimates to measure the capital requirements. However, to use the internal models, the institution is subject to the approval of the regulator, and it is necessary to comply with a set of requirements.

In summary, within the IRB, banks can choose a basic internship (Foundation) or an advanced internship (Advanced). In the first, banks use internal estimates for the default probability associated with borrower's category, and supervisors provide other inputs (risk components). In the second, banks are allowed to develop an internal capital allocation process considering internal estimates for the risk components. (Pereira, 2019)

In the IRB approach, financial institutions can assess the Expected Credit Losses (ECL) of their credit exposure. The percentage of EL is calculated by the product of the PD with the LGD; when multiplied by EAD, the expected loss (EL) is obtained in absolute value - according to Equation:

$$ECL_t = LGD_t \times PD_t \times EAD_t$$

There are three variable that can be developed for LGD and PD. For present dissertation will focus on the PD calculating method, but it is important to understand the concept.

The probability of default is the probability of counterparty defaulting, it is meaning that there not be able to make payments previously agreed the completion of the credit assignment agreement. The LGD reflects the percentage of exposure the bank expects to lose4 if the counterparty default, and the EAD reflects an estimate of outstanding amount in the case of the counterparty default.

The parameters described above depend an idiosyncratic and systematic component. The systematic component can be explained by external factors, such as macroeconomic components.

2.1.4. Macroeconomic components are influenced credit risk

A perspective of forecasting and developing stress scenarios, motivated by factors external, in order to respond to the challenges set out above (stress test), banks were forced to develop models in which the default variable, it can potentially be explained by macroeconomic factors, exogenous to the dependent variable. The formulation of these econometric models aims to try to predict the probability of default, but also that of the various transitions between risk classes, represented typically by a matrix of migrations.

Macroeconomic stability is a fundamental determinant in the banking system (Chaves, 2017). Macroeconomic variables influence the banking system, as well as a country's GDP growth, inflation rate, the interest rate, loans granted, unemployment rate, household disposable income, exchange rate was influence economy.

There is a large literature on credit default risk and economic activity, that is referred to a contagious effect cycle, the main factors are credit risk, its default and economic activity. The most studied hypothesis emphasizes the relationship between the default rate, income and revenues being interconnected, in expansionary phases these variables have opposite signs, low default rate and high yield. Likewise, when the economy is recession, the charge off increases and the remaining variables decrease. (Chaves, 2017)

GDP is the business estimate of all goods and services created in a territory in a given period of time. GDP growth is seen as an image of progression, composed of the totality of private and public consumption and investment, public and private. The symbols of a country's economic growth is GDP growth, this is a variable intrinsically linked to the development of the financial system. GDP was characterized by the business estimate of goods and services created in a territory, during a period of time, usually one year. GDP growth is seen as an image of the country's progression, adding private and public consumption, with public and private investment. (Yahaya & Oni, 2016)

Repullo & Salas (2011) suggest the need for a capital cushion when the economy is high, in order to leverage the economy when it presents lower than expected GDP results and a recession trend, happens at the moment when debtors fail to repay credits, leading to high default rates and major bank losses.

There are studies that denoted GDP growth rate has a negative effect on problematic loans, times of recession, credit defaults increase. (Chaves, 2017)

Another similar study by Amuakwa-Mensah and Boakye, cited by (Chaves, 2017) refers a significant empirical evidence of a negative relationship between real GDP growth and credit default. The negative relationship is related to the fact that with the increase in real GDP, it generally translates into an increase in disposable income, there may be a decrease in charge off.

A healthy economic environment means an increase disposable income and consequently a reduction of unemployment. According to several authors who studied the relationship between credit variables and unemployment, they found a strong positive correlation between credit and unemployment. That means that with the lack of employment the borrowers fail the payments. (Chaves, 2017)

Disposable income is the amount of money that households have available for spending and saving after income taxes. Disposable income is closest to the concept of income as generally understood in economics. Household disposable income is the sum of wages and salaries, mixed income, net property income, net current transfer and social benefits. (OECD, 2020)

Inflation occurs when there is a persistent increase of prices of goods and services without an increase level of production. It means currency unit is able to buy less goods and services from another economy. This factor is associated with an increase currency in economy. (Yahaya & Oni, 2016)

When this situation occurs, of rising inflation, monetary regulators try to keep up with the increase interest rate, in order to control inflation. This measure has consequences on the level of credit, leading to an increase in borrowing costs. Inflation also has an influence on households' purchasing power. (Chaves, 2017) It can mean an increase in credit default. Therefore, it is expected that there will be a positive relationship between inflation and credit default.

The exchange rate is value of a national currency, in units of foreign currency. The nominal exchange rate is expressed in monetary units, on the other hand, the real exchange rate expresses the purchasing power of a national currency involved in foreign transactions of goods to be acquired in a country in exchange for the same set in the outside. (Yahaya & Oni, 2016)

The exchange rate has an effect on the competitiveness of domestic products abroad, so the devaluation increases the competitiveness of domestic products abroad, which may increase exports, production and employment, and there may be an increase in domestic prices causing inflation. (Chaves, 2017)

A devaluation of the value of domestic currency can make imported goods very expensive, so banks are at high risk of defaulting on credit. (Chaves, 2017)

Euribor is meaning Euro Interbank Offered Rate. The Euribor Rates are based on the average interest rates at which a large panel of European banks borrow funds from one another. There are different maturities, ranging from one week to one year. The Euribor rates are considered to be the most reference rates in European money market. (Euribor, 2020)

The relationship between the default and the interest rate is through the cost to borrowers, when interest rate increase default will be also increase.

Cited by Chaves, the interest rates on loans for the evolution of credit default rates are relatively small, since they only have an impact on the short-term policies established by central banks.

2.2. SECTION II STRESS TEST

2.2.1. A brief history of stress testing on banks

Before the financial crisis, banks performed stress tests to assess their internal risks, but it was a simple exercise with few impacts on policies and decision-making. After the financial crisis, stress tests became an important tool to support risk management and assumed a leading role in regulatory activity.

The crisis in the 1990s and the current financial instability have increased the importance of a better understanding of possible vulnerabilities in the financial system for regulators and bankers. Thus, several quantitative techniques have been developed to assess potential risks in financial institutions. These techniques are called stress tests. Basel Committee on banking supervision suggested testing in the financial sector (Chowdhury, 2010).

The first stress tests based on scenario analysis appeared in the mid-1990s. Managers began to assess their portfolios through statistical analysis based on historical and hypothetical scenarios. Historical scenarios are based on past events with a view to the future. Although this is an essential tool, the problem is that past events may not be repeated in the future, hence the need to introduce hypothetical tests, based on serious but plausible events. These hypothetical events are based on changes in the outlook for economic growth. At the time, there was no pattern for the use of stress tests, there were banks that used the tests to quantify the maximum loss of a bank in a given portfolio, while other banks sought limits on trading or quantified the amount of capital to finance a specific portfolio (Westwood, Dent, & Segoviano , 2016)

In 1996, there was a change to the international regulatory capital regime for the market risk, that is, the risk of losses in positions due to changes in market prices. After this change, banks began to use their internal models to quantify market risk to determine the capital required in the default's event.

In 1999, the Basel Committee on Banking Supervision (BCBS) saw little progress in the techniques and their application on the market, therefore it developed techniques to implement the stress test applied to credit risk.

In 2004, Basel II, arises the first steps to assess credit and market risks arise in order to determine the necessary capital, known as regulatory capital. After this standard, banks were required to assess their credit risk stress tests. Despite this, Basel II had not been implemented by all economies before the start of the financial crisis. Before the crisis, even banks that had the stress test model in place were unable to predict the 2009 crisis. The purpose of these tests is to provide a quantitative measure of the vulnerability of a country's financial system to different macro-financial scenarios and to complement the ideas collected by other components of the evaluation. This includes qualitative vulnerability assessments and a review of regulatory and crisis management in a country. (Westwood, Dent, & Segoviano , 2016)

In 2007, the United States experienced the worst financial crisis since the 30's. The crisis rapidly spread from the United States to other countries and from financial markets to the real economy. Some financial institutions failed. Many more had to be bailed out by national governments. There can be no question that the first decade of the twenty-first century was disastrous for the financial sector. Risk management has now assumed a much greater importance in financial institutions (Hull, 2018)

Stress tests evolved greatly when central banks started to develop their own tests. The global financial crisis has highlighted substantial deficiencies in risk measurement and management across the financial sector. The financial crisis has also brought about a radical change in the use of stress testing in the regulatory sphere. Regulatory stress tests have moved from isolated small-scale exercises within the broader risk assessment program to comprehensive large-scale risk assessment programs in their own right, leading directly to political responses. (Westwood, Dent, & Segoviano , 2016)

There are some lessons to be learned from the last crisis, so that the same mistakes are not repeated. Risk managers must observe the situations that occur, even if they are good for the economy and make sure that difficult times may arise. Managers must also observe and make calculations to stimulate the economy, they must be aware that in stressed markets, correlations of normal market conditions shall not be used. Always bear in mind that recovery rates are always at odds with default rates, as the recovery rate decreases, the default rate increases. (Hull, 2018)

2.2.2. Banking system overview

The banking stress test is designed to test banks' resilience to severe shocks. This means shaping the impact of hypothetical adverse macroeconomic and financial scenarios on banks' profitability and balance sheets.

Adverse scenarios usually contain hypothetical future paths for a set of economic and financial variables in the market, which, together, can stress the banking business models and lead to losses. These scenarios were designed to be much worse than the central expectations of the stress test authorities about how economic activity and financial market development are likely to do. These examples may include scenarios similar to severe recessions with falling GDP, sharp contractions in house prices and rising unemployment. Analysis of the impact of a scenario involves modeling the way in which it would likely affect different aspects of the participating of the banks' businesses. For example, an increase in unemployment reduces the income of some families and therefore more families may fail to pay their mortgages and other loans.

From the point of view of central banks and regulators, stress tests have the potential to support risk measurement and management. In other words, in addition to helping to measure the impact of possible future shocks on individual banks and a wider banking system, they can also be used to help define prudential policies designed to ensure that individual banks (microprudential policy) and the system banking as a whole (macroprudential policy) are adequately resilient. For example, the results of stress tests help policymakers to define the capital requirements that exist to ensure that banks benefit from sufficient loss-absorbing capital to reduce the probability of failure. (Westwood, Dent, & Segoviano , 2016)

The impact evolution between banks at the same time, allows to understand possible specific shocks that will affect all banks. Therefore, it is possible to determine the impact of the shock on the entire system, thus the risks for the provision of financial services to families and companies. This exercise combined with others supports the attempt to quantify the impact of the feedback and amplification channels that operate in the banking sector and between banks, the broader financial system and the economy in general. These mechanisms serve to exacerbate the impact of an initial shock and spread its effects to a greater number of institutions. For example, banks that seek to limit the impact of stress

can reduce their lending, thereby contributing to a further squeeze on the economic activity and further increasing the probability of damaging their lending. The incorporation of feedback and amplification channels in a stress test helps macro-prudential authorities to quantify the impact of adverse events throughout the system and supports them in the development of policies that apply to all banks in order to promote and improve the financial stability. (Westwood, Dent, & Segoviano , 2016)

2.2.3. How to use stress test results

When Hull (Hull, 2018) refers to use scenarios where there is a large move in one variable and other variables are unchanged. Examples of this type of scenarios of this type that are considered sometimes are:

1. A 100-basis-point parallel shift (up or down) in a yield curve.

2. Increasing or decreasing all the implied volatilities used for an asset by 50% of current values.

3. Increasing or decreasing an equity index by 10%.

4. Increasing or decreasing the exchange rate for a major currency by 6%.

5. Increasing or decreasing the exchange rate for a minor currency by 20%.

The results of stress tests can have many purposes. The stress tests are tools for measuring and managing the risks that banks face prospectively. Regulators use this information as a result of a quantitative assessment of the risk scale to which banks are exposed, that allows the decision making according the obtained results, and the production of microprudential[4] and macroprudential[5]. policies.

A major objective is to ensure that regulators use the stress tests in a properly and understood way, becoming important the communication of results and the adaptation of political decisions to results.

The publication of the stress test must be done clearly to the scenarios, together with the results, so that external observers can perceive the banks' resilience to the various risks incorporated. It is also intended to increase a bank credibility with the stress test, providing information to investors about the risks. A combination of a clear communication strategy and a political reaction structure can positively influence the bank's behavior. That is, the bank can take preventive measures to strengthen its capital position before the results of the stress test are released.

[4] The microprudential policy aims to ensure the solvency and financial strength of each of the institutions in the long term and, therefore, the stability of the financial system and to ensure the security of the funds entrusted to the institutions. Consulted by https://www.bportugal.pt/page/micro-objetivos-e-principios.

[5] The macroprudential goals is to make the financial system resilient to risk absorption, ensuring adequate levels of financial intermediation and contributing to sustainable economic growth. As a national macroprudential authority, Banco de Portugal defines and implements macroprudential policy. Consulted by https://www.bportugal.pt/page/politica-macroprudencial.

Stress tests focused on regulatory capital, also called solvency-oriented tests, are an analytical tool to assess the requirements established for the capital structure.

The results of stress tests are subject to a great degree of uncertainty, because it depends on the methodology used. Regulators should place more emphasis on the development of stress tests in order to increase their utility in micro and macro-prudential policies. In order to improve the ability of stress tests to assess banks' resilience and explore the types of risks, integrate amplification and feedback mechanisms in response to behaviors resulting from stress tests, and finally, expand the scope of stress tests beyond the main banking sector. (Westwood, Dent, & Segoviano , 2016)

2.2.4. Main objective of Stress Test

The stress test involves analyzing the impact of one or more hypothetical scenarios, in relation to the bank's capital. (Portugal, Banco de Portugal, 2020)

The hypothetical tensions involved are designed to test banks resilience against the risks they face and tend to be adverse scenarios macroeconomic and financial market, such as a severe recession combined with financial market problems. These projections represent unlikely severe results, chosen by stress testers, because they can have a material adverse impact on banks. If these hypothetical events were to materialize, they would likely lead banks to make losses and reduce the amount of capital available to absorb other losses. (Portugal, Banco de Portugal, 2020)

Stress testers often supplement these adverse scenarios with a baseline scenario in which the macroeconomic and financial environment evolves according to their central expectations. Baseline projections can provide useful information on banks' expected strategies for the coming years, as well as providing a benchmark for analyzing results under hypothetical stress.

Projections of banks capital positions conditioned to the stress scenario tend to be the main results of a stress test. The results can be used for a variety of purposes, with some authorities using them as a tool to highlight financial stability risks, some using them as part of their approach to define individual bank capital requirements and others using them to help define macroprudential policies.

Stress testing is a simulation technique used to determine the reactions of different financial institutions under a set of exceptional but plausible assumptions, through series of tests. At the institutional level, stress testing techniques provide a way to quantify the impact of changes in various risk factors on the institutions' asset and liability portfolio. For example, a portfolio stress test makes a rough estimate of the portfolio's value using a set of exceptional, but plausible, events in abnormal markets. However, one of the limitations of this technique is that stress tests do not explain the probability that these exceptional events will occur. To this end, other techniques, for example, Value at Risk (VaR) models, etc., are used to complement stress tests. These tests assist in risk management within a financial institution to ensure the optimal allocation of capital across its risk profile (Chowdhury , 2010).

Financial firms used stress testing to potential their vulnerability to exceptional. The most common of these techniques involve the determination of the impact on the portfolio in the market risk or simultaneous in a number of risk factors. After that they need to develop to analysis, they draw with

experienced in the past, historical scenarios or they think through the consequences of a plausible market event, hypothetical scenarios. Other techniques used by some firms to capture their exposure to extreme market events include a maximum loss approach, in which risk managers estimate the combination of market moves that would be most damaging to a portfolio, and extreme value theory, which is the statistical theory concerned with the behavior of the "tails" of a distribution of market returns (Stress Testing Best Practice for Member Firms, December 2015).

At the system level, stress tests are primarily designed to quantify the impact of possible changes in the economic environment on the financial system. System-level stress tests also complement institutional-level stress testing, providing information about the sensitivity of the general financial system to various risk factors. These tests help regulators to identify structural vulnerabilities and general exposure to risk that can cause disruption in financial markets. Its prominence lies in possible externalities and market failures (Chowdhury , 2010). Companies that manage assets and investments generally use stress tests to determine portfolio risk and then establish the necessary hedge strategies to mitigate possible losses. Specifically, their portfolio managers use internal stress testing programs to assess how well the assets they manage can face with certain market events and external events.

2.2.5. Subjective vs objective probabilities

Hull defined two types of probability estimates: objective and subjective. An objective probability of an event is a probability calculated by observing the frequency of an event happens in repeated trials. Unfortunately, most of the objective probabilities calculated in real life are usually less reliable, because of the probability of the event occurring does not remain constant for the observations that are available and the observations may not be independent.

A subjective probability is a probability derived from an individual's personal judgment about the chance of a particular event occurring. The probability is not based on historical data. It is a degree of belief. Different people are liable to have different subjective probabilities for the same event.

The probabilities in historical simulation are objective whereas the probabilities assigned to the stress testing scenarios are subjective. Many analysts are uncomfortable with subjective probabilities because they are not based on observed data. It is also unfortunately the case that political considerations may play a part in a financial institution's decision to focus on historical data.

However, if it is based only on objective probabilities, risk management is inevitably backward looking and fails to capitalize on the judgment and expertise of senior managers. It is the responsibility of those managers to steer the financial institution so that catastrophic risks are avoided.

2.2.6. Improvement stress test to assess the resilience of the bank

Carrying out the stress tests, with the assessment of possible impacts of severe hypothetical shocks, allows to provide useful information to top managers for the creation of microprudential policies on

the institution's resilience. There are two metrics being developed by the new stress tests: liquidity and financing resilience. Both provide information regarding the bank's ability to meet its short-term obligations as depositors and other creditors withdraw their deposits. Another metric is the assessment of how quickly and easily banks are able to convert their assets into cash. (Westwood, Dent, & Segoviano , 2016).

Financial institutions have evolved their internal stress test structures. There are three strands where the stress tests are used. Business planning, through the identification of potential obstacles that the business plan may face and the analysis of hypothesis. The second is capital planning, contributing to the analysis of the institution's adequacy in different capital scenarios, so that they meet the solvency requirements. Finally, risk management is the central tool that defines and monitors the institution's exposer risk. In order to fulfill these objectives, financial institutions have integrated the following requirements in the management of the stress test: Involvement of the management in the definition of the stress test structure and the consequent dissemination of results; evaluation of stress tests by several specialists in each area; Linking the results of the stress tests through risk weighting metrics against equity; monitoring the results of the risk assessment and the consequent implementation of corrective measures in case of deviations; balance between the gravity and plausibility of the scenarios; definition of limits, incentives, policies and procedures; finally, incorporation of the stress test into the institution's corporate policy, in order to prevent adverse events. (Carazo, Naveira, Martin, & Vidales, 2013)

2.2.7. Scenario analysis

The first stage of setting up a stress test is to design a scenario. The two main elements of this stage are:

- The selection of the risks types to be explored by the test;
- Calibration of the severity of shocks. (Westwood, Dent, & Segoviano , 2016)

Scenario analysis is one of the most important activities for financial institutions and consists on exploring the full range of situations that may exist at a given moment future. Generally, adverse outcomes are what receive the most attention. The most frequent and important question asked by risk managers who work at the financial institution: "How can bad things get?" (Hull, 2018)

The test can simulate a serious broad-based crisis affecting the real economy, as well as affecting financial markets and other asset prices; this approach is taken by most stress test authorities. An advantage of this type of testing is that it allows stress testing authorities to take into account the correlation of different risks, faced by banks and their impact on different parts of banks' balance sheets. For such scenarios, authorities tend to use economic models to help project coherent tensions - scenarios in which the combination of shocks makes sense together. (Westwood, Dent, & Segoviano , 2016)

Adverse scenarios include projections for economic variables such as unemployment, production growth and asset prices, which are largely consistent with the paths these variables can expect during severe downturns. This means that asset prices and production fall materially, while unemployment tends to rise substantially.

Adverse broad-based macroeconomic scenarios can affect banks capital positions through various channels. For example, higher unemployment can reduce households ability to pay mortgages and unsecured loans. A fall in house prices can decrease the value of collateral held against mortgages and, therefore, increase bank losses when households fail to pay these mortgages. Stress also increases the risk of banks' portfolios making loans. This, in turn, increases the amount of regulatory capital[6].

Some stress tests also include adverse traded risk scenarios, in which changes in prices and financial market conditions reduce the profitability of banks trading operations. Stress tests contain as well, elements less related to economic conditions, such as an increase in reparation payments related to past episodes of misconduct.

At the other extreme of broad-based testing, authorities may be interested in exploring a specific risk and, therefore, perform a more restricted stress scenario.

Given the variety of options for calibrating stress scenarios, ultimately, the severity of a stress is likely to depend on the risk appetite of a stress-testing authority. Because banks provide valuable services that support investment and economic growth, regulators try to ensure that bankruptcy is adequately unlikely. The appropriate likelihood of bank failure will be a judgment call for the relevant authority.

In scenario analysis, we are interested in knowing how market variables behave in the real world. This is done by analyzing the historical data necessary to obtain an estimate. One approach is to use the capital asset pricing model. First, we estimate ρ, the correlation between the return on the stock and the return on an index representative of the entire market, such as the S&P 500.

Historical simulation is the most popular approach to calculate the value at risk (VaR) and the expected deficit (ES) for market risk, to estimate the probability distribution of the change in the value of the current portfolio between today and tomorrow. (Hull, 2018)

The VaR measure is central for the determination of the regulatory capital for credit risk and for much of the credit risk management carried out internally by financial and non-financial companies.

Credit risk VaR is the loss of credit risk over a period of time that will not be exceeded with a certain level of confidence. Some credit risk VaR models only consider default losses; others consider losses due to downgrades or changes in the credit spread, as well as defaults.

Banks calculate the VaR of credit risk to determine regulatory capital and economic capital. Economic capital is estimated by the financial institution itself of the capital required for the risks it is taking and is used to calculate the measured return on capital for its business units. Sometimes, the VaR model that a bank chooses to use to determine the credit risk economic capital is different from the one necessary for determining regulatory capital.

Value at risk is a measure of scenario analysis. The probability of default estimates used to develop alternative horizon date scenarios must therefore be real-world estimates. Risk-neutral estimates should be used to assess the underlying portfolio at the VaR horizon date.

Credit risk VaR, for instruments that are not held for trading, is usually calculated over a one-year time horizon. Historical simulation is the main tool used to calculate the VaR for market risk, but a more elaborate model is usually needed to calculate the VaR for credit risk.

[6] The regulatory capital framework requires banks to fund themselves with a minimum amount of capital. This increases banks' ability to absorb losses that could otherwise threaten their solvency.

A fundamental aspect of any credit risk VaR model is the credit correlation. The standards for different companies do not happen independently of each other. During an economic downturn, most companies are adversely affected and become more likely to stop paying. When the economy is doing well, they are favorably affected and less likely to default. This relationship between default rates and economic factors is one of the main reasons for the credit correlation. If the credit correlation increases (as it usually does under stressed economic conditions), the risk for a financial institution with a portfolio of credit exposures increases. (Hull, 2018)

To determine the VaR or ES for credit spread-dependent instruments, there are two approaches:

To collect historical data on companies' credit spread variations and use a historical simulation methodology.

To model corporate rating transitions and movements in average credit spreads associated with different rating categories. (Hull, 2018)

2.2.8. Stress testing and Value at Risk

Berkowitz (2000) suggests that the stress test will have better results if they are integrated into the VaR calculation. This can be done by assigning a probability to each stress scenario considered. Suppose a financial institution has considered stress scenarios and the total probability attributed to stress scenarios is p. Assume there are VaR scenarios generated using historical simulation in the usual way.

Unfortunately, human beings are not good at estimating a subjective probability that a rare event will occur. To make the task for the stress test committee feasible, one approach is to ask the stress test committee to allocate each scenario to categories with pre-assigned probabilities. The categories can be:

Probability = 0.05%. Extremely unlikely. One chance out of 2,000.

Probability = 0.2%. Very unlikely, but the scenario must be presented in the same way as the 500 scenarios used in the historical analysis of the simulation.

Probability = 0.5%. Unlikely, but the scenario should be given more weight than the 500 scenarios used in historical simulation analysis.

Stress testing involves evaluating the impact of extreme, but plausible, scenarios that

are not considered by VaR or expected shortfall (ES) models. If there is one lesson to be learned from the market turmoil that started in the summer of 2007, it is that more emphasis should be placed on stress testing and less emphasis should be placed on the mechanistic application of VaR and ES models. VaR and ES models are useful, but they are inevitably backward looking (Hull, 2018).

Stress tests meaning VaR. VaR is thought to be a critical tool, and it can be a risk of a firm’s portfolio on a day level and performance of individual business units. VaR has been found to be of limited use to extreme market events. It happens because by definition, such events occur too rarely to be captured by empirically driven statistical models. There are correlation patterns between financial

prices (the correlation that would be estimated using data from ordinary times). Stress tests offer a way of measuring and monitoring the portfolio consequence of extreme price movements of this type.

The best approach is the integration of objective and subjective probabilities. This means that on the one hand, Var and ES models must be integrated through historical and retrospective simulations but on the other hand, subjective probabilities must be integrated in the creation of scenarios through senior managers, where there is an analysis of various market variables, such as the economic environment and analysis of diversified market scenarios. (Hull, 2018).

2.3. SECTION III COVID-19 PANDEMIC

2.3.1. Framework COVID-19 Pandemic

The COVID-19 pandemic is bringing a lot of instability to the world, and countries also have difficulty on choosing the best options to apply in their country, because many of these measures, such as the case of social confinement, will have very significant economic consequences. The most relevant reason is that small and medium-sized companies and individuals are being affected by this public health crisis, which has economic consequences, in which they may suffer from liquidity problems and difficulties on paying their financial commitments. Consequently, this will have an impact on financial institutions and on their credit obligations. A delay in the payment of credit obligations will lead to a large number of defaults and an increase in fund requirements for these same institutions.

The pandemic crisis has a significant impact on working, either for reasons of illness of workers and need to support their families or health security and mandatory distance. The interaction of these factors clearly results a decrease production on companies, despite the heterogeneity observed between sectors of activity. In parallel with the context of uncertainty underlying the evolution of the pandemic fall confidence of economic agents, this led to a significant decrease in the demand for goods and services. After the gradual reduction in containment measures, and despite some improvement observed, the maintenance of an unfavorable macroeconomic environment and high uncertainty, resulted in an increase in unemployment and a drop income, loss of confidence. Leading to an increase in savings for reasons of precaution and to the weakening of consumption and investment.

In this context, in an attempt to minimize the medium and long-term economic impacts to contain the pandemic COVID-19, the countries of the European Union have implemented a wide range of support measures. These measures are in the form of payments of credit obligations, in order to support the operational and liquidity part of the credit debtors.

2.3.2. Recommendations by European Central Bank

ECB (European Central Bank) has implemented a series of measures to help the banks to deal with the current situation we are living nowadays due to COVID-19, which have led many companies, banks and organizations to limit their processes, activities and human resources. It has created an approach called SREP [7] - supervisory review and evaluation process. This approach aims to ensure an efficient and structured assessment of the banks. Throughout 2020, this process will focus on the banks' ability to

[7] It is a set of procedures led annually by the supervisor authorities that ensures that each credit institution has strategies, processes, capital and liquidity appropriate to the risks that it may be exposed. This process makes the Basel II operational in the European and National regularization. In the SREP it is also evaluated the risk that each institution is for the financial system

respond the current challenges and risks related to the crisis and manage the impact in the upcoming months. Supervisors will assess the four fundamental Pillar:

I. Scenario design: consists of the design of the macro-financial scenarios to be imposed on the banking sector;
II. Top-down satellite models: consists of the modules used to translate the scenarios into variables affecting the valuation of bank balance sheet components and banks' loss absorption capacity;
III. Balance sheet module: takes the projected profit and losses derived from the satellite models to individual bank balance sheets with the aim of calculating the resulting impact on each bank's solvency positions;
IV. Feedback modules: takes the analysis beyond the first-round impact on bank capitalization to assess what could be the derived second-round effects of the initial bank solvency impact in terms of contagion within the financial system and in terms of feedback effects to the real economy.

The main focus will be to assess the banks' ability to deal with the crisis and manage the impact in the coming months.

ECB adopted an extraordinary package in order to help sovereign debt yields. The first announcement was the purchase of assets in the initial amount of 750 billion euros, increasing to 1350 billion euros, which will continue until the end of June 2021 (Pandemic Emergency Purchase Program).

Internal capital adequacy assessment process (ICAAP[8]) and Internal Liquidity Adequacy Assessment Process (ILAAP[9]) are important sources of information for understanding how banks manage capital and liquidity in this very challenging time. Supervisors are collecting evidence of bank's assessment of the current processes of managing capital and liquidity, including the decision making, the ability to update liquidity and financial planning, as well as stress test scenarios.

The ECB published a press release stating that banks could temporarily operate below the level of capital defined by Pillar 2, capital conservation and the liquidity coverage ratio.

Another measure recommended by the ECB is that banks should not distribute dividends or variable remunerations and they should use their capital to support the economy. It also points out that banks should continue to apply solid underwriting standards, seek appropriate policies in the relation to the recognition and coverage of non-productive exposures, conduct a solid capital and liquidity planning and have a strong risk management.

[8] The rigorous evaluation and determination of the level of internal capital underlying the risk profile of a credit institution or investment company are essential conditions for the implementation of sustainable business strategies, on the assumption that they are supported by appropriate controls. In particular, the planning of the evolution of internal capital is considered fundamental to ensure its adaptation on a permanent basis to the risk profile of the institutions, particularly in the face of crisis or recession.

[9] The recent financial crisis has shown the fundamental importance of liquidity for credit institutions, given that their insufficiency represents an immediate threat to their continuity. One of the main lessons learned is that liquidity risk management has to ensure the ability of credit institutions to meet their payment obligations at all times, even under adverse conditions.

Banks will also be able to implement Pillar 2[10] requirements partially with an inferior capital (as additional instruments of Level 1 or Level 2). This anticipates a measure in the CRD5 that should have taken effect in January 2021 (Article 104a) - EU banks will be able to service the P2R with 56.25% CET1 and the remaining with AT1 and Tier 2 capital.

The ECB also warns of the need for banks to prepare for possible negative effects caused by the spread of the coronavirus.

In the euro area, the ECB's announcement a set of extraordinary measures has partially reversed the increase in sovereign debt yields. The measures to be highlighted by the new emergency asset purchase program (Pandemic Emergency Purchase Program, PEPP), initially amounted to 750 billion euros, followed by the increase to 1350 billion euros, which should be maintained until the end of June 2021. In any case, the expectation of a longer economic contraction is reflected in a different valuation of risk premiums for the sectors of activity and market segments most vulnerable to the effects of the COVID-19 pandemic. Confinement measures and limitations on international mobility had a particularly significant impact on airlines and tourism-related activities, where devaluations of more than 40% were observed during March 2020, with a more recent limited recovery.

2.3.3. Recommendation by European Baking Authority

EBA is one of the three entities that are part of European System of Financial Supervision (ESFS). There more two entities: European Securities and Markets Authorities (ESMA) and European Insurance and Occupational Pensions Authority (EIOPA). The date of foundation of EBA is 1st of January of 2011.

The EBA has created guidelines to face the crisis created by the pandemic COVID-19. The measures are limited and are applied only to the economic situation caused by COVID-19. The beneficiaries of these guidelines are short-term borrowers, which include small and medium-sized enterprises, mortgage loans or industrial sectors affected by this crisis. The measures are not applied to debtors identified before the COVID-19 pandemic outbreak, neither to debtors whose maturity has been unchanged. New loans granted after the outbreak of COVID-19 are also not covered by these measures.

The conditions of these guidelines are to change the payment schedule in order to address the shortage of liquidity. Consequently, payments are suspended, postponed or reduced, within a limited period. This will affect the entire payment schedule and may lead to an increase in payments after the

[10] European banking law defines three elements of own funds. **Common Equity Tier 1 capital** (CET1) is the highest quality of own funds and is mainly composed of shares and retained earnings from previous years. **Additional Tier 1 capital** (AT1) and **Tier 2 capital** can be equity or liability instruments and are of lower quality. **Pillar 2 capital** consists of two parts. One is the **Pillar 2 Requirement or P2R**, covering risks which are underestimated or not sufficiently covered by **Pillar 1**. The other is the **Pillar 2 Guidance or P2G**, which indicates to banks the adequate level of capital to be maintained in order to have sufficient capital as a buffer to withstand stressed situations, in particular as assessed on the basis of the adverse scenario in the supervisory stress tests. Under the new Capital Requirements Directive V (CRDV) banks can fulfil Pillar 2 Requirements with a minimum 56.25% CET1 as a general principle. The remaining P2R can be filled with Additional Tier 1 and Tier 2 instruments. This law was initially scheduled to come into effect in January 2021 as part of the latest revision of the CRDV.

period of the special loan conditions, in particular the interest rate, in order to avoid major losses by the financial institution, and the impact on net present value to be neutralized. However, this change should not affect interest rates.

A final point to consider is that financial institutions must continue to borrow to new customers. However, the new loan must follow normal credit policies and be based on an assessment of customers' creditworthiness. These new loans must be assessed against current payment capabilities and individual conditions must be assessed on a case-by-case basis.

The main objective is that financial institutions continue to apply risk policies, paying special attention to the assessment of debtors most likely to face payment difficulties. EBA also recognizes that policies and practices regarding the assessment of improbability of payment may differ depending on the portfolio and the type of debtor, taking into account the availability of information. These checks are expected to continue for the duration of the payments and at their completion.

Likewise, it is expected that corporate customers, where the potential improbability of payment is assessed manually as part of the regular monitoring process, based on the debtors' financial statements and other information, should continue throughout the duration of the payments until its term.

Institutions must identify possible economic losses that may suffer due to the application of the guidelines, including through additional charges for impairment.

Financial institutions must continue to assess the likelihood and default of payments. All government measures to provide additional support to debtors during the course of the COVID-19 pandemic should be reviewed, and be available, so that if the debtor is in creditworthiness, they should be considered in non-payments. Thus, the financial institution must mitigate its credit risks, using non-payment assessments.

The risk of a generalized downgrade to lower levels of investment assumes particular relevance for economic agents who, in a prolonged context of low interest rates, adjusted the composition of their portfolios looking for greater search-for-yield. In the eurozone, investment was mostly in investment funds, increasing its exposure to lower credit quality assets and higher risk of counterparty. Given the significant size of investment funds in the European context and the high proportion of securities at the threshold of the level of investment in their portfolios may imply an abrupt devaluation in the value of assets, representing a source of risk in Europe.

EBA wrote guidelines to help combat the crisis caused by COVID-19:

- Criteria for credit payments not to trigger other classifications;
- Prudential requirements in the context of default;
- Ensure consistent treatment of measures and calculation of capital requirements.

EBA also has a guidelines for stress test, that the main risk to assess are:

- Credit risk;
- Market risk;
- Securitization;
- Cost of funding.

Credit risk is meaning a possibility of loss resulting from a borrower's failure to repay a loan or agreement between two parts. It refers to the risk that a lender may not receive the owed principal and interest, which results in an interruption of cash flow and increased costs.

Market risk is the risk associated to the possibility that a bank, as investor, suffers losses due to factors that affected negatively the performance of the financial markets. This type of risk is also called systematic.

Securitization is a complex process that uses financial engineering to transform an illiquid asset or group of illiquid assets into securities. The risks associated to this process increase when the complexity of the instruments increase, making harder the analysis of the future security performance. Securitization offers opportunities for investors and frees up capital for originators, both of which promote liquidity in the marketplace.

Cost of funds is a reference to the interest rate paid by financial institutions for the funds that used by business. The spread between the cost of funds and the interest rate charged is one of the most important sources of profit of the financial institutions. The risk in this type of process comes when the cost of funding increases. If the cost of funding increases, the bank has three options. First, charge a bigger rate on loans, finding new costumers and making profit in these new loans. Second, keep the same rate, finding new costumers and losing money in this new loans. Third, charge a bigger rate on loans, but did not find new costumers, losing also money

The measures are aimed at suspending or postponing payments to debtors affected by the COVID-19 pandemic, in which they saw a reduction in their budget, allowing them to later resume regular payments when the pandemic situation is already solved.

The EBA recommends that financial institutions should continue to assess and identify situations, in which short-term payments are committed, and in the long term that could lead to insolvency. The real impact of the economic shock can only be assessed on the basis of risk ratings and measurements. (Final report - Guidelines on legislative and non-legislative moratoria on loan repayments applied in the light of the COVID-19 crisis, 2020)

It should be noted that since the previous international financial crisis, regulatory standards and supervisory practices have been adopted, at national and international levels, in order to increase resilience in the financial sector. In the particular case of the banking sector, these resulted in a strengthening of capital ratios and liquidity position. This factor is particularly relevant in the current pandemic context, since the vulnerabilities of the economies, mitigating the economic impact of shocks. (Bank, 2020)

The first effects of the pandemic crisis and the first measures adopted for mitigation point to a very significant contraction in world economic activity in 2020. Contrary to previous crisis, its origin was outside the financial sector. The first economic impact was reflected in the disruption of distribution and production chairs at a global level. The confinement measures adopted by government authorities and the drop in the confidence of economic agents, associated with uncertainty about the evolution of the pandemic crisis, caused, in a second phase, a demand shock. In this way, the current crisis stands out from previous crisis due to simultaneous shocks on the supply and demand side. The confidence of economic agents reached historic lows and below market expectations.

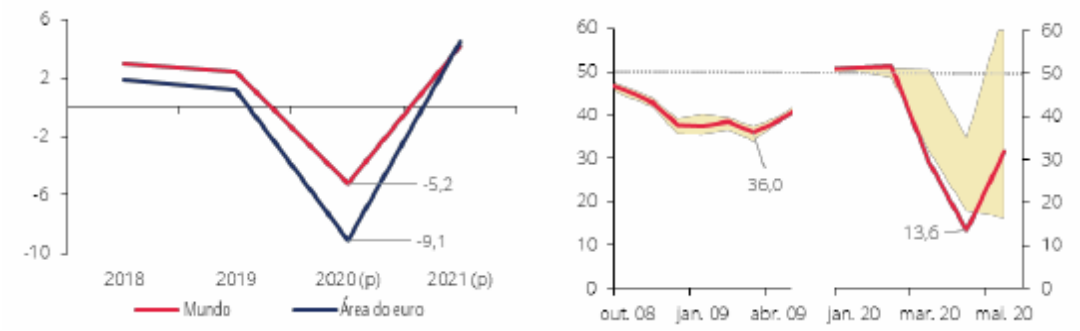


Figure 1 Global Economic Prospects - June 2020 (Source: The World Bank (Left)); Purchasing Managers Index – (Source: IHS Markit e Refinitiv. (Right))

As the spread of the SARS-CoV-2 virus took on a global dimension, the uncertainty and the expectation of economic effects were reflected in increase risk premiums and an abrupt devaluation of financial assets. This effect was especially visible in higher risk assets, namely shares and debt securities of lower credit quality, as the pressure to sell these instruments and the scarcity of liquidity was reflected in the increase in volatility to historic highs.

2.3.4. Macro-financial models used to calibrate shocks and produce scenarios

Macroeconomic scenario is exogenous shocks, should reflect the underlying systemic risksto be analysed. A mapping systemic risks into exogenous shocks has a simulation tools are employed to determine the relevant shock sizes and profiles. The shocks can be used by data base on historical distributions and to compute a 1 % Value -at-Risk measure the entirety of markets under scrutiny.

In what concerns COVID-19 it is still hard to predict what will happen since it is a new situation, a new and an unknown virus. The government has to take measures to prevent a U or L break and try to have the V shape, hence the importance of analyzing scenarios.

In general, the effects of the pandemic and the consequent abrupt and significant reduction in economic activity at international and national levels, pose additional challenges for non-financial companies in Portugal. The decrease of activity, and the falling of revenues take to consequent meaning of insolvency situation and default obligations in the short term. The confinement measures and limitations on international mobility had a significant impact on airlines and tourism activities. Consequently, there were breaks in the order of 40% during March 2020.

At the financial level, unlike other sectors of activity, it continues to record a very strong devaluation, approximately 40%, since the beginning of the COVID-19 pandemic in Europe. Interest rates on the lowest risk assets are registered, combined with the most recent devaluation of the assets to which it is exposed. A possible consequence is an increase in the default of credit granted to the non-financial sector.

Institutions expect a considerable reduction in the demand for credit by individuals, having already seen a drop in the first quarter, a decrease in consumer confidence and a deterioration in expectations for the evolution of housing prices. The unfavorable evolution of these factors could be accentuated

in a strong economic recession, increasing unemployment and a very uncertain economic recovery. The first effect of the pandemic on the financial markets was an increase in risk premiums, and a devaluation of these securities.

The pandemic crisis constitutes a macroeconomic shock with substantial impacts not only on the economic crisis, but also with long-term negative effects. The current crisis will tend to imply permanent losses in terms of productive capacity. This result will be associated with the destruction or less accumulation of physical and human capital and the interruption of commercial and knowledge networks.

The long-term macroeconomic shock calls for joint European Union response measures in order to avoid an asymmetric economic recovery, and possible asymmetric consequences for national banking sectors.

In short, the pandemic crisis has created a situation of exacerbated uncertainty, which is particularly challenging for financial stability at national and international levels. The current pandemic crisis is a test of the financial sector's resilience. In turn, the nature and implications of the pandemic crisis require a coordinated response at European level.

2.4. CLIMATE STRESS TESTING PILOT EXERCISE

European Central Bank and Bank of England will conduct climate stress testing exercises on the basis of the same scenarios provided by Network for Greening the Financial System (NGFS), while the Basel Committee is advancing on its strategy to integrate climate financial risks into banking prudential regulation.

There are some limitations due to the pioneering nature of this exercise which of raising awareness on climate-related financial risk. The future is to test a climate stress that banks and insurers will have to gain expertise in climate scenario modeling, understanding climate risk transmission channels and rely on better forward-looking data and improved methodologies. Climate change is expected to have aggregate financial impacts that are pervasive in nature. The main important is to build a exposure analysis, which involves mapping millions of firm and address-level climate risk drivers to financial balance sheets. On financial system losses could increase by almost 10% in the event of credit rating downgrades to high-emitting from rapid rises in the carbon price to ensure alignment with Paris Agreement levels.

The present exercise involves stressing the balance sheets banks and insurers with a set of common hypotheses:

- A long time horizon (2050), the use of transition and physical risk scenarios broken down in sectors and a dynamic balance sheet;
- Participants were subject to three transition risk scenarios: zero emission, once physical risk scenario and based on a 30 years time frame.

Physical risks lead to a significant increase in sinistrality and insurers balance sheets. The exposures of banks and insurers to transition risk is deemed as moderate, with an increase cost of risk between 30% and 40% to covid-19 crisis increased it by 100%.

Physical risk in the banking system are firms exposed to high or increasing risk. Around 10,6% of bank credit exposures to high or increasing flood risk, 1,4% to coastal floods/ sea level rise, 11,2% to heat

stress, 12,2% to water stress and 4,8% to wildfires. The distinction between hazard probability and intensity becomes important when translating hazard into economic damage. (ECB/ESRB, 2021)

The banking sector is exposed to firms transition risk by credit and market risk. The main analysis suggests transition risks for the banking system are predominantly from credit risk. These exposures are related to 14% in total balance sheet are risks to financial stability appear broadly manageable. The euro area banking system may be exposed to tail risk in the event of sudden changes in carbon prices if firms do not reduce their emissions.

Scenarios rely on a decoupling between emissions and GDP growth, since GDP growth reach emissions neutrality. This implies that a rapid reduction of emissions could be achieved without a significant impact on GDP that stress test conducted by the EBA require scenarios based on three consecutive years of GDP contraction. Consequently, banks credit exposures are subject to variations in prices from the trajectory of a carbon tax and productivity of factors.

Scenario analysis requires hypothetical but plausible scenarios to highlight the impact of climate risks on the financial system. It could help central banks and supervisors to integrate climate risk into financial stability monitoring. Mitigation policies can be introduced either immediately, later on, or remain insufficient and include a number of technological assumptions, for instance regarding the availability of carbon dioxide removal technologies. (ECB/ESRB, 2021)

The banking sector is a intermediating funds to corporates and is thereby exposed to firms transition risk. Bank loan exposures to climate sectors, around half of total loans. European Union Member States exposures to the housing (36%) and energy-intensive sectors amount (8%) of total loans across the euro area.

Mainly concentrated sectors of exposures in the euro area are manufacturing, electricity, transportation and construction sectors, contribute to around two-thirds of bank loan-weighted emissions intensity.

3. METHODOLOGY

The theoretical approach is the one made in the previous chapter, following the methodological phase, which helps to define the path of investigation of the empirical study.

In this chapter there will be several phases showing the path of the investigation, the method to be used, the definition of the sample and the collection of financial data.

3.1. RESEARCH METHODOLOGY

The investigation method to be used in this investigation is the mixed, qualitative and quantitative method. The choice of this method was due to the need for the present study to have an objective of analyzing the possible financial performances of credit risk in Portugal due to the impact of the COVID-19 pandemic, the quantitative method will be the predominant one in the investigation. That is, the investigation will be focused on the observation of objective facts and precise phenomenon, existing independently of the researcher, which is, the analysis of data taken by the Portugal Banks. However, there will be a positioning of knowledge development, in order to describe and interpret.

The quantitative research method allows for greater precision, in which objectivity is compared to similar situations. The process consists on a systematic process where objective and event data are collected (Freixo , 2013). The quantitative approach analysis and records the causes of the occurrences using a mathematical language.

The qualitative approach values subjectivity has multiple realities, where a discover something is referred description and understanding is mentioned, the researcher is part of the process (Freixo , 2013). The present investigation aims to analyze scenarios, in which it will have this qualitative, understanding and interpretative component.

The research instruments, in this case, is documentary research, which consists on a series of operations that aim to study and analyze one or more documents, in order to visualize the social and economic circumstances, as is the case of this research. In order to understand how the impact of the COVID-19 pandemic is affecting the economy as far as we are.

3.2. HYPOTHESIS

The Portuguese government has been implementing many measures to combat the new Coronavirus. They issued a statement stating that the COVID-19 epidemic may have a significant impact on the economic activity, companies and employment. Either because the interruption of supplies may restraint the continuity of activity in full, or because the sudden reduction in demand - particularly sensitive in the travel and tourism sectors - can lead to a large decrease in the turnover of companies. In any case, companies may find it difficult to fulfill their obligations, due to the loss of revenue or keeping their staff fully employed. These outcomes may be felt with intensity in the coming weeks,

until the epidemic can be controlled and normal economic activity resumed. In order to mitigate the economic impact of the epidemic and reduce the companies' treasury effort in the coming months, the Government presented a set of measures to the social partners, covering the following areas: support to the company's treasury and work and social security.

Based on Portugal's macroeconomic plan, it is intended to study the following assumptions, in order to be able to mitigate possible risks.

Hypotheses 1: The loans rate influence positively credit default rate.

Hypotheses 2: The mortgage credit influence default credit rate.

Hypotheses 3: The consumer credit influence default credit rate.

Hypotheses 4: The business credit influence default credit rate.

Hypotheses 5: The unemployment rate influence positively credit default rate.

Hypotheses 6: The 3-month Euribor interest rate influence credit default rate.

Hypotheses 7: Nominal GDP growth rate influence negatively credit default rate.

Hypotheses 8: The Price Stock Index of the best twenty companies in Lisbon influence credit default rate.

Hypotheses 9: The nominal Disposable Income influence negatively credit default rate.

Hypotheses 10: The Consumer Price Index influence positively credit default rate.

Hypotheses 11: The exchange rate influence credit default rate.

Hypotheses 12: There is a relationship between credit and macroeconomics variables.

Hypotheses 13: The carbon price index influence credit default rate.

3.3. Research Question

In view of the presented hypotheses, it is necessary to analyze the main objective of this investigation. What is the influence of macroeconomic factors on credit default in Portugal, during the management of the pandemic caused by COVID-19 and the climate change crisis?

3.4. Sample and Data Collection

Literature suggests that there is a relationship between macroeconomic variables and the risk of credit default. Considering this fact, the purpose of this study is to prove this relationship by applying various stress scenarios. By doing so this study opens possibilities for mitigating problems related to that

matter in the future. Credit risk ratio is referred to as the dependent variable, and macroeconomic variables are referred to as the independent variables or explanatory variables. As referred, the goal is to demonstrate the linear relationship between these two variables.

The macroeconomic variables that will be applied are the quarterly GDP growth rate, the quarterly unemployment rate, the quarterly disposable income rate, the quarterly consumer price index, the growth rate of the stock market index of the 20 best companies in Lisbon, the loans growth rate, the exchange rate Euro to Dollar and the TBA-Euribor rate, making the total of eight explanatory variables.

The data collected are time series with quarterly periodicity, starting in the first quarter of 2003 (2003Q1) until the last quarter of 2020 (2020Q4), in order to be able to analyze a period of onset of the pandemic.

The Law on the National Statistical System (Law No. 22/2008 of 13 May) recognizes *Banco de Portugal* as a statistical authority and, as such, *Banco de Portugal* is part of the National Statistical System (SEN), without prejudice to guarantees independence resulting from its participation in the European System of Central Banks (ESCB). Within the scope of the National Statistical System, Banco de Portugal publishes plans and reports on its statistical activity. (Portugal, 2020). The data collected by this entity are relevant to the study in question because it makes forecasts and prepares studies on the Portuguese economy. It was also taken in account the recommendation given by Basel sources.

3.5. MODEL TYPE

The main objective of present dissertation is to find the main determinants of stress tests results for Central Bank institutions. The investigation has an objective of analyzing the possible financial performances of credit risk in Portugal due to the impact of the COVID-19 pandemic. That is, the investigation will be focused on the observation of objective facts and precise phenomenon, existing independently of the researcher, which is, the analysis of data taken by the Portugal Banks. However, there will be a positioning of knowledge development, in order to describe and interpret.

Credit risk is characterized by the ratio between the amount of credit granted to companies and individuals, but whose repayment is doubtful. Considering this, the dependent variable is measured as the ratio between doubtful loans repayment and gross value of loans in the bank's financial statements.

In order to assess the evolution of credit risk, it is necessary to understand the extent to which its evolution is influenced by macroeconomic variables. At this economic juncture it is possible to purge the main influencing factors and to take corrective measures on them.

The quantitative approach analysis and records the causes of the occurrences using a linear regression model with dependent and independent variables.

The present investigation aims to analyze scenarios, in which it will have this qualitative, understanding and interpretative component.

The research instruments, in this case, is documentary research, which consists on a series of operations that aim to study and analyze one or more documents, in order to visualize the social and

economic circumstances, as is the case of this research. In order to understand how the impact of the COVID-19 pandemic is affecting the economy as far as we are.

Statistics is a science that studies variable presented by data. It makes it possible, from the data, not only to draw conclusions. Statistical inference is the process by which it is feasible to draw conclusions and take decisions about a population using information from a sample. The investigator wants to track to answer initial investigation question. The variables, with regard to the nature of the values that can assume, can be: qualitative variables and quantitative variables. The values of a quantitative variable are represented by numbers.

Data base was manipulated by Microsoft excel and SPSS.

3.6. LINEAR REGRESSION MODEL

Linear regression analysis studies the relationship between the dependent variable and the independent variables. The relationship between the variables (dependent with the independent) is made through a mathematical model. This model is called a simple linear regression model, when a relationship between a dependent variable and an independent one is defined. In the case of several several independents, it is called multiple linear regression model. (Bussab & Morettin, 2015)

Linear had relationship with two parameters, the regression that explains the form of the relationship and the correlation, which quantifies the strength or degree of the relationship. Both techniques are very interconnected. The data for the analysis of regression and correlation are in the form: $(x_1,y_1),(x_2,y_2),\ldots,(x_i,y_i),\ldots,(x_n,y_n)$. Based on the data, the dispersion diagram is constructed, which reflects the linear trend of the regression. Thus, with this diagram you can perceive the relationship between the variables X and Y, and degree of linear relationship between the variables whether it is strong or weak, according to the way in which the points are located on the line. (Bussab & Morettin, 2015).

The term linear is used to indicate that the model is linear between the parameters of α and β.

When studying a model based on data, a certain phenomenon of a social nature, in particular of an economic nature, with the aim of describing, explaining, predicting its behavior, one seeks to conceive in an approximate or simplified way the mechanism underlying the phenomenon observable. This mechanism is called a theoretical model. The model is objectivated to emphasize that it must be based on a theory. However, this model can be built on a less formal analysis based on common sense and intuition. (Murteira, Ribeiro, Silva, Pimenta, & Pimenta, 2010).

Relation of the proposed theoretical model seeks to establish the behavior of a variable z, in function of the other variables w_1 ,w_2,…, w_p. The z variable is the dependent one, that is, the explained variable or the answer, w_1 ,w_2,…, w_p they are independent variables, that is, the explanatory or control variables. Then α involves a set of unknown parameters. (Murteira, Ribeiro, Silva, Pimenta, & Pimenta, 2010)

A particular case of the theoretical model is characterized by linearity with respect to the parameters, in the form:

$$y = \beta_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k$$

Where y is the explained variable, or a function of that variable, x_1 ,x_2,…, x_k are the explanatory variables, and functions of those variables and β_1, β_2,…,β_k are the parameters. The parameter β_1 it is the independent or constant term, it is introduced in the model since only in very special cases is the nullity of the explanatory variables supposed. (Murteira, Ribeiro, Silva, Pimenta, & Pimenta, 2010)

In many situations the model is not linear with respect to the parameters, but through a transformation of the variable z, g(z) it is possible to obtain a relationship of the shape. A linear or linearizable relationship is said to be intrinsically linear with respect to the parameters. (Murteira, Ribeiro, Silva, Pimenta, & Pimenta, 2010)

This regression consistent if the error term is not correlated with regressors.

$$cov(x_t, \varepsilon_t)$$

Where:

x_t: regressors on period t;

ε_t: error on period t.

Although if the covariance between the regressors and the error is zero, composite error are serially correlated.

3.7. AUTOREGRESSIVE DISTRIBUTED LAG MODEL

Considering the linear model for time series:

$$Y_t = \alpha + \emptyset Y_{t-1} + D(L)X_t + \varepsilon_t$$

Where $D(L) = \delta_0 + \delta_1 L + \cdots + \delta_s L^s$, with L to represent the lag, it is meaning that $LX_t = X_{t-1}$; $L^2 X_t = X_{t-2}$;…; $L^s = X_{t-s}$; X_t represents the set of explanatory variables of the model, and ε_t represents the term error. This is the simplest version of ADL Model, which assumes the satisfaction of the stability condition, $|\emptyset| < 1$, regarding not to have the unit roots problem.

A potential problem of this model is the presence of unit roots in the autoregressive component model, which can affect the consistency the estimators OLS. However, if there are cointegration, they will converge to the real value of the parameter at higher rate. In this case, it is common to test the presence of unit roots by Dickey-Fuller (DF and ADF) test.

In particularly, simpler case of this model is eliminated the component autoregressive for non-statistical significance ($\emptyset = 0$), it is called the DL model (Distributed Lag Model). This type of model is dynamic and it is also considering explanatory variables lags. Model can be represented by following formula:

$$Y_t = \mu + D(L)x_t + u_t$$

Where t = 1, 2, … , T and $D(L) = \delta_0 + \delta_1 L + \cdots + \delta_s L^s$ is the lag polynomial.

3.7.1. The maximum Lag

The first problem of this type of model is related to the maximum lag s, in order not to lose a important information. More specifically, to choose a s small means loss of important information the model explain, which can lead to autocorrelation errors model, because there is one of the

hypotheses is violated, the fundamentals which are based on hypotheses of absence autocorrelation. Although, to choose a s that is too large can result in a loss significant observation. In this case, it will be consider the values of sample only from the point immediately following to the maximum lag value. It is also meaning a great uncertainty regarding the statistical inference.

Faced with this problem, econometricians propose two solutions: the use of information criteria, such as the AIC or the SBC, in which the underlying method consists of choosing the model that minimizes the statistic reflecting the problem of choosing the maximum lag; and the use of F-tests on the last lag coefficients, determining the statistical significance of these and the plausibility of its inclusion, called the GTS (General to Specific). Both procedures require a maximum lag ($Smax$). This value should be chosen sample size and data periodicity.

3.8. SPECIFIC TEST

3.8.1. Durbin-Watson and Breusch-Godfrey

In time series, sometimes, there are autocorrelated data, consequently there are residuals autocorrelation on estimated model. Therefore, this autocorrelation puts in causes the validity and efficiency of predictions based on the model, which predictions constitute the basis of the project. In this way, two very common tests will be used in the econometric environment for identify the presence of autocorrelation.

The first test is Durbin-Watson is based on the null hypothesis residues autocorrelation:

$$\begin{cases} H_0: \rho = 0 \\ H_1: \rho \neq 0 \end{cases}$$

Where ρ is the regression coefficient test:

$$e_t = \rho e_{t-1} + v_t$$

Where e_t is represented by estimates errors model. The statistics test is obtained by the following formula:

$$d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e^2} \cong 2(1 - \hat{\rho})$$

Where $\hat{\rho}$ represents the autocorrelation sample residues.

Breusch-Godfrey is another test that study the null hypothesis and it is considering no autocorrelation in order to ρ value:

$$\begin{cases} H_0: \rho_i = 0 \\ H_1: \exists \rho_i \neq 0 \end{cases}$$

Where $i = 1, 2, \dots, p$ and p is provided by regression test:

$$u_t = p_1 u_{t-1} + p_2 u_{t-2} + \cdots + p_p u_{t-p} + e_t$$

Where residuals are removed by OLS and it is implemented by auxiliar regression:

$$e_t = \alpha_0 + \alpha_1 X_{t,1} + \alpha_2 X_{t,2} + \cdots + \alpha_k X_{t,k} + p_1 e_{t-2} + \cdots + p_p e_{t-p}$$

The regression rest for DW test is augmented by explanatory variables for the original model $X_{t,1}, X_{t,2}, \dots, X_{t,k}$. The statistic test is obtained by R^2 to auxiliar regression.

3.8.2. Test-t and Test-F

The simplest version significance tests are test-t (for individual significance) and test-F (for global significance). The test-F is adaptation of the test-t. Considering the Linear regression equation:

$$y = \beta_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k$$

In this case, hypothesis null for test-t can be H_0: $\beta_i = 0$ and hypothesis null for test-F can be H_0: $\beta_i = 0, where\ i = 1, \dots, k$. The statistic test for an individual significance test can be given by:

$$t = \frac{\hat{\beta}}{\hat{\sigma}_{\hat{\beta}} \Big/ \sqrt{n}}$$

Where $\hat{\beta}$ is model OLS estimator, $\hat{\sigma}_{\hat{\beta}}$ is the standard deviation estimate of the OLS estimator and n is number of observations.

In the case of test-F, it is necessary to estimate an auxiliar regression, imposing by restrictions test and all coefficients is equal to zero. The statistic test can be given by following equation:

$$F = \frac{\frac{R^2_{UR} - R^2_R}{q}}{\frac{1 - R^2_{UR}}{T - p}}$$

Where R^2_{UR} is measure by R^2unrestricted model, R^2_R is the model with imposed restrictions, q is the number of restrictions to be test and $T - p$ number of degrees of freedom

3.9. MODEL VARIABLES

3.9.1. Stress Test

The dependent variable, credit default, of the model is the stress tests results. Credit default is a dummy variable and if the result is equal to 1, credit default will be fail in period t. However, if the results is equal to 0, credit default in Portugal will not be fail, so debtors can pay their mortgages or loans.

3.9.2. Unemployment rate

The unemployment rate is the percentage of the total labor force that's unemployed and actively seeking work. The unemployment rate is an important measure of economic health. It goes up during a crisis period of economic when demand for goods and services is low. The unemployment rate is one of the determinants of the non-performing loans, because households unemployed have less income and therefore the probability is goes up to their loans payments, so default credit is increase and economic will fail.

When unemployment rate is higher, therefore default credit is higher. So, it is expected that $\beta_2 UR_t$ will has a positive sign, since the unemployment rate is positively correlated with the dependent variable.

3.9.3. Loans

Credit is an agreement between a credit institution (lender) and a customer (debtor), who is obliged to replay the amount an agreed period, with interest charge and other costs.

Loans to deposits ratio is the ratio between the total loans and the total deposits of the bank. Deposits as debt issuance and shareholders equity are main sources of funds of a bank, being deposits the most stable source of funding. Bigger loans to deposits ratio, means that deposits, increasing the credit risk. Also, Silva citied Apergis and Payne that it is expected that $\beta_3 LR_t$ presents a positive sign, since loans to deposits ratio is positively correlated with the dependent variable.

Only credit institutions and certain financial companies registered in Banco de Portugal can grant credit. The three most important categories used by customers are: mortgage credit, consumer credit and business credit.

3.9.3.1. Mortgage credit

Mortgage credit is an agreement between two parts that the main purpose is a acquisition or construction of permanent, secondary or rental house. It also includes credit contracts for the acquisition or maintenance of property rights. This type of credit is a long-term loan, the mortgage is given as a guarantee of repayment.

Credit contracts that not corresponding to a mortgage loan, are guaranteed by a mortgage or by another equivalent guarantee commonly used on real estate, such as consolidated credit or credit in which purpose is not defined. It is expected that $\beta_4 LMC_t$ presents a positive sign, since Mortgage Credit to deposits ratio is positively correlated with the dependent variable.

3.9.3.2. Consumer credit

Consumer credit is a specific type of personal credit in which specialized financial institution available to a individual private, certain amount to goods or services. Also included consumer credit category are credit cards and salary accounts. Regarding the payment terms of consumer credits are generally in a short-term, at most up 5 or 6 years. It is expected that $\beta_5 LCC_t$ presents a positive sign, since Consumer Credit to deposits ratio is positively correlated with the dependent variable.

3.9.3.3. Business Credit

Business credit is a specific credit to a business's accounts and activity to a business credit. Business credit is used for Small Business Administration, business's insurance premiums, credit limit from vendors and suppliers, to raise money from investors and contracts with other organizations.

It is expected that $\beta_6 LBC_t$ presents a positive sign, since Business Credit to deposits ratio is positively correlated with the dependent variable.

3.9.4. TBA – Euribor interest rate

TBA – EURIBOR interest rate is the combination of the words Euro Interbank Offered Rate. Euribor rates are based on the average interest rate on euro interbank loans by a large number of prominent European banks (the Banking panel). For the determination of Euribor rates, 15 per cent of both the highest and the lowest reported percentages are excluded. Every business day, at 11:00 am Central European Time, Euribor interest rates are released and transmitted to all participating parties and the press. It is expected that $\beta_7 EUR_t$ presents a negative sign, since TBA – Euribor interest rate correlated with the dependent variable.

3.9.5. Nominal GDP growth rate

GDP growth is one of the kay indicators of economic health. If the economy is growing, there is less risk of a bank failure. GDP represents the sum (in monetary values) of all goods and services produced in region, over a period of time. In counting GDP, goods and services are considered, excluding intermediate consumption goods, avoiding the problem of double counting. Nominal GDP refers to the value calculated in terms of current prices, that is, in the year in which the product was produced and marketed.

In 2018, Silva cited Mayes and Stremmel that found GDP growth has a good predictive power and a negative effect when predicting banks distress. So, it is expected that $\beta_8 GDP_t$ presents a negative sign, since GDP growth is negatively correlated with the dependent variable.

3.9.6. PSI 20

Price Stock Index 20 is a index aggregates the largest 20 companies listed on Euronext Lisbon. The main purpose of PSI 20 is an indicator of the evolution of Portuguese stock market and to support the negotiation of futures and options. The PSI 20 index has a characteristics that it was a good indicator of Portuguese stock market and consequently the Portuguese economy. It is expected that $\beta_9 PSI_t$ presents a negative sign, since the PSI 20 index is negatively correlated with the dependent variable.

3.9.7. Disposable Income Growth

Represents the amount of money that households have available for spending and saving after income taxes. Generally, a decrease in disposable income, consequently there is less money available for the same things. It is expected that $\beta_{10} DIG_t$ presents a negative sign, since the disposable income

3.9.8. Consumer Price Index

The Consumer Price Index measures the rate of inflation by determining price changes of a hypothetical basket of goods, such as food, housing, clothing, medical care, appliances, automobiles, and so forth, bought by a typical household. The CPI are used to assess price changes associated with inflation or deflation and it is a major concept in macroeconomics. Banks generally profit in

environments of inflation, so probability of a bank failure decrease. It is expected that $\beta_{11}CPI_t$ presents a negative sign, since the inflation rate is negatively correlated with the dependent variable.

3.9.9. Exchange rate

The exchange is the operation of change one currency for another, the exchange rate is the price at which this exchange is made, that is, the value of a currency in monetary units of another currency. It is expected that $\beta_{12}ER_t$presents a negative sign, since the exchange rate is negatively correlated with the dependent variable.

3.9.10. Carbon Price

The banking system is exposed to tail risks in the event of sudden changes in carbon prices if firms do not reduce their emissions, but the impact would be contained with more gradual or efficient emissions reductions by firms. This variable is to analysis the exposures of loans in Portugal. If carbon price changes it will be impact on firms, consequently this firms have loans and turn an impact on probabilities of default. It is expected that $\beta_{13}CP_t$ presents a positive sign, since the carbon price rate is positively correlated with the dependent variable.

3.10. INITIAL MODEL

According to the theoretical basis mentioned above, the following equation serves as the basis for the model:

$$CD = \beta_1 + \beta_2 UR_t + \beta_3 LR_t + \beta_4 LMC_t + \beta_5 LCC_t + \beta_6 LBC_t + \beta_7 EUR_t + +\beta_8 GDP_t + \beta_9 PSI_t + \beta_{10} DIG_t + \beta_{11} CPI_t + \beta_{12} ER_t + \beta_{13} CP_t$$

Where:

t: represent the quarterly data period de t = 01/2003 ... 12/2020

β_1: Constant that represents the ordinate at the origin of the model.

$\beta_2, \dots, \beta_{13}$: represent the coefficients associated with the respective variables.

CD: Credit Default coefficient is the dependent variable represented by the specific default rate index

UR: Represents the unemployment rate in Portugal.

LR: Represents the rate of loans granted in Portugal

LMC: Represents the rate of loans – Mortgage Credit granted in Portugal

LCC: Represents the rate of loans – Consumer Credit granted in Portugal

LBC: Represents the rate of loans – Business Credit granted in Portugal

EUR: It represents the average interest rate on interbank loans in the euro area.

GDP: Represents the nominal value of GDP.

PSI: Represents the rate of the value of the 20 largest companies in Portugal.

DIG: Represents the nominal value rate disposable income growth.

CPI: Represents the rate of inflation value.

ER: Represents the exchange rate against the US dollar.

CP: Carbon Price rate.

3.11. SCENARIO ANALYSIS

The main objective of scenario analysis is to offer a flexible methodological framework which can take into account the forward-looking risks. It can provide a systematic way of making structured assumptions about different possible futures to explore the risks. The present study, the scenario analysis requires hypothetical but plausible scenarios if climate risks have impact on financial institutions and another variable.

The first release of climate scenarios was introduced in June 2020, include elements of both transition and physical risks. The present study it included carbon dioxide removal technologies.

The first phase of scenario analysis consisted on motorization of macroeconomic variables studied, as stated in Pillar II, which consists of strengthening external supervision to help mitigate the risks inherent in the banking system.

The scenario analysis was based on the linear regression model previously studied, in order to predict the output variable of credit default. *Banco de Portugal* and *ECB* have projections for some of the variables studied, and these made projections will be used for the analysis of different scenarios, *Banco de Portugal* and *ECB* have some information available that the explorer does not have, the asymmetric information. Variables have not a projection in *Banco de Portugal* were projected according to historical data, fundamentally in maintaining the behavior and trajectory observed in the variables originally reported by *Banco De Portugal*.

4. RESULTS AND DISCUSSION

4.1. RESULTS ANALYSES

In present chapter the case study is presented with the application of the methodology in the previous chapter, organized in two parts: a first part that consists on measuring the variables that draw the model, a second part that consists on the development of the application of the results for obtaining base and stress scenarios in the context of the current pandemic.

All data extraction and treatment were performed in SPSS and Microsoft Excel.

4.1.1. Practical example

The model was taken from several sources of information, such as *Banco de Portugal*, Stooq and OECD.

The model to be built is based on the country's historical data from 2003 to the last quarter of 2020, in order to be able to cover a major crisis and thus be able to make future projections of the current situation we live due to the effect of COVID -19.

The main goals of the analysis is the occurrence of credit default by customers and its effect on the economy. As there is a possible contagion effect of credit risk, the lack of supply (labor) may lead to a rupture in demand, or in the current situation, both break simultaneously, the analysis covers all important criteria for the analysis, such as Unemployment, nominal GDP, nominal disposable income growth, CPI inflation rate, psi20 index, Loans, Exchange rate, TBA - 3-month Euribor and carbon price rate.

The distributions of losses estimated using the model will be reflected in macroeconomic terms, in order to assist in the construction of policies and strategies for risk mitigation in adverse circumstances.

4.1.2. Variables

Due to the pandemic situation that Portugal and the world are experiencing, the climate change , it is necessary to resort to some macroeconomics variables, in order to observe which of these variables have the greatest impact on unfavorable economic environment that could lead to an increased risk of credit default, leading to a very vulnerable situation. In this way, it becomes pertinent to analyze the selected variables, assess how they may affect the credit default and what are the best policies to implement.

The present study has a purposes evidence of the relationship between credit risk (dependent variable) and macroeconomics variables that is explanatory variables.

4.2. SELECTION AND ANALYSIS OF VARIABLES

4.2.1. Dependent variable

The dependent variable is the default credit rate, whose value has been taken by *Banco de Portugal's* database. The default credit rate is a ratio between the amount of credit have been taken by companies and particulars, but the total amount of credit attributed to these two categories of economic agents are repayment is doubtful.

Figure 4 presents the historic evolution of credit default rate in Portugal. The last international financial crisis was originated in the USA, derived from the problems with housing loans, the well-known subprime crisis, in the summer of 2007. The American economy reached a critical point in 2008 with the bankruptcy of Lehman Brothers, one of the main banking institutions in the country. The effects of the recession in the American economy have spread globally, causing a sharp drop in credit default. Portugal was struggling with a stagnant economy and a rising unemployment. Although Portugal fell into a serious recession, reflecting a critical point between 2012 to 2015 in credit default. Portugal fell into a serious recession, reflecting a critical point between 2012 to 2015 in credit default.

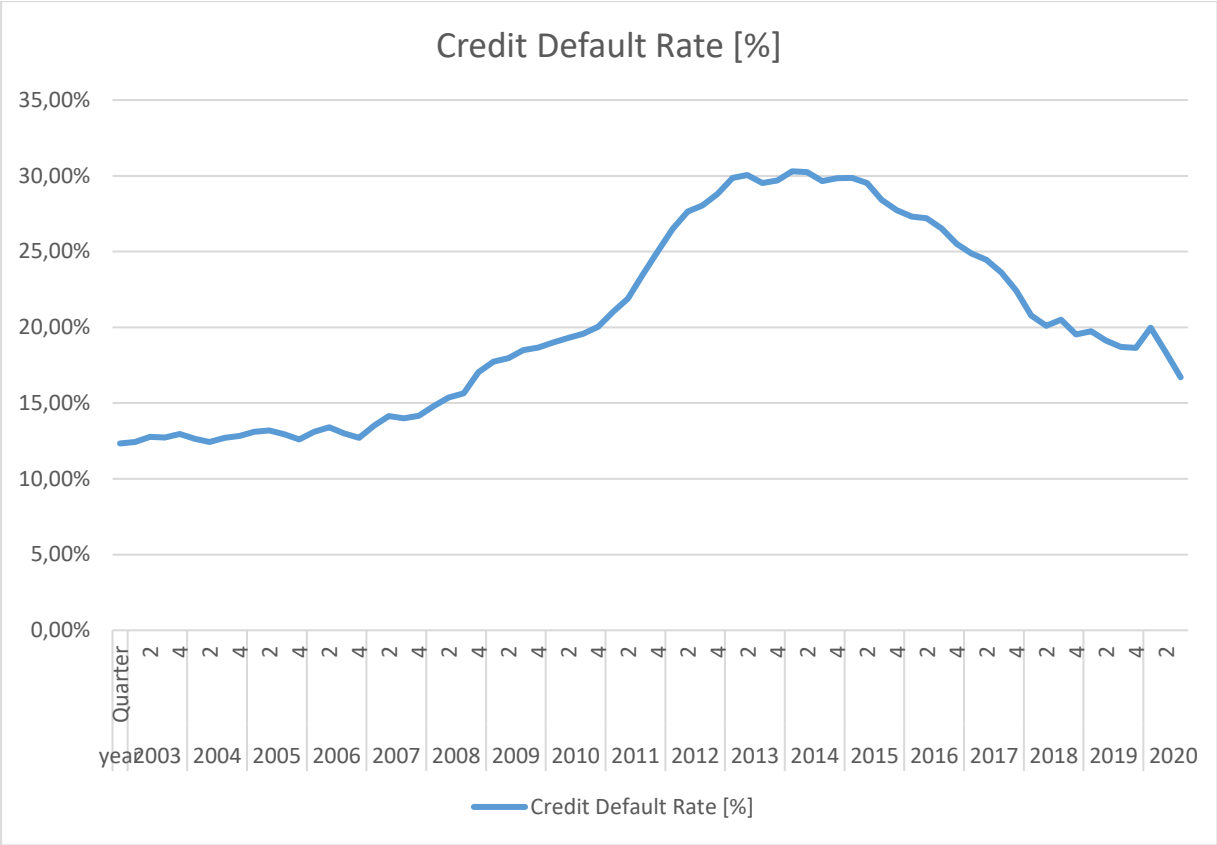


Figure 2 – Evolution of credit default since 2003Q1 to (source: prepared by the author with data base of *Banco de Portugal.)*

4.2.2. Independent variable

All variables mentioned above are important for construction model, as they all influence the default rate in Portugal. In this way, the model uses all variables, such as Unemployment Rate (UR), Loans Rate (LR), Mortgage Credit (LMC), Consumer Credit (LCC), Business Credit (LBC), Three Mouth TBA – EURIBOR (EUR), Nominal GDP Growth Rate (GDP), Portugal Stock Index 20 (PSI), Disposable Income Growth Rate (DIG), Consumer Price of Inflation Rate (CPI), Exchange Rate (ER) and Carbon Price (CP).

4.2.3. Stationary Test

The first step is to analyse whether the series is stationary or not, in order to choose absolute values or lag values. A stationary series circulates between two bands (a maximum and a minimum) floating uniformly around a midpoint – process I(0). A non-stationary series has no band, since the probability of 1 exceeds it and does not fluctuate around a midpoint – process I(1). There are two characteristics of a stationary series: their properties are constant and have zero mean and constant variance. Thus, it is necessary to distinguish processes I(0) and I(1). Stationary tests are used to understand the extent to which the series has a tendency, and thus remove them in order to observe the real fluctuations of the variable. The main objective is to observe the real fluctuations of the variable. There are several tests of stationarity such as the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests, Elliot's ADF-GLS tests, Rothenberg and Stock test, M tests of Ng and Perron, KPSS tests, among others. (Rodrigues, 2013)

The chosen tests were the ADF tests, developed by Dickey and Fuller, prior to the unit root tests, to find out whether the observed time series present a stochastic trend over the time or, if on the other hand, the series present a deterministic trend, with stationary fluctuations over time. (Ferreira, 2013) The ADF model is illustrated using the following model:

$$Y_t = \phi * Y_{t-1} + \varepsilon_t$$

whose, $\varepsilon_t \sim N(0, \sigma^2)$.

The main objective is to estimate the value of ϕ. If $\phi = 1$, it means that the series have a unitary root, therefore is not stationary. Next step is to manipulated series in order to reverse stationary and it is consisting of that differences is mandatory. If $\phi \neq 1$ means that series is level stationary, it can be used without transformation to establish a linear regression with another stationary variable. There are two alternative hypotheses for checking stationary:

$H_0: \phi = 1$, there are unitary square, means, series is not stationary

$H_1: \phi < 1$, there are not unitary square, means, series is stationary.

The present study was based on the probability's values calculated in Microsoft Excel at significance level of 5%, in order to reach a conclusion regarding the stationarity of the series. If the value is less than 5%, the hypothesis H_0 is rejected and hypothesis H_1 of series stationarity is accepted. Appendix on table A presents all results of ADF stationary test to all variables in absolutes values and different lags. In same way of ADF test, PP tests consists to verify if null hypothesis have a unitary root ($H_0: \phi = 1$). The decision criterion defines that, if $t_1 < r^{crit}$, the null hypothesis will be rejected, we used Standard Critical Values for significant statistical level of 5%, with t = - 1,65.

The results obtained show that variable Business Credit has lagged with ρ=0,0001, Nominal GDP has lagged with ρ<0,0001, Nominal Disposable Income has lagged with ρ<0,0001, CPI inflation has lagged with ρ<0,0001, PSI20 has lagged with ρ<0,0001, Exchange Rate has lagged with ρ=0,001735 and Carbon price with ρ<0,0001, meaning that these variables rejected null hypothesis and accept hypothesis H_1 series is stationarity, all absolutes values will be used on linear regression. All other variables presented only reveal to be stationary at different lagged, and the return values are used in the estimates.

With the series transformed into stationary series and using levels that have already been shown to be stationary, the regression is estimated between the various endogenous and explanatory variables.

4.2.4. Database description

The database used starts in January 2003 and to 2021, evaluated by quarters.

Analyzing the series of the collected data, it should observe the main characteristics of central tendency and variables of the study is dispersion. Appendix B shows values of the descriptive statistics for all variables collected by the absolute values and lagged differences.

Regarding standard deviation can be observed that there is not negative value, as expected and all variables have a low standard deviation value, this means that values are around the average with few deviations. The variables with the highest standard deviation are ER (Exchange rate), that have a standard deviation of 0,1244, and PSI (Portuguese Stock Index) with a standard deviation of 0,1111, although it is not a cause for risk.

Skewness is a measure of the symmetry of a distribution. In an asymmetrical distribution, a negative skew indicates that the tail on the left side is longer than on the right, conversely a positive skew indicates the tail on the right side is longer than on the left. Asymmetric distributions occur when extreme values lead to a distortion of the normal distribution. (Encyclopedia, 2021) From the statistical skewness values obtained, the one that is closest to the symmetrical values of the normal distribution is the credit default (the value is 0,307). As credit default indicated LR (loans rate) (the value is 0,281), LMC (Mortgage credit) the value is 0,307, LBC (Business Credit) the value is 0,331, EUR (TBA – 3 months Euribor) the value is 0,852, UR (Unemployment rate) the value is 0,796, DIG (Disposable Income Growth) the value is 0,153, CPI (Consumer Price Index) the value is 0,018, ER (exchange rate) the value is 0,1217, the variables have a longer tail on the right than on the left side. It means that there are more variations in values over a period of time, even though they are low. The variables with more variations are EUR and UR. On the other hand, LCC (Consumer Credit) the value is -0,147, CP (Carbon Price) is a value of -0,673, PSI (Portugal Stock Index) the value is -0,693 and GDP (Nominal GDP rate) is value is -2,564, this means that it has a longer left tail than the right. This measure indicates that the observed values have remained homogeneous over a long period of time like, for instance, the GDP.

Kurtosis measures whether a series has peaks (peaked) or is constant (flat) relative to the values of the normal distribution. In the event that a variable has a very high kurtosis value, it tends to have a very high peak value around the mean and it decreases rapidly, with very heavy tails. If a series shows lower kurtosis values, it tends to have a flat top close to the mean instead of an acute peak. The expected values of kurtosis in a standard normal distribution are values that tend to or are close to zero, in this case all variables are constant CD(-1,308), LR(-0,959), LMC(-1,119), LBC(0,280), LCC(-0,775), EUR(-0,263), UR(-0,557), DIG(-0,044), CPI(-1,072) PSI (0,017) and ER(-0,585), with the exception of GDP which has a peak value of 8,439 and CP the value is 5,104.

4.2.5. Model performance evaluation

Now we have a Z series estimated and we move on to the next goal of this dissertation, which is precisely to try to explain the behavior of this Z-factor series with macroeconomic variables representative of the country's economic situation, such as Unemployment Rate (UR), Loans Rate (LR), this loans contains aggregate demand, with all type of loans, Mortgage Credit (LMC), Consumer Credit (LCC), Business Credit (LBC), Euribor interest rate – 3 months (EUR), GDP, Price Stock Index 20 Lisbon (PSI), Disposable Income Growth (DIG), Consumer Price Index (CPI), Exchange Rate (ER) and Carbon Price (CP) in order to prevision Z series.

One of major concerns that must be present when estimate credit risk regression and explanatory variables is the existence of spurious variables. In order to avoid this appearance, several estimates of different models were carried out to assess the credibility of the estimates. Generally, these regressions are characterized by a high R^2 and low value of the Durbin Watson test. To avoid this problem, the series of the first different lagged was used, however this solution eliminates the trend of the series and hides the long-term relationship between the variables.

The model is:

$$CD = 0{,}188_1 + (-0{,}689)_2 LR_t + (-0{,}586)_3 LMC_t + 0{,}043_4 LCC_t + (-0{,}195)_5 LBC_t + 0{,}201_6 EUR_t + 0{,}452_7 UR_t + (-0{,}149)_8 GDP_t + 0{,}013_9 PSI_t + 0{,}019_{10} DIG_t + (-0{,}653)_{11} CPI_t + (-0{,}014)_{12} ER_t + 0{,}021_{13} CP_t$$

In order to verify the credibility of estimation, the model was estimated with 99% to prevision the dependent variable. This results suggest a high relationship between Default Credit and macroeconomic variables.

On table x of appendix C Adjusted R-square are quite high, in terms of explanatory variables, indicating that the predictor implement improved the output variable. On present Model contains twelve explanatory variables, such as Unemployment Rate (UR), Loans Rate (LR), this loans contains aggregate demand, with all type of loans, Mortgage Credit (LMC), Consumer Credit (LCC), Business Credit (LBC), Euribor interest rate – 3 months (EUR), GDP, Price Stock Index 20 Lisbon (PSI), Disposable Income Growth (DIG), Consumer Price Index (CPI), Exchange Rate (ER) and Carbon Price (CP). The variables improved in relation to the model without predictors, the ability to predict credit default by 89% value given by the R^2 Change. This model is statistically significant [F(12,35)=283,629; ρ<0,001; R^2=0,99], to a significance level of 1%. Therefore, it accepts the null hypothesis (H_0: $model\ 1\ adjustment = model\ without\ predictor\ adjustment$).

The statistical value of F is 283,629, higher than the critical F (12,35), therefore, the regression as a whole is significant, this suggests that it predict the Default Credit.

In addition, sig. of the model is <0,001, which also suggest that the Credit Default is predicted with a 100% probability for UR, LR, LMC, LCC, LBC, EUR, GDP, PSI, DIG, CPI, ER and CP together and shows a relationship statistically significant between them.

It will be the model to be adopted in the creation of the linear regression and stress test.

Type of model specification was used in order to be able to control the existence of sent results and to check the extent to which explanatory variables are added and their power to explain the model and understand how the variables have statistical significance.

Durbin-Watson is a test statistic used to detect the presence of autocorrelation at lag 1 in the residuals from regression analysis. Durbin-Watson coefficient is expected to approximate to 2 and to higher than Adjusted R^2. Results demonstrated that fact is verified, Durbin-Watson coefficient is higher than Adjusted R^2, which values are 1,515 and 0,986, respectively. All criteria's is verified, it is concluded that model is not a spurious regression. The results suggest that 99% of variation Credit Default can be explanation by a linear relations involving independent variables.

The adjusted R^2 (98,6%) avoids the overestimation effect by adding all independent variables of the model. Therefore, adjusted R^2 is differed by 0,4% (99 % - 98,6 %).

To confirm that can be used the model it is necessary to check the residues that are given by table x on appendix D, in which it confirms that there is an absence of outliers since it is within the range [-3;3]. The graph above can prove normally distributed.

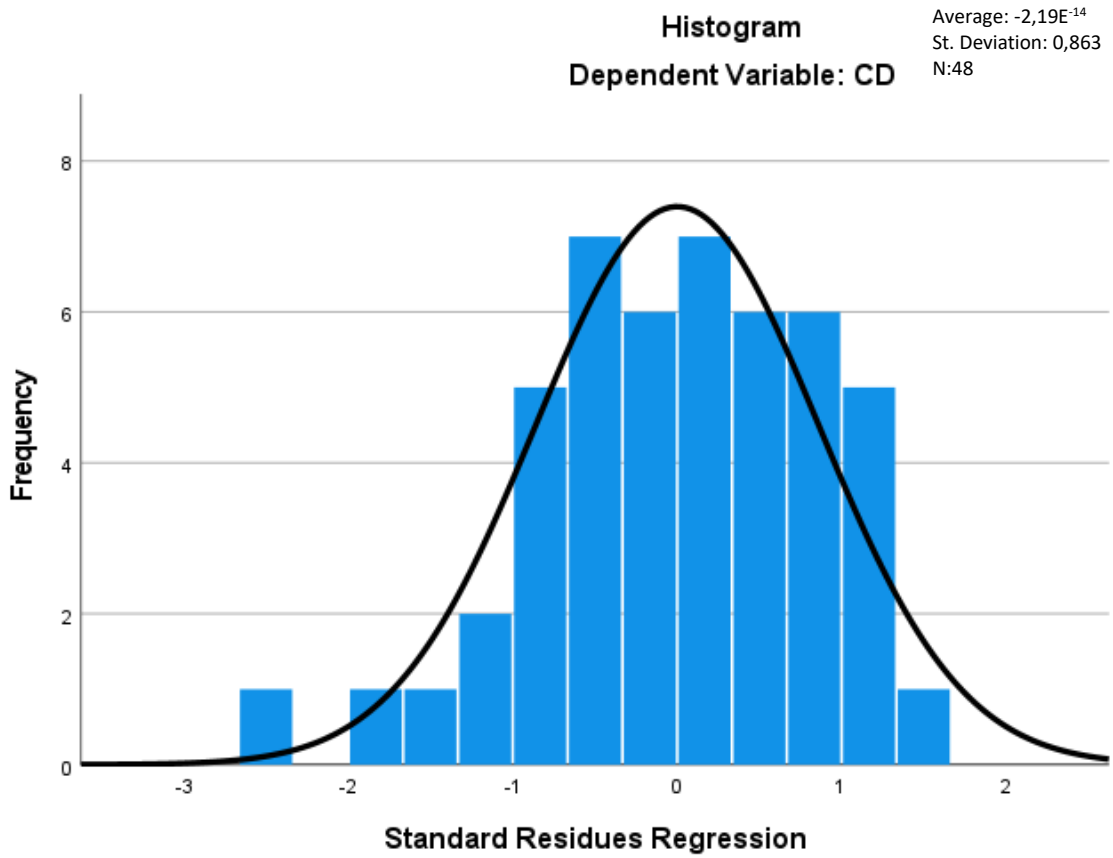


Figure 5 – Histogram Standard Residues Regression (source: prepared by the author).

4.2.6. Specification of model variables

According to the theoretical basis mentioned above, the following equation serves as the basis for the model:

$$CD = 0{,}188_1 + (-0{,}689)_2 LR_t + (-0{,}586)_3 LMC_t + 0{,}043_4 LCC_t + (-0{,}195)_5 LBC_t + 0{,}201_6 EUR_t + 0{,}452_7 UR_t + (-0{,}149)_8 GDP_t + 0{,}013_9 PSI_t + 0{,}019_{10} DIG_t + (-0{,}653)_{11} CPI_t + (-0{,}014)_{12} ER_t + 0{,}021_{13} CP_t$$

Where:

t: represent the quarterly data period de t = 01/2003 ... 9/2021

β_1: Constant that represents the ordinate at the origin of the model.

$\beta_2, \dots, \beta_{13}$: represent the coefficients associated with the respective variables.

CD: Credit Default coefficient is the dependent variable represented by the specific default rate index

UR: Represents the unemployment rate in Portugal.

LR: Represents the rate of loans granted in Portugal

LMC: Represents the rate of loans – Mortgage Credit granted in Portugal

LCC: Represents the rate of loans – Consumer Credit granted in Portugal

LBC: Represents the rate of loans – Business Credit granted in Portugal

EUR: It represents the average interest rate on interbank loans in the euro area.

GDP: Represents the nominal value of GDP.

PSI: Represents the rate of the value of the 20 largest companies in Portugal.

DIG: Represents the nominal value rate disposable income growth.

CPI: Represents the rate of inflation value.

ER: Represents the exchange rate against the US dollar.

CP: Carbon Price rate.

Based on this information, the next step is to identify the most appropriate technique for the development of the theoretical model that should consider the historical default rate of the different portfolios. All prerequisites were attended, next step is to proceed with the model. Through multiple linear regression was used to verify whether macroeconomic variable such as Unemployment Rate (UR), Loans Rate (LR), Mortgage Credit (LMC), Consumer Credit (LCC), Business Credit (LBC), Euribor interest rate – 3 months (EUR), GDP, Price Stock Index 20 Lisbon (PSI), Disposable Income Growth (DIG), Consumer Price Index (CPI), Exchange Rate (ER) and Carbon Price (CP) in Portugal.

Analysis was resulted in a model statistically significant [F(12,35)=283,629; ρ<0,001; R^2=0,990]. Checking each variable individually, the constant is [β_1: 0,188; t=22,860; ρ<0,001]. The regression analysis conducted for the variables, suggests that loans rate (all types of loans) has an effect negative on Credit Default (CD) with a coefficient [β_3= -0,689; t=-4,182; ρ<0,001], that is meaning for each unit

increase in loans, there is an decrease of 68,9 % in Credit Default. The statistical is significant of CD in 0,001, this suggests that of the variation 99% in Credit Default can be predicted by loans, this suggests that the variable is statistically significant.

Mortgage Credit has an effect negative on Credit Default (CD) with a coefficient [β_4=-0,586; t=-3,756; ρ<0,001], that is meaning for each unit increase in Mortgage Credit, there is an decrease of 58,6 % in Credit Default. The statistical is significant of CD is <0,001, this suggests that of the variation in Credit Default can be predicted 99% by Mortgage Credit, this suggests that the variable is statistically significant.

We have more three variables statistically significant, such as Unemployment rate has an effect positive on Credit Default (CD) with a coefficient [β_7=0,452; t=6,282; ρ<0,001], that is meaning for each unit increase in Unemployment Rate, there is an increase of 45,2 % in Credit Default. The statistical is significant of CD is <0,001, this suggests that of the variation in Credit Default can be predicted 99% by Unemployment, this suggests that the variable is statistically significant. GDP growth rate has an effect negative on Credit Default (CD) with a coefficient [β_8=-0,149; t=-3,516; ρ=0,001], that is meaning for each unit increase in GDP, there is a decrease of 14,9 % in Credit Default. The statistical is significant of CD is 0,001, this suggests that of the variation in Credit Default can be predicted 99% by GDP, this suggests that the variable is statistically significant. Finally, the variable Consumer Price Index has a negative impact on Credit Default, coefficient [β_{11}=-0,653; t=-6,452; ρ<0,001], this suggests that of the variation in Credit Default can be predicted 99% by CPI, the variable is statistically significant.

After analyses can be concluded that F statistic are no longer relevant, regardless of the model adopted and most of the coefficients of statistical significance.

In order to be able to assess the credit default risk, it is necessary to understand how macroeconomic variables was influenced on credit risk. The economic situation translates into the evolution of credit risk in economy. The availability of resources in the financial system is provided by monetary indicators. The model indicates that financial obligations is not fulfilled, risk of credit default is greater.

4.3. ROBUST TEST

4.3.1. Correlation Matrix

The theory of probability and statistics, correlation, also called the correlation coefficient, indicates the strength and direction of the linear relationship between two random variables. In general, statistical use, correlation or correlation coefficient refers to the measurement of the relationship between two variables, although correlation does not imply causality. In this general sense, there are several coefficients measuring the degree of correlation, adapted to the nature of the data. (Chaves, 2017)

The correlation analysis allows to study the intensity of the association between two variables. The correlation is weak if the coefficient estimated in absolute value is less than 0.249, moderate if it is between 0.25 and 0.499, strong if it is between 0.5 and 0.749, and finally very strong if it is between

0.75 and 1. The correlation coefficients between each pair of variables are shown in the Table. (Chaves, 2017)

The correlation matrix allows to evaluate the existence of linear dependence between the variables. To verify the existence of multicollinearity, a high correlation is necessary. But, when two or more regressors are involved in linear dependency, the correlation matrix is not efficient.

The correlation indicates the shape and direction of the linear relationship between the random variables, as measured by their relationship. On appendix F shows correlations between the explanatory variables, second part of table show p-value of Pearson Correlation. It is observed that the higher the correlation, the more interrelated between credit default and explonatory variables. The best variable is correlated with dependent variable is LR (R=-0,958; ρ=0,000), it can be said that it will be the best provisor that relates to the exit. Similarly, LMC has a higher negative correlation (R=-0,943; ρ<0,000) and LBC has a higher negative correlation with (R=-0,887; ρ=0,000). On the contrary, there is a high correlation between default and unemployment, in which the value rises by (R=0,733; ρ<0,000). In contrast LCC has a moderate negative correlation (R=-0,279; ρ=0,027). All of these variables indicate that there is a low relationship, which goes against the initial expectations of influencing the dependent variable. Although this influence can only be concluded after the analysis of linear regression.

4.3.2. Evaluation of the multicollinearity

In order to verify the existence or not of multicollinearity involved between the study variables, Pearson's correlation was calculated. Pearson's correlation coefficient measures the degree of correlation and the direction of that correlation, positive or negative, between the variables. The results of which are presented in the Appendix F. It appears that excluding the correlation values between the credit risk variables, all other values are less than 0,7, except for LR, LMC, LBC and UR.

Appendix E confirms that there is no multicollinearity, since all values obtained are greater than 0,01 in tolerance and VIF all values are <10, that is, all residues are independent, indicating the absence of multicollinearity in the adopted variables.

4.4. SCENARIO ANALYSIS

The stress tests contain a variety of methodologies, the methodology applied in the present study consists in a sensitivity analysis that aims to assess the macroeconomic impact resulting from the pandemic, on economic capital, variable of credit default in Portugal. The stress test performed aims to assess credit risk.

The initial model has 13 explanatory variables. In order to select variables for model, several considerations needed to be taken. A low number of variables was used, for reasons of data being

reduced, to keep the number of degrees of freedom high. Therefore, variables had the greatest explanatory power in the model were used.

The first phase of scenario analysis consisted on motorization of macroeconomic variables studied, as stated in Pillar II, which consists of strengthening external supervision to help mitigate the risks inherent in the banking system.

After the re-estimation of the models without the variables with less influence on dependent variable. The choice is regarding of statistically significant, that the p-value associated to the individual significance tests are higher the usual significance level, and to not reject of the null hypothesis.

T-test hypothesis:

$$\begin{cases} H_0: \beta_i = 0 \\ H_{1:} \beta_i \neq 0 \end{cases}$$

With i = 1, …, n.

After the estimation models, the resulting is equal to:

$$Stress\ Test_t = \beta_1 + \beta_2 LR_t + \beta_3 LMC_t + \beta_4 UR_t + \beta_5 GDP_t + \beta_5 CPI_t + \beta_5 CP_t$$

In spite of, CP in present model is not statistically significant, we will use according to the new approaches of the ECB, it is important a multinational macroeconomic model should be used to provide a more complete financial information. The present study we used unemployment, loans granted, Mortgage Credit granted, nominal value of GDP, Consumer Price Index. In order to simulate the macroeconomic impacts of climate policies, Carbon Price is added.

The mean idea of climate change is regarding the transition of the low carbon economy, it will affect different sectors to be more exposed and sensitive to the associated structural.

The scenario analysis was based on the linear regression model previously studied, in order to predict the output variable of credit default. *Banco de Portugal* and *ECB* have projections for some of the variables studied, and these made projections will be used for the analysis of different scenarios, *Banco de Portugal* has some information available that the explorer does not have, the asymmetric information. Variables have not a projection in *Banco de Portugal* were projected according to historical data, fundamentally in maintaining the behavior and trajectory observed in the variables originally reported by *Banco De Portugal* and *ECB* (ECB, 2021).

4.5. FINAL MODEL QUALITY

After re-estimated coefficients are statistically significate, except CP. The next step is to test the model multicollinearity, the individual and the mean VIF are bellow 10, so there is no evidence of multicollinearity.

Another point is to test the autocorrelation and analysis was resulted in a model statistically significant [F(6,65)=293,781; ρ<0,001; R^2=0,964].

The re-estimation models, the resulting is equal to:

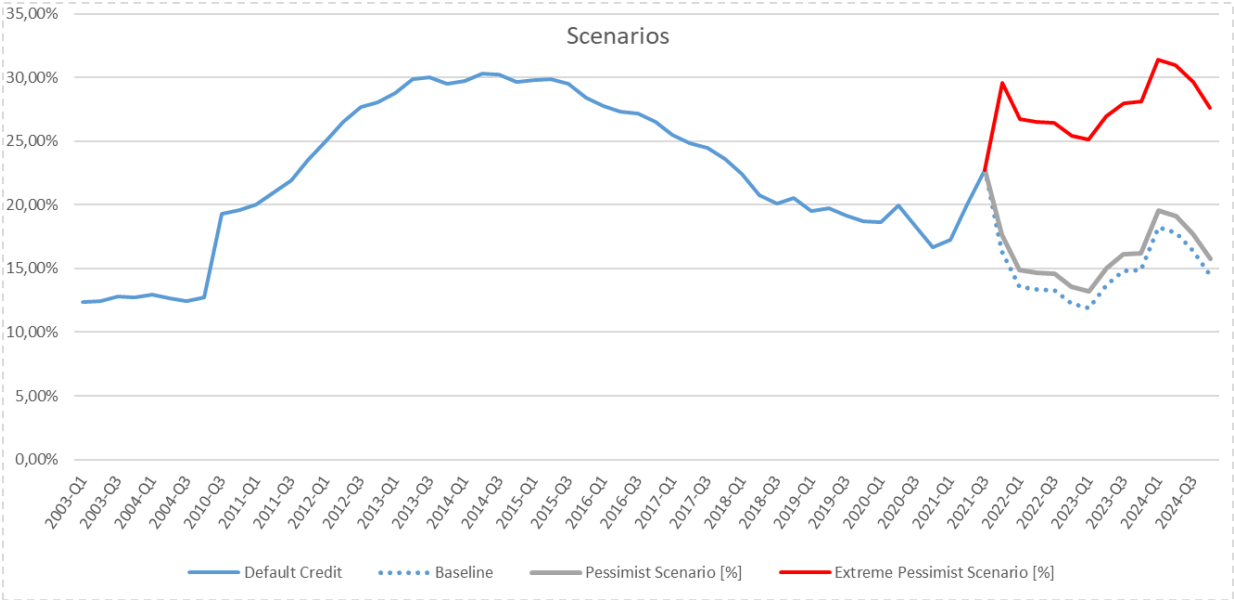
$$Stress\ Test_t = 0{,}164_1 + (-0{,}215)_2 LR_t + (-0{,}715)_3 LMC_t + 0{,}697_4 UR_t + (-0{,}235)_5 GDP_t + (-0{,}762)_5 CPI_t + 0{,}017_5 CP_t$$

The credit risk assessment exercises are based on three macroeconomic scenarios, they include a baseline that reflects the expected trajectory of credit default of two struggling scenarios.

Baseline scenario: This is the scenario that has the reference and aims to capture the expected evolution of economic activity with regression studied and projections by *EBC* and *Banco de Portugal*, called by baseline.

Scenario 1: This scenario is created causing a decrease by 0,5 percentage points for 4 consecutive quarters, falls 1 percentage point for 2 consecutive quarters and goes down to 2 percentage points in the last quarter of 2023 on Unemployment rate, loans and Carbon Price, called by pessimist scenario.

Scenario 2: This scenario is created causing a worsening in all 5% percentage points for 4 consecutive quarters, falls 5 percentage points in the last quarter of 2023 in the same variables of scenario 1, called by extreme pessimist scenario.



Graphic 1 - Analyses Scenarios - combination macroeconomics factors with Charge Off (source: prepared by the author)

The projected scenarios confirm that there may be a large increase in credit default, therefore confirming the need to apply improvement actions. Graphic 1 shows the base, pessimist and extreme pessimist provision of the 3 scenarios with the combination of the calculated macroeconomic variables with the coefficients found resulting in the Credit Default value.

From the prevailing information that is currently in force, regarding credit default, the lag in the escalation of the variables was applied and reflects a possible increase in credit default after the end of moratorium credit. The extreme pessimist scenario alerts to levels of credit default never reached in Portugal before.

The following graphics provide forecasts for the various macroeconomic variables analyzed combined with the planned Credit Default. Credit Default is calculated using all indicators performed in the

analysis of scenarios, for this reason, CD will be the same in all graphics presented, and is between 25% to 26% in the upcoming years. Charge off is to consider as a loss a debt that will probably not be paid.

Returning to the pandemic situation, elaborated provisions are for an increase of unemployment in Portugal in the upcoming years. The currently unemployment rate has not reached very high levels due to policies applied in Portugal, such as the layoff, so there is a shortfall in the impact of the employment crisis, with its peak expected in 2022.

Layoff is the temporary suspension or permanent termination of employment of an employee or a group of employees for a business reasons, in this case, cause by a pandemic situation. There is a significant decrease of work in any organization, in some cases there is no business.

Measures of credit default have been implemented, it leads to an extended payment rent, in a period of time, to banks. Therefore, there is no sharp drop in credit default. Banks continue to grant loans, helping to promote private consumption and investment.

4.6. Testing The Study Hypothesis

The present dissertation had as the mean goals of study the credit default in Portugal and sough to answer the research question: What is the influence of macroeconomic factors on credit default in Portugal, during the management of the pandemic caused by COVID-19 and the climate change crisis?

To test the hypotheses of the study, a consideration was given to the analysis of linear regression, which was critical for the acceptance or rejection of the hypotheses proposed in the study. In order to optimize the model we opted for elimination same explanatory variable which it is not statically significant. Through this procedure, the final models are composed of six explanatory variables, such as LR, LMC, UR, GDP, CPI and CP.

Hypotheses 1: The loans rate influence negatively credit default rate.

The present analyses suggest that 96,4% of Credit Default variation may be explained by second model of a linear relationship. The results suggests that coefficients were obtained by linear regression LR had β=-0,215 that means loans contribute negatively for impact on output variable, more specific a increase on LR to decrease 21,5% on CD. Pearson correlation is confirmed with ρ=-0,914 and there is no multicollinearity with VIF bellow 10. Thus validating the hypothesis 1, the negatively influence of loans on Credit Default.

The results collected go against our initial expectations, we can observe that the whole period under analysis the moments in which there was a low rate of credit default, there was a greater supply of credit through banking institutions, and in periods of high default, like the case between 2012 and 2016 that originated the subprime crisis in the USA, which was reflected in Portugal years later, was particularly marked by a contraction in credit supply. This period was particularly marked by a high rate of credit default, on the other hand, this period was also marked by a control on the bank's part in the provision of loans, as can be seen in graph s. The granting of credit has adversarial signs on the default of credit.

The ECB allowed the institutions to supervise the operation temporarily with a lower level of own funds guidance (PILLAR 2) and that of the combined own funds reserve, and with liquidity levels below the liquidity coverage requirement. In this way, it is possible to free financial resources from economic activity, thus preserving financial stability. It should be noted that the ECB and the Bank of Portugal have decided to recommend banks not to distribute dividends for the years 2019 and 2020, in order to promote their performance in financing the economy and the capacity to absorb potential losses. (Portugal, Financial Stability Report, June 2020)

Hypotheses 2: The mortgage credit influence default credit rate.

Similarly with hypotheses 1, mortgage credit is statistically significant on model 1 and this variable is included on model 2. Mortgage Credit has an effect negative on Credit Default (CD) with a coefficient on model 2 [β_3=-0,715; t=-2,122; ρ=0,038], that is meaning for each unit increase in Mortgage Credit, there is an decrease of 71,5 % in Credit Default. The statistical is significant of CD is <0,001, this suggests that of the variation in Credit Default can be predicted 96,4% by Mortgage Credit, this suggests that the variable is statistically significant. Standardized coefficients reflects that the variable with the greatest impact on credit default was Mortgage Credit. Pearson coefficients was confirmed in the same way, with ρ = -0,929 and p-value=<0,0001 and there is no multicollinearity with VIF bellow 10. Mortgage Credit is the variable according to the model studied, with the greatest influence on credit default, and for this reason it is an alert variable. The competent entities have also this variable as crucial one in the form of risk mitigation, for this reason they have implemented some preventive measures. Thus validating the hypothesis 2, the negatively influence of loans on Credit Default.

The Portuguese government, like other European countries, defined Decree-Law no. 10-J / 2020, of March 26, with a term that will remain in force until March 31, 2021, establishes a set of extraordinary measures to protect debtors and payees:

1. The extension for a period equal to the term of the moratorium measure, of credits with payment of capital at the end of the contract.
2. The suspension of credits with partial repayment of capital or with partial maturity of other cash benefits, during the period in which the measure of capital payment, rents and interest with effective maturity is in effect until the end of that period.
3. The prohibition on the revocation of credit lines contracted and loans granted in the amounts contracted at the date of entry into force of the Decree-Law.

Moratoriums represent a fundamental measure, which aims to reconcile the continuity of business activity after the immediate impact of the health crisis, avoiding cash flow problems from turning into insolvencies, and on the other hand, the safeguarding of the economy's financing capacity by the banking system, minimizing its consumption of capital. (Portugal, Financial Stability Report, June 2020)

The question that arises is with the end of these arrears, the default of credit can increase quickly, and for that reason, the possible impact was studied in the stress test. Through the affected study, the variable that can mitigate these risks is to act on the unemployment variable, in order to particulars to continue fulfilling their obligations.

Hypotheses 3: The consumer credit influence credit default rate.

Regarding hypothesis 3, the results of the study suggest that the correlation between Credit Default and the LCC is not statistically significant. Not validating hypothesis 3, the influence of consumer credit on credit default. Although, this result is not consistent with previous studies that referred to the existence of relationship between variables, (Nunes, 2009 - quoted by (Veloso, 2016), is, however consistent with studies that do not confirm the existence of a direct relationship.

Hypotheses 4: The business credit influence default credit rate.

Regarding hypothesis 4, in the same way, the results of the study suggest that the correlation between Credit Default and the LBC is not statistically significant. Not validating hypothesis 4, the influence of consumer credit on credit default. Although, this result is not consistent with previous studies that referred to the existence of relationship between variables, (Nunes, 2009 - quoted by (Veloso, 2016), is, however consistent with studies that do not confirm the existence of a direct relationship.

Hypotheses 5: The unemployment rate influence positively credit default rate.

The results obtained from the present study the hypotheses 5 is confirming the initial expectations of the positive signals between variables unemployment and credit default. Linear regression model β=0,452 presents a great weigh in the output variable, credit default. In the same way Standardized Beta on model 2, with all variables, confirmed that unemployment rate had a great influence on the credit default with Standardized β=0,697. The test Pearson correlation carried out reveals a strong correlation of ρ = 0,797 with p-value=0,0001, this means that the increase in the unemployment rate is related to credit default. This leads to an urgent need to mitigate the possible risks of high unemployment and to control high level of credit default is to take preventive measures to control the unemployment rate.

Present literature mention the unemployment rate is another warning signal variable to the financial situation of a country. When unemployment rate increases translates into a decrease in expected earnings, as there are fewer people contributing to a country's wealth. Consequently, there will be less aggregate demand, resulting in a credit default to individuals who have their conditional income and for companies. The expected sign between the credit default variables and unemployment rate are positive. With the deterioration of economic and financial conditions, financial agents condition of access to credit.

The Portuguese government, like other governments, has promoted layoff schemes through, which it seeks to maintain employment links and contributing to a progressive resumption of economic activity. In this way it is possible to realize that this lay-off scheme may have been a good, adopted measure for the progressive return of economic activity.

Hypotheses 6: The 3-month Euribor interest rate influence credit default rate.

Regarding hypothesis 6, On model 1 loans β=0,201 with p-value=0,247, it is meaning that it is not statistically significant of level 1%. Pearson correlation reinforces the same idea, with a low positive

correlation between TBA-Euribor 3 months and Default Credit. The results of the study suggest that the correlation between Credit Default and the EUR is not statistically significant. Not validating hypothesis 6, the influence of 3-month Euribor interest rate on credit default. Although, this result is not consistent with previous studies that referred to the existence of relationship between variables, Cited by Chaves, is, however consistent with studies that do not confirm the existence of a direct relationship.

The interest rate has an essential role, monetary authorities can manipulate the risk to stabilization performance. The interest rate is increased, the greater the risk of default, as borrowers will have to pay more for the same loan, resulting in a disposable income decrease.

The countries that adhered to European currency, known as the euro area, as in the case of Portugal, the issuance of banknotes is the responsibility of the European Central Bank, which is responsible for monetary policy, in particular the control of the growth of money supply. The Central Bank increases or decreases the interest rate as a measure of control of the money supply, when interest rate increase, it is meaning credit is more expensive, consequently creditors find it more difficult to meet their obligations. On the other hand, when interest rate decreases economic agents look for other alternatives to the application of their deposits. For this reason, the ECB controls the interest rate according to the other economic variables to research a balance in economy.

The results obtained go against initial expectations, reflecting an opposite effect on the relationship between TBA-Euribor and credit default. This opposite effect is explained by the preventive measures applied by the European Central Bank, since the way to mitigate the risks of default is through measures to reduce the interest rate.

Hypotheses 7: Nominal GDP growth rate influence negatively credit default rate.

The results suggests that nominal GDP has lagged with ρ<0,0001, meaning that these variables rejected null hypothesis and accept hypothesis H_1 series is stationarity, different lag is used on linear regression.

The results suggests that coefficients were obtained by linear regression GDP had β=-0,149 that means GDP contribute negatively for impact on output variable. Pearson correlation is confirmed with ρ=-0,053, indicating a weak correlation and there is no multicollinearity with VIF bellow 10. The present analyses suggest that 96,4% of Credit Default variation may be explained by second model of a linear relationship. On model 2, goes against initial expectations with contradictory signals. Reinforcing the idea conveyed in the sub-chapter specification of the model variable, this can be explained by the effect of credit default on later years, in which there was a greater default of credit, between 2012 and 2016, progress in economic GDP started to make progress. Since, according to the historical data analyzed, the effects of a shock can take about 2 years to be reflected. The GDP had a long period of time with negative values, between 2008 (contagious effect of the subprime crisis) and 2013. The effect on the credit default variable only worsened between 2012 and 2016. This may explain the positive signs between the variables, despite that, GDP has little impact on the output variable due to the time lag that the impact on GDP has on the variable dependent on credit default.

The decrease in GDP is due to the pandemic situation COVID-19, characterized by the interaction of supply and demand shocks, together with the high degree of uncertainty about how the economic situation will evolve, accompanied by a fall in productivity, due to the closure partial or total of companies. At the same time, consumption and investment levels were also affected, with negative consequences on job search.

Contextualizing the economic theory that translates into a phase of expansion, there is a decrease credit default. This expansion phase is characterized by a tendency for economic agents to borrow, because there is more disposable income at present. But this expansionary phase usually brings a consequent recession phase, called economic cycles. Second phase of recession is verified by a trend towards a credit default increase. For this reason, the theory explains that there is a negative association between credit risk and the GDP growth rate.

In the coming years, GDP is expected to recover due to the evolution of global productivity, leading to an increase in exports. This scenario is based on the non-adoption of containment measures.

Thus validating the hypothesis 7, the negatively influence of GDP on Credit Default.

Hypotheses 8: The Price Stock Index of the best twenty companies in Lisbon influence credit default rate.

Regarding hypothesis 8, the results of the study suggest that the correlation between Credit Default and the PSI is not statistically significant. Not validating hypothesis 8, the influence of Price Stock Index on credit default. The Since the coefficient obtained through linear regression was negative, with β=0,013 for model 1 and ρ=0,047, it means that PSI and CD had a weak correlation. Although there is a weak correlation between PSI 20 and output variable, the stock price index allows to know the influence of the financial conditions of companies listed on the Lisbon stock exchange on credit risk. An increase in the stock market index can translate into good financial health for listed companies, which can contribute to reducing the risk of credit default. The theoretical point of view is not the expected relationship of the variables, of a positive sign between credit default and PSI20.

Hypotheses 9: The nominal Disposable Income growth influence negatively credit default rate.

Regarding hypothesis 9, the results of the study suggest that the correlation between Credit Default and the DIG is not statistically significant. The test of the correlation between the variables confirms that there is a negative weak correlation between the two factors of ρ = -0,090, meaning when increase disposable income will lead to a decrease in Credit Default. DIG had a β=0,019. Therefore, when there are levels of savings on the part of individuals and companies, in situations without liquidity agents can use savings to fulfil obligations, for this reason, an increase in the increase in DIG has a decreasing impact on credit default.

The disposable income of families is also expected to fall, because of the government measures applied, specifically the lay-off system in which the worker offers an income of 100%, as well as, of the self-employed workers, in order to maintain nominal disposable income level of families. Other cases are COVID patients, who, in contrast to individuals in prophylactic isolation who offer their income in the order of 100%, COVID patients have their salary in the order of 55%, in the first 30 days of the disease (Social, 2020). Consequently, there is a drop in purchasing power. Likewise, there is no provision for any government policy to deal with the loss of income.

Disposable income is limited by borrowing, since purchasing power is lost to meet commitments. Disposable income expresses the value available, this means that a high value translates into greater savings for consumers. Lower levels of savings mean greater risks of default.

Hypotheses 10: The Consumer Price Index influence positively credit default rate.

The present analyses suggest that 96,4% of Credit Default variation may be explained by second model of a linear relationship. The results suggests that coefficients were obtained by linear regression CPI had β=-0,762 that means CPI contribute negatively for impact on output variable, more specific a decrease on CPI to increase 76,2% on CD. Pearson correlation is confirmed with ρ=-0,395 and there is no multicollinearity with VIF bellow 10. Thus validating the hypothesis 10, the negatively influence of CPI on Credit Default.

Regarding the inflationary impact on credit risk, from a theoretical point of view, inflation occurs when there is a persistent increase in the prices of goods and services without a corresponding increase in the level of production. When there is an increase in inflation in the economy, monetary regulators accompany the increase in interest rates, as a contractionary measure to control inflation. This measure, as a general rule, leads to an increase in the cost of borrowing. (Yahaya & Oni, 2016) Despite this, Castro cited by (Rodrigues, 2013) says that a higher inflation rate can make debt service easier by reducing the real value of loans in force. The signal between the CPI and the credit default risk is indeterminate from a theoretical point of view, in this particular case the signal is negative.

Hypotheses 11: The exchange rate influence credit default rate.

Regarding hypothesis 11, the results of the study suggest that the correlation between Credit Default and the ER is not statistically significant. Not validating hypothesis 11, the influence of exchange rate on credit default. Although, this result is not consistent with previous studies that referred to the existence of relationship between variables, the effective real exchange rate is the measure of the Portuguese economy's competitiveness than a outside world. Theoretically, a decrease in the exchange rate represents a depreciation of the local currency, translating into more competitive goods and services produced in Portugal, consequently there is greater income to fulfil obligations.

Although, on model 1 it can be verified with theorical literature, the increase of 1,4% on exchange rate decrease on CD, with β=-0,014. Despite of hypothesis being verified; it is concluded it is not statistically significant to credit default.

Hypotheses 12: There is a relationship between credit and macroeconomics variables.

Regarding to hypotheses 12, the results of model 2 suggest an improvement in the quality if same measures is to applied with defaulting customers, such as LR, LMC, UR, GDP, CPI and CP.

Hypotheses 13: The carbon price index influence credit default rate.

Regarding hypothesis 13, the results of the study suggest that the correlation between Credit Default and the CP is not statistically significant. Not validating hypothesis 13, the influence of carbon price on credit default. Although, this result is not consistent with previous studies that referred to the existence of relationship between variables, the climate change is very important (ECB, 2021). For this reason, CP was estimated for model 2. The results suggest that increase on Carbon Price, will be a increase on 1,7% Credit Default.

In view of the hypotheses presented, it is necessary to analyze the main objective of the investigation. Check through the assessment and management model of credit risk, What is the influence of macroeconomic factors on credit default in Portugal, during the management of the pandemic caused by COVID-19 and the climate change crisis?

After the study carried out, it was time for reflection and discussion, in which the focus of the work developed is related to the economic impact on financial sector, specifically in credit default, but which started in health, with the confinement measures to control the transmission of the virus.

There have been other economic fluctuations in history, but the current crisis requires new instruments and actions, since in Portugal we had two confinements. The companies had to readjust, and those that failed to do so have high levels of indebtedness, consequently, the insolvency of the companies. In companies there is a lot of human capital that has not been reallocated, some inevitably went to the layoff, others were enrolled in the unemployment fund. Still, there are sectors such as tourism and air transport that have greater difficulty in readjusting business, but there are creative solutions for the sectors in question. For example, readjusting rooms to receive telecommuting employees at more affordable prices, ensuring daily meals, either for guests or with workers from a certain company, making rooms available to people on the front lines, examples to fill the weak demand.

As it was verified, the measures of the first confinement led to a drop in GDP of around 16% in the quarter corresponding to the first confinement. a very serious reason for alerting the financial sector. There are studies that indicate that the world economic crisis is more serious than the great depression of 1930. The measures of social confinement, the restrictions of circulation and the loss of working hours are limiting the global production, the chains global trade and services sector.

The European Central Bank approved a program called the Pandemic Emergency Purchase Program that was launched to combat the economic effects of the pandemic, such as the case of loan default. The current economic crisis was marked by the fall in aggregate demand, but which has an impact on the supply side. Consequently, it dragged the corporate fabric, leading to significant billing losses, increasing liquidity problems. These losses on the supply side are reflected in unemployment, loss of income, retraction in demand, bankruptcies and closures, financial difficulties and the sharp rise in uncertainty and risk.

The government's response was, in the first instance, to combat the health emergency, then by the deployment of social support aimed at mitigating the first relevant impacts on income and employment and, from then on, by the mobilization of resources aimed at sustaining markets, companies and the economic intervention of the State itself. This new context requires a lot of resilience from the business fabric, as well as adapting to this new way of being, in which face-to-face work gives way to teleworking. Reallocating human capital involves providing more services, providing training, strengthening the business for digital commerce and, finally, reaching the final consumer through home deliveries.

One way to prevent credit default is to ensure liquidity on the part of companies and jobs, on the part of individuals, as studied, is one of the variables with the greatest impact according to our model. The fact that there is a vaccine against the new coronavirus has increased confidence levels, but since the future is not known, if this will become the new normal of everyday life, there is an emergency of adaptation. If this adjustment is not made, we will be facing a very serious crisis, with effects on credit defaults never felt before.

5. CONCLUSIONS

In this dissertation, a study was execute for the possible relationship between credit risk and variables macroeconomics in Portugal resulting from the pandemic. Risk is part of the granting of credit, but this should be minimized as much as possible, so that lending institutions take care. However, it is necessary to take into account credit policies and macroeconomic variables. The statistical inference based on linear regression model, highlighted a series of results that allow us to draw a conclusion about the evolution of credit risks in relation to the other macroeconomic variables in the Portuguese economy, where in the period from 2003Q1 to 2021Q3, two regressions were estimated for the dependent variable under study.

With the present research work it was possible to answer the scientific problem initially mentioned, the general and specific objectives, as well as the hypothesis. Evaluating each specific objective and the proposed main one:

The main objective proposed was to identify the macroeconomic variables that affect credit default. The objective was fulfilled. At the macroeconomic level, the main determinants of economic activity measures stand out: loans, mortgage credit, unemployment rate, GDP, consumer price index and carbon price were the variables used in the analysis of the scenario, as they are the variables with the greatest impact on the dependent variable and statistically significant.

The present work had as its first specific objective to study the existing literature regarding credit risk, stress testing, identification of the main macroeconomic variables that affect the economy. In this way, we were able to propose a methodology for building a stress test in the Portuguese economy, with a greater focus on preventing credit default. This was the main focus, since all the previous financial crises started with credit default and had a contagious effect on the rest of the economy. Likewise, the studied literature contributed to the construction of the stress test, so that the methodology would take into account the Basel agreements in the connection between macroeconomic and credit risk factors.

There is an increasing need for the creation of risk control and mitigation instruments in an economy, in order to understand, predict, manage and measure risks in it. As we are facing a situation never before experienced, COVID-19, these instruments are valuable in the performance of corrective measures in future events.

The second specific objective was to create a model that detects the default rate. The objective was achieved through the exploratory descriptive research model with the quantitative approach as a research strategy, it was possible to collect macroeconomic data and from the descriptive statistics, namely the analysis of multiple linear regression, it was possible to achieve this objective.

The current situation did not start with credit default, but through the analysis of the various macroeconomic variables, the objective is to prevent this situation from happening. Thus, the study made it possible to conduct a policy analysis on the effect of changes in macroeconomic risk factors.

The third objective was to test the model and check its variables. It was concluded that the model has variables according to the studied literature, such as the loans, mortgage credit, unemployment rate, GDP, consumer price index and carbon price are related to credit default. The remaining macroeconomic variables studied cannot be concluded.

The fourth objective was to evaluate the results obtained, taking into account the main objective of studying the relationship between macroeconomic variables in relation to credit default, due to the pandemic situation currently felt. With the study carried out, through the correlational analysis between the variables, it was concluded that the macroeconomic variables with an impact on credit default are the unemployment rate, the loans granted and, finally, the EURIBOR rate. The remaining macroeconomic variables, such as LR, LMC, UR, GDP, CPI and CP, according to the model built, will have little impact on credit default. In this way, policies can be designed in Portugal in order to prevent a financial crisis due to credit default. Thus, it is concluded that the measures imposed by the government are in accordance with the test carried out. More specifically, with the layoff regime, ensuring that there is no sharp increase in the unemployment rate, and awaiting the progressive recovery of the economy.

Credit also has a major influence on charge-off, as we are experiencing an extraordinary situation. Government measures regarding credit default have been well implemented. As a result, there was a suspension of the loan instalments, avoiding default. The economic and financial consequences of this pandemic may extend well beyond the expected end of the term of the moratorium regimes, so that, after its end, there may be an increase in non-compliance with credit obligations of both individuals and companies. In this sense, it is essential that the moratorium regimes are accompanied by other measures to support the liquidity and solvency of the different economic agents and to revive the economy.

Finally, the Euribor rate also has an impact on credit default, so the measure taken to lower it has effects on preventing default.

> *Classically, financial crisis hurt the supply side of the economy. There is a long history of this crisis, and policymakers have learned a lot about how to deal with them. But the coronavirus extends liquidity and capital problems to the real economy - and it does so on an unprecedented scale. As if the double risk of financial shocks and real liquidity were not enough, they are also interrelated, increasing the stakes. (Carlsson-Szlezak, Reeves, & Swartz, 2020).*

6. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORKS

The present study had a major limitation, since the current situation started in March of the year, 2020, the difficulty of obtaining database regarding the studied variables is highlighted, as well as little knowledge exists about the new coronavirus. It is not known how the virus behaves and how it can act more effectively. Another limitation is the lack of similar situations in world history, since it is the first time that a financial crisis does not start with the default of credit, but with shocks in supply and demand.

We had currently lived in time of great uncertainty and there are uncertainty of economic agents reactions to the pandemic context. There are another limitations regarding the present study, for example, the world faces the challenge to make structural changes consumption pattern and saving. Therefore, there is a great intervention of the state that it is not known what measures will be implement.

As a recommendation for future work, there is a range of possibilities to be studied, and the more progress is made in investigating the new virus, the more data can be obtained. Thus, it is proposed to systematically reassess macroeconomic variables as more data is obtained.

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8. APPENDIX

8.1. APPENDIX A – STATIONARY TEST

SUMMARY OUTPUT	CD							
Regression Statistics								
Multiple R	0,483152							
R Square	0,233436							
Adjusted R Square	0,211534							
Standard Error	0,006474							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,000893	0,000447	10,6583	9,1E-05			
Residual	70	0,002934	4,19E-05					
Total	72	0,003827						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,00407	0,0026	1,565114	0,122066	-0,00112	0,009256	-0,00112	0,009256
Lagged Credit Default	-0,01804	0,012316	-1,46445	0,147547	-0,0426	0,006527	-0,0426	0,006527
Differente Lagged Credit Default	0,489945	0,114791	4,268136	6,08E-05	0,261001	0,71889	0,261001	0,71889

SUMMARY OUTPUT	LMC							
Regression Statistics								
Multiple R	0,523019							
R Square	0,273549							
Adjusted R Square	0,252793							
Standard Error	0,008588							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,001944	0,000972	13,17942	1,39E-05			
Residual	70	0,005163	7,38E-05					
Total	72	0,007107						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,000264	0,001095	0,240844	0,81038	-0,00192	0,002447	-0,00192	0,002447
Lagged Mortgage Credit	-0,04547	0,023334	-1,94856	0,055357	-0,09201	0,001071	-0,09201	0,001071
Different Lagged Mortgage Credit	0,393256	0,083148	4,729614	1,13E-05	0,227424	0,559089	0,227424	0,559089

SUMMARY OUTPUT	LCC							
Regression Statistics								
Multiple R	0,53479							
R Square	0,286							
Adjusted R Square	0,2656							
Standard Error	0,013782							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,005326	0,002663	14,01964	7,58E-06			
Residual	70	0,013296	0,00019					
Total	72	0,018622						
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,000495	0,001803	0,274334	0,784636	-0,0031	0,004091	-0,0031	0,004091
Lagged Consumer Credit	-0,04639	0,024733	-1,87582	0,06485	-0,09572	0,002934	-0,09572	0,002934
Different Lagged Consumer Credit	0,473545	0,10124	4,677461	1,37E-05	0,271629	0,675462	0,271629	0,675462

SUMMARY OUTPUT	LBC							
Regression Statistics								
Multiple R	0,62883							
R Square	0,395427							
Adjusted R Square	0,369141							
Standard Error	0,005891							
Observations	49							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,001044	0,000522	15,04336	9,4E-06			
Residual	46	0,001596	3,47E-05					
Total	48	0,00264						
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	-0,00064	0,000845	-0,75455	0,454362	-0,00234	0,001064	-0,00234	0,001064
Lagged Business Credit	-0,15291	0,036634	-4,17406	0,000132	-0,22665	-0,07917	-0,22665	-0,07917
Different Laged Business Credit	0,41214	0,123997	3,323797	0,001749	0,162548	0,661733	0,162548	0,661733

Regression Statistics		UR						
Multiple R	0,659047							
R Square	0,434342							
Adjusted R Square	0,418181							
Standard Error	0,005243							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,001478	0,000739	26,87488	2,18E-09			
Residual	70	0,001924	2,75E-05					
Total	72	0,003402						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,002298	0,001961	1,172056	0,245148	-0,00161	0,006209	-0,00161	0,006209
Lagged Unemployment	-0,02442	0,019249	-1,26842	0,208849	-0,06281	0,013975	-0,06281	0,013975
Differente Lagged Unemployment	0,465432	0,064718	7,191682	5,58E-10	0,336356	0,594508	0,336356	0,594508

SUMMARY OUTPUT		GDP						
Regression Statistics								
Multiple R	0,872981							
R Square	0,762096							
Adjusted R Square	0,755201							
Standard Error	0,017412							
Observations	72							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,067013	0,033506	110,5167	3,06E-22			
Residual	69	0,020919	0,000303					
Total	71	0,087932						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,001685	0,002053	0,820877	0,414543	-0,00241	0,00578	-0,00241	0,00578
Lagged GDP	-0,37325	0,055931	-6,67337	5,17E-09	-0,48483	-0,26167	-0,48483	-0,26167
Differente Lagged GDP	0,62154	0,044767	13,88397	1,17E-21	0,532232	0,710847	0,532232	0,710847

SUMMARY OUTPUT		DIG						
Regression Statistics								
Multiple R	0,980487							
R Square	0,961354							
Adjusted R Square	0,960234							
Standard Error	0,01801							
Observations	72							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,55673	0,278365	858,2272	1,8E-49			
Residual	69	0,02238	0,000324					
Total	71	0,57911						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,045443	0,005533	8,212873	8,16E-12	0,034404	0,056481	0,034404	0,056481
Lagged Nominal Disposible Income	-0,53214	0,059734	-8,90852	4,38E-13	-0,65131	-0,41298	-0,65131	-0,41298
Differente Lagged Nominal Disposible Incon	0,619524	0,018397	33,67536	1,46E-44	0,582823	0,656225	0,582823	0,656225

SUMMARY OUTPUT	CPI							
Regression Statistics								
Multiple R	0,674985							
R Square	0,455605							
Adjusted R Square	0,440051							
Standard Error	0,004399							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,001134	0,000567	29,29153	5,71E-10			
Residual	70	0,001355	1,94E-05					
Total	72	0,002488						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,001681	0,000761	2,209063	0,030445	0,000163	0,003199	0,000163	0,003199
Lagged Consumer Price Index	-0,13774	0,037863	-3,63781	0,000522	-0,21325	-0,06222	-0,21325	-0,06222
Differente Lagged Consumer Price Index	0,477734	0,075664	6,313867	2,17E-08	0,326826	0,628641	0,326826	0,628641

Regression Statistics		PSI						
Multiple R	0,942222							
R Square	0,887782							
Adjusted R Square	0,884432							
Standard Error	0,050868							
Observations	70							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	1,371541	0,68577	265,0257	1,5E-32			
Residual	67	0,173367	0,002588					
Total	69	1,544907						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	-0,00501	0,006112	-0,81938	0,415477	-0,01721	0,007191	-0,01721	0,007191
Lagged PSI20	-0,55533	0,061111	-9,08711	2,67E-13	-0,6773	-0,43335	-0,6773	-0,43335
Different Lagged PSI20	0,594371	0,025817	23,0228	1,55E-33	0,542841	0,645901	0,542841	0,645901

SUMMARY OUTPUT	LR							
Regression Statistics								
Multiple R	0,505989							
R Square	0,256024							
Adjusted R Square	0,234768							
Standard Error	0,008214							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,001625	0,000813	12,04455	3,2E-05			
Residual	70	0,004723	6,75E-05					
Total	72	0,006348						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,000344	0,001059	0,324959	0,746181	-0,00177	0,002456	-0,00177	0,002456
Lagged Loans	-0,04996	0,022095	-2,26097	0,026871	-0,09402	-0,00589	-0,09402	-0,00589
Different Lagged Loans	0,464117	0,113512	4,088686	0,000114	0,237723	0,69051	0,237723	0,69051

SUMMARY OUTPUT	ER							
Regression Statistics								
Multiple R	0,651539							
R Square	0,424504							
Adjusted R Square	0,408061							
Standard Error	0,039336							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,079894	0,039947	25,81707	3,99E-09			
Residual	70	0,108312	0,001547					
Total	72	0,188207						
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,033173	0,010756	3,084165	0,002921	0,011721	0,054625	0,011721	0,054625
Lagged Exchange Rate	-0,12639	0,038237	-3,30549	0,001498	-0,20266	-0,05013	-0,20266	-0,05013
Different Lagged Exchange Rate	0,470453	0,077809	6,046243	6,49E-08	0,315268	0,625639	0,315268	0,625639

SUMMARY OUTPUT	TBA							
Regression Statistics								
Multiple R	0,490641							
R Square	0,240729							
Adjusted R Square	0,219036							
Standard Error	0,002909							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,000188	9,39E-05	11,09685	6,51E-05			
Residual	70	0,000592	8,46E-06					
Total	72	0,00078						
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	-5,3E-05	0,000425	-0,12371	0,901902	-0,0009	0,000795	-0,0009	0,000795
Lagged TBA - 3 months Euribor	-0,03049	0,021996	-1,38634	0,170044	-0,07436	0,013376	-0,07436	0,013376
Different Lagged TBA - 3 months Euribor	0,477281	0,110621	4,314559	5,15E-05	0,256654	0,697908	0,256654	0,697908

SUMMARY OUTPUT	CP							
Regression Statistics								
Multiple R	0,966597							
R Square	0,93431							
Adjusted R Square	0,932378							
Standard Error	0,026918							
Observations	71							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	2	0,700789	0,350395	483,5819	6,24E-41			
Residual	68	0,049272	0,000725					
Total	70	0,750061						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	0,007775	0,003249	2,392771	0,019489	0,001291	0,014259	0,001291	0,014259
Lagged Carbon Price	-0,70389	0,055409	-12,7035	1,27E-19	-0,81446	-0,59333	-0,81446	-0,59333
Different Lagged Carbon Price	0,625814	0,020207	30,97026	8,09E-42	0,585491	0,666136	0,585491	0,666136

8.2. Appendix B – Descriptive Statistics

Statistics

		CD	LR	LMC	LBC	LCC	EUR	UR	GDP	DIG	CPI	PSI	ER	CP
N	Valid	73	73	73	51	73	73	73	72	72	73	70	73	73
	Missing	1	1	1	23	1	1	1	2	2	1	4	1	1
Std. Deviation		,06120925408	,04290905756	,04304774270	,02296689213	,06589571635	,01568645562	,03205288984	,03713084075	,05352011746	,01376933937	,10896519645	,12176164127	,06572157650
Skewness		,307	,321	,307	,331	-,147	,852	,796	-2,564	,153	,018	-,693	,397	-,673
Std. Error of Skewness		,281	,281	,281	,333	,281	,281	,281	,283	,283	,281	,287	,281	,281
Kurtosis		-1,308	-,959	-1,119	,280	-,775	-,263	-,557	8,439	-,044	-1,072	,017	-,585	5,104
Std. Error of Kurtosis		,555	,555	,555	,656	,555	,555	,555	,559	,559	,555	,566	,555	,555

8.3. Appendix C – Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	,995[a]	,990	,986	,00540346369	,990	283,629	12	35	<,001	1,515

a. Predictors: (Constant), CP, ER, PSI, DIG, LR, CPI, GDP, EUR, LCC, UR, LBC, LMC

b. Dependent Variable: CD

8.4. Appendix D – ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,099	12	,008	283,629	<,001[b]
	Residual	,001	35	,000		
	Total	,100	47			

a. Dependent Variable: CD

b. Predictors: (Constant), CP, ER, PSI, DIG, LR, CPI, GDP, EUR, LCC, UR, LBC, LMC

8.5. APPENDIX E – COEFFICIENTS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	,188	,008		22,860	<,001	,171	,204					
	LR	-,689	,165	-,394	-4,182	<,001	-1,023	-,354	-,958	-,577	-,071	,033	9,561
	LMC	-,586	,156	-,347	-3,756	<,001	-,903	-,269	-,943	-,536	-,064	,034	9,368
	LBC	-,195	,108	-,099	-1,804	,080	-,415	,025	-,887	-,292	-,031	,096	9,373
	LCC	,043	,031	,059	1,394	,172	-,020	,106	-,279	,229	,024	,160	6,246
	EUR	,201	,171	,048	1,176	,247	-,146	,548	-,230	,195	,020	,172	5,814
	UR	,452	,072	,322	6,282	<,001	,306	,598	,733	,728	,107	,111	9,027
	GDP	-,149	,042	-,111	-3,516	,001	,063	,235	,053	,511	,060	,290	3,445
	DIG	,019	,017	,023	1,158	,255	-,014	,053	-,090	,192	,020	,742	1,348
	CPI	-,653	,101	-,185	-6,452	<,001	-,858	-,447	,049	-,737	-,110	,354	2,825
	PSI	,013	,008	,031	1,615	,115	-,003	,029	,047	,263	,028	,769	1,300
	ER	-,014	,015	-,037	-,937	,355	-,043	,016	,014	-,156	-,016	,187	5,352
	CP	,021	,013	,029	1,581	,123	-,006	,047	-,242	,258	,027	,838	1,193

a. Dependent Variable: CD

8.6. APPENDIX F -CORRELATIONS

Correlations

		CD	LR	LMC	LBC	LCC	EUR	UR	GDP	DIG	CPI	PSI	ER	CP
Pearson Correlation	CD	1,000	-,958	-,943	-,887	-,279	-,230	,733	-,053	-,090	,049	,047	,014	-,242
	LR	-,958	1,000	,952	,843	,292	,215	-,690	,054	,090	-,168	,028	,066	,221
	LMC	-,943	,952	1,000	,814	,266	,227	-,663	-,130	,134	-,280	,005	,051	,252
	LBC	-,887	,843	,814	1,000	,295	,426	-,636	,013	,049	,083	-,101	-,009	,334
	LCC	-,279	,292	,266	,295	1,000	-,409	-,775	,527	-,192	-,448	,133	-,655	,059
	EUR	-,230	,215	,227	,426	-,409	1,000	,252	-,260	,115	,403	-,276	,685	,174
	UR	,733	-,690	-,663	-,636	-,775	,252	1,000	-,327	,079	,326	-,040	,522	-,182
	GDP	-,053	,054	-,130	,013	,527	-,260	-,327	1,000	-,440	-,044	-,022	-,275	-,067
	DIG	-,090	,090	,134	,049	-,192	,115	,079	-,440	1,000	-,039	,000	,165	,101
	CPI	,049	-,168	-,280	,083	-,448	,403	,326	-,044	-,039	1,000	-,204	,221	,060
	PSI	,047	,028	,005	-,101	,133	-,276	-,040	-,022	,000	-,204	1,000	-,037	-,023
	ER	,014	,066	,051	-,009	-,655	,685	,522	-,275	,165	,221	-,037	1,000	,017
	CP	-,242	,221	,252	,334	,059	,174	-,182	-,067	,101	,060	-,023	,017	1,000
Sig. (1-tailed)	CD	.	<,001	<,001	<,001	,027	,058	<,001	,360	,272	,369	,376	,462	,049
	LR	,000	.	,000	,000	,022	,071	,000	,359	,271	,127	,426	,328	,066
	LMC	,000	,000	.	,000	,034	,060	,000	,190	,181	,027	,488	,365	,042
	LBC	,000	,000	,000	.	,021	,001	,000	,465	,370	,287	,247	,475	,010
	LCC	,027	,022	,034	,021	.	,002	,000	,000	,096	,001	,184	,000	,345
	EUR	,058	,071	,060	,001	,002	.	,042	,037	,218	,002	,029	,000	,119
	UR	,000	,000	,000	,000	,000	,042	.	,012	,297	,012	,393	,000	,108
	GDP	,360	,359	,190	,465	,000	,037	,012	.	,001	,382	,442	,029	,327
	DIG	,272	,271	,181	,370	,096	,218	,297	,001	.	,397	,499	,131	,247
	CPI	,369	,127	,027	,287	,001	,002	,012	,382	,397	.	,082	,065	,342
	PSI	,376	,426	,488	,247	,184	,029	,393	,442	,499	,082	.	,402	,440
	ER	,462	,328	,365	,475	,000	,000	,000	,029	,131	,065	,402	.	,453
	CP	,049	,066	,042	,010	,345	,119	,108	,327	,247	,342	,440	,453	.
N	CD	48	48	48	48	48	48	48	48	48	48	48	48	48
	LR	48	48	48	48	48	48	48	48	48	48	48	48	48
	LMC	48	48	48	48	48	48	48	48	48	48	48	48	48
	LBC	48	48	48	48	48	48	48	48	48	48	48	48	48
	LCC	48	48	48	48	48	48	48	48	48	48	48	48	48
	EUR	48	48	48	48	48	48	48	48	48	48	48	48	48
	UR	48	48	48	48	48	48	48	48	48	48	48	48	48
	GDP	48	48	48	48	48	48	48	48	48	48	48	48	48
	DIG	48	48	48	48	48	48	48	48	48	48	48	48	48
	CPI	48	48	48	48	48	48	48	48	48	48	48	48	48
	PSI	48	48	48	48	48	48	48	48	48	48	48	48	48
	ER	48	48	48	48	48	48	48	48	48	48	48	48	48
	CP	48	48	48	48	48	48	48	48	48	48	48	48	48

8.7. Appendix G – Descriptive Statistics (Model 2)

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
CD	70	,12066666667	,31033333333	,20308571429	,00753087712	,06300783853	,219	,287	-1,382	,566
UR	70	,02700000000	,17700000000	,09767142857	,00401940023	,03362871505	,574	,287	-,540	,566
LR	70	-,0423333333	,11266666667	,02017619005	,00536777924	,04491006318	,294	,287	-1,093	,566
LMC	73	-,0373333333	,09900000000	,01841552511	,00507697713	,04337771164	,304	,281	-1,155	,555
GDP	70	-,1630000000	,03800000000	,00212857143	,00384976251	,03220942405	-2,474	,287	9,208	,566
CPI	70	-,0150000000	,03900000000	,01427142857	,00160861342	,01345862543	-,003	,287	-1,052	,566
CP	73	-,2380860312	,24827790700	,01102928184	,00769212871	,06572157650	-,673	,281	5,104	,555
Valid N (listwise)	70									

8.8. Appendix H – Model Summary (Model 2)

Model Summary[b]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	,982[a]	,964	,961	,01209343120	,964	293,781	6	65	<,001	,744

a. Predictors: (Constant), CP, CPI, GDP, UR, LMC, LR

b. Dependent Variable: CD

8.9. Appendix I – ANOVA (Model 2)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,258	6	,043	293,781	<,001[b]
	Residual	,010	65	,000		
	Total	,267	71			

a. Dependent Variable: CD

b. Predictors: (Constant), CP, CPI, GDP, UR, LMC, LR

8.10. Appendix J – Coefficients (Model 2)

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	,164	,007		23,637	<,001	,150	,178					
	LR	-,215	,101	-,151	-2,122	,038	-,418	-,013	-,914	-,254	-,050	,108	9,298
	LMC	-,715	,097	-,504	-7,364	<,001	-,908	-,521	-,929	-,674	-,172	,117	8,558
	UR	,697	,065	,363	10,666	<,001	,566	,827	,797	,798	,249	,471	2,121
	GDP	-,235	,040	-,142	-5,955	<,001	,156	,314	,026	,594	,139	,956	1,046
	CPI	-,762	,118	-,172	-6,449	<,001	-,998	-,526	-,395	-,625	-,151	,773	1,294
	CP	,017	,023	,019	,756	,452	-,028	,063	-,153	,093	,018	,911	1,097

a. Dependent Variable: CD

8.11. APPENDIX L – CORRELATIONS (MODEL 2)

Correlations

		CD	LR	LMC	UR	GDP	CPI	CP
Pearson Correlation	CD	1,000	-,914	-,929	,797	,026	-,395	-,153
	LR	-,914	1,000	,931	-,682	,119	,375	,099
	LMC	-,929	,931	1,000	-,685	,078	,289	,188
	UR	,797	-,682	-,685	1,000	-,158	-,059	-,150
	GDP	,026	,119	,078	-,158	1,000	,002	-,072
	CPI	-,395	,375	,289	-,059	,002	1,000	-,022
	CP	-,153	,099	,188	-,150	-,072	-,022	1,000
Sig. (1-tailed)	CD	.	<,001	<,001	<,001	,414	<,001	,100
	LR	,000	.	,000	,000	,160	,001	,204
	LMC	,000	,000	.	,000	,258	,007	,056
	UR	,000	,000	,000	.	,092	,310	,104
	GDP	,414	,160	,258	,092	.	,492	,273
	CPI	,000	,001	,007	,310	,492	.	,428
	CP	,100	,204	,056	,104	,273	,428	.
N	CD	72	72	72	72	72	72	72
	LR	72	72	72	72	72	72	72
	LMC	72	72	72	72	72	72	72
	UR	72	72	72	72	72	72	72
	GDP	72	72	72	72	72	72	72
	CPI	72	72	72	72	72	72	72
	CP	72	72	72	72	72	72	72