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UNIVERSIDADE D
COIMBRA

Eduardo Carcelen Machado

**Economic crises and its impact on the
suicide rate: THE CASE OF BRAZIL BETWEEN 2004
AND 2020**

Project work undertaken as part of the master's degree in economics, with a specialization in Financial Economics, supervised by Professor José Alberto Fuinhas, presented to the Faculty of Economics of the University of Coimbra.

July, 2023



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Supervisor:

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Abstract

This research aims to establish a relationship between the economic and financial impacts on its inhabitants and the suicide rate in the 27 states of Brazil from 2004 to 2020. Additionally, it seeks to analyse and discuss the impact of relevant macroeconomic factors on economic agents, such as default rate, unemployment rate, and Gini index, among others. It is crucial to understand the connection between these factors and the true impact of this phenomenon on Brazilian reality. To achieve this goal, an empirical model with linear interaction between suicide deaths and social and economic factors was used, estimated through a panel of autoregressive distributed lag (ARDL) with a dynamic fixed-effects estimator. The analysis reveals that economic crises, as well as economic and social factors, significantly affect the number of suicides in the states of Brazil, both in the long term and in the short term. Furthermore, the results indicate that both GDP and income equality are statistically significant in the long-term relationship, and both show a negative relationship with the dependent variable. However, when examining the combination of GDP with income equality, both show a positive relationship. In other words, higher income and equality are associated with an increase in the number of suicides. It is important to conduct more in-depth studies on variables related to individuals' quality of life to better analyse this phenomenon. Additionally, it is essential for the government to ensure investments in the healthcare sector, particularly in suicide prevention during periods of economic crisis and instability.

JEL classification: I11; I12, I18, P36

Keywords: Suicide rate; Economic crisis; Socioeconomics; Mental health; Life quality.

Resumo

Esta pesquisa tem como objetivo estabelecer uma relação entre os impactos econômicos e financeiros sobre seus habitantes e a taxa de suicídio nos 27 estados do Brasil no período de 2004 a 2020. Além disso, busca analisar e discutir o impacto de fatores macroeconômicos relevantes dos agentes econômicos, como a taxa de inadimplência, taxa de desemprego e índice de Gini, entre outros. É crucial compreender a relação entre esses fatores e o verdadeiro impacto desse fenômeno na realidade brasileira. Para atingir esse objetivo, foi utilizado um modelo empírico com interação linear entre as mortes por suicídio e fatores sociais e econômicos, estimado por meio de painel de defasagem distribuída auto-regressiva (ARDL) com um estimador de efeito fixo dinâmico. A análise revela que crises econômicas, bem como fatores econômicos e sociais, afetam significativamente o número de suicídios nos estados do Brasil, tanto no longo prazo quanto no curto prazo. Além disso, os resultados indicam que tanto o PIB quanto a igualdade de renda são estatisticamente significativos na relação de longo prazo e ambos apresentam uma relação negativa com a variável dependente. No entanto, ao examinar a combinação do PIB com a igualdade de renda, ambos mostram uma relação positiva. Em outras palavras, maior renda e igualdade estão associadas a um aumento no número de suicídios. É importante conduzir estudos mais aprofundados sobre variáveis relacionadas à qualidade de vida dos indivíduos para melhor analisar esse fenômeno. Além disso, é essencial que o governo garanta investimentos no setor de saúde, especialmente na prevenção do suicídio durante períodos de crise econômica e instabilidade.

Classificação JEL: I11; I12, I18, P36

Palavras-chave: Taxa de suicídio; Crise econômica; Socioeconomia; Saúde mental; Qualidade de vida.

Acronyms and Abbreviations

WHO: *World Health Organization*

ILO: *International Labour Organisation*

IMF: *International Monetary Fund*

AMC: *Asset Management Agency*

GDP: *Gross Domestic Product*

HDI: *Human Development Index*

CDO: *Collateralized Debt Obligation*

MBS: *Mortgage-Backed Security*

TCU: *Tribunal de Contas da União*

OECD: *Organisation for Economic Co-operation and Development*

UNCTAD: *United Nations Conference on Trade and Development*

IMF: *International Monetary Fund*

IBGE: *Instituto Brasileiro de Geografia e Estatística*

COVID-19: *Coronavirus Disease 2019*

SELIC: *Sistema Especial de Liquidação e de Custódia*

IPA-DI: *Índice de Preços ao Produtor Amplo - Disponibilidade Interna*

IPCA: *Índice Nacional de Preços ao Consumidor Amplo*

IGP-M: *Índice Geral de Preços – Mercado*

CAGED: *Cadastro Geral de Empregados e Desempregados*

IPEA: *Instituto de Pesquisa Econômica Aplicada*

DATASUS: *Departamento de Informática do Sistema Único de Saúde*

ARDL: *Autoregressive Distributed Lag*

BACEN: *Banco Central do Brasil*

PEIC: *Pesquisa de Endividamento e Inadimplência do Consumidor*

Contents

Abstract	iii
Resumo	iv
Acronyms and Abbreviations	v
List of Tables	vii
List of Figures	viii
Chapter 1. Introduction	1
Chapter 2. Literature Review	3
2.1. Mental Health and Suicide	3
2.2. Causes of Suicide	4
2.3. Economic Crises	5
Chapter 3. Methodology	16
3.1. Method	16
3.2. Data	16
3.3. Econometric Model	20
Chapter 4. Results	22
Chapter 5. Econometric Analysis and discussion	30
Chapter 6. Conclusion	34
References	36

List of Tables

Table 1. Variables used in the econometric model	19
Table 2. Descriptive analysis of variables (2004-2020)	23
Table 3. Panel unit root test results. LLC—Levin, Lin, and Chu; IPS—Im, Pesaran, and Shin; ADF— Augmented Dickey-Fuller	24
Table 4. Cointegration test	25
Table 5. Choice tests for modelling the idiosyncratic term for the long-term model.	25
Table 6. Models' estimation results.	29

List of Figures

Figure 1 - Financial account of Brazil's balance of payments (2000-2010) _____	08
Figure 2 - GDP Evolution - Year by Year, in % (2010-2020) _____	11
Figure 3 - Evolution of Net and Gross Debt - % of GDP (2011-2020) _____	13
Figure 4 - Flow to extract deaths data from DATASUS _____	18
Figure 5 - Suicide deaths in Brazil by 1,000,000 hab. (2004-2020) _____	21
Figure 6 - Suicide deaths by 1,000,000 in Brazilian states (2004-2020) _____	22

Chapter 1. Introduction

The economic crisis is one of the biggest concerns of contemporary society. It can negatively impact a country's economy, leading to unemployment, decreased income, and financial insecurity. However, in addition to its economic consequences, crises also significantly impact the mental health of the population. One of these consequences is an increase in the suicide rate.

Studies indicate that the increase in economic uncertainty, job loss, and income reduction can contribute to the increase in the suicide rate during economic crises. In addition, decreased access to mental health goods and services and the lack of social support can worsen the situation (Andres et al., 2010; Stack, 2021; Denney et al., 2015).

There are several reasons why this research is justified. Firstly, understanding the consequences of economic uncertainty on the population's mental health is essential for developing policies and measures that can protect people during times of crisis. Additionally, economic crises have a significant impact on a country's economy, and understanding the impact of these crises on the suicide rate is important for the development of more effective economic policies.

Secondly, the increase in the suicide rate has serious consequences for public health, including increased healthcare costs, increased burden of stress-related diseases, and loss of productive lives. Therefore, it is crucial to understand the causes of this increase and develop measures to prevent its occurrence.

Lastly, the topic is important for promoting mental health and the population's well-being. Understanding the relationship between economic crises and the suicide rate can help identify at-risk groups and develop effective interventions to prevent the increase in the suicide rate during times of economic crisis.

Within this context, the objective of this study is to analyse the impact of economic crises on the suicide rate in Brazilian states. For this purpose, the following goals have been defined: a) analyse the relationship between mental health and suicide; b) examine the correlation between economic factors and the suicide rate; and c) present the main economic crises of recent years.

The hypothesis of this study is that economic factors and moments of crisis significantly impact the suicide rate due to increased economic uncertainty, job losses,

income reductions, as well as reduced access to mental health goods and services, and lack of social support.

This work is divided into three parts, excluding this introduction and the conclusion. Initially, a theoretical review will be conducted on mental health, suicide, and its causes, along with an overview of the two main economic crises that have affected the Brazilian economy in recent years. Finally, the econometric model to be estimated will be presented, along with the results and interpretations derived from this model.

Chapter 2. Literature Review

In this chapter, we will address issues related to suicide and the main economic crises in the Brazilian scenario in recent years. We must recognize and be concerned about Brazilian public health, as well as give due importance to diseases that have recently been causing concern and fear for families, such as depression which can lead to suicide. Additionally, we will delve into relatively recent economic crises in the Brazilian scenario, such as the subprime crisis and COVID-19, which was not necessarily directly an economic crisis but certainly led to the country's economic collapse. Therefore, we have divided this chapter into subsections where we will develop issues on suicide and mental health, the causes of suicide, and finally, economic crises.

2.1. Mental Health and Suicide

The World Health Organization (WHO) states that "there is no health without mental health," recognizing the importance of considering mental health problems and psychiatric illnesses. According to Newton et al. (2017), about one in five children and adolescents and one in four adults are affected by mental health problems at some point. Additionally, mental illnesses significantly impact the quality of life of individuals and their communities (Avdic et al., 2021).

The loss of productivity resulting from common mental disorders, such as anxiety and depression, annually causes costs of around one trillion US dollars to the global economy (Chisholm et al., 2016). Moreover, there are inequalities in mental health among different population groups, suggesting that the economic environment is an important factor in mental health (Avdic et al., 2021).

The WHO defines suicide as "a deliberate act with knowledge or expectation of a fatal outcome" (Souza & Moreira, 2018). Suicide is a complex phenomenon that encompasses multiple areas of a person's life and requires attention and awareness (Glenn et al., 2020). According to the WHO, in 2019, more than 700,000 people died by suicide.

Although suicide is preventable and avoidable, it remains a major challenge for public health issues. In addition to causing emotional pain for the survivors' families, suicide also results in considerable economic losses (Okada & Samreth, 2013).

2.2. Causes of Suicide

Suicide is a complex issue that can be influenced by various factors, including alcohol and drug dependence, personality disorders, and mental illnesses (Claveria, 2022). According to (Goldney, 2004), since 1822, Morselli studies has linked suicide rates to socioeconomic factors; since then, many studies have been conducted on the topic. The most common economic variables related to suicide include unemployment rates, economic growth, economic recession, and indebtedness (Andres et al., 2010; Altinanahtar & Halicioglu, 2009; Denney et al., 2015; Maki & Martikainen, 2009; Richardson et al., 2013; Stack, 2021).

According to (Ridley et al., 2020), the economic environment can be a significant factor in mental health problems that may lead to suicide. During periods of economic crisis, especially when unemployment and poverty rates are higher than normal, suicide rates tend to increase (Stuckler et al., 2009; Uutela, 2010). In addition, socioeconomic factors affect the availability of services for individuals and their health and are important in defining material, behavioural, and psychosocial living standards (Machado et al., 2015).

According to Mcmillan et al. (2011), we live in an era of economic globalization, with greater integration between global trade negotiations and technological transfers between markets. While this has transformed the way companies operate, resulting in increased productivity and efficiency, there has been a corruption in business ethics, where companies prioritize their profits over the mental well-being of their employees (Andres et al., 2010).

Economic crises, broadly defined as negative phases of the growth cycle, have been repeatedly associated with an increased risk of suicide. This link can be explained by a series of factors, including loss of income and employment, financial insecurity, difficulty accessing basic goods and services, social and psychological pressure, lack of prospects, and loss of hope and self-esteem (OECD, 2020).

In addition, during economic crises, there may be an increase in violence and crime, which can also negatively affect people's mental health. For these reasons, governments and civil society organizations need to take measures to minimize the negative effects of economic crises on people's mental health, including the implementation of public policies aimed at protecting employment and income, ensuring access to basic goods and services, and providing psychological and social assistance to those in need (Claveria, 2022; Machado et al., 2015).

The impact of these situations can be even more severe for vulnerable groups such as the elderly and young people. Furthermore, socio-economic factors also influence accessibility to mental health resources, including therapy and medication services, making it more difficult for those needing help (Claveria, 2022).

2.3. Economic Crises

Our society has constantly been exposed to a wide range of crises, which can be primary, such as the pandemic, or secondary, such as impacts associated with physical and mental health (Castaño-Rosa et al., 2022). However, we know that economic crises have haunted society at various times in history, as we saw in the Great Depression, which occurred between 1929-1933, and the Great Financial Crisis of 2008-2009. According to (Norström & Grönqvist, 2015), the biggest economic crisis since World War II affected almost all organizations and businesses globally, including the public/private sector and even the government (Johansson & Nord, 2017). In a way, it is inevitable to think that both were colossal worldwide events that challenged our view of the economy (Fратиanni & Giri, 2017).

However, we have recently faced another crisis that had an unprecedented impact on society, aggravating problems already faced, such as social and economic issues (World Economic Forum, 2021). According to data from The World Bank (2021), the Covid-19 crisis forced about 150 million people into extreme poverty and brought about a significant loss in employment. Furthermore, data from (ILO, 2021) shows that employment fell by around 114 million from 2019 to 2020, and approximately 9% of work hours were lost in 2020.

Therefore, crises are complex due to unclear objectives and conflicting priorities (Gogalniceanu et al., 2021). Furthermore, according to Gogalniceanu et al. (2022), crises are generally dynamic, new, uncertain, sensitive, and critical to security. Therefore, it is logical to perceive that economic crises bring uncertainty, an important impact variable in understanding the relationship between economic crises and suicide (Claveria, 2022). Therefore, this section will delve into three distinct crises, namely the Asian Financial Crisis, Subprime Crisis, and Covid-19 Crisis, respectively.

SUBPRIME CRISIS

The US real estate market experienced the longest appreciation period from 1997 to 2006. According to Borça Junior & Torres Filho (2008), the continuous increase in real estate prices tripled their value, related to the increase in US real estate credit.

From 2000 to 2003, long-term interest rates continued to fall. For example, Greenspan (2008) reported that ten-year Treasury bond rates were reduced from 7% to 3.5%. After that, however, US long-term interest rates plummeted, and world interest rates followed a downward trend.

Gontijo (2008) described a new push to lower interest rates promoted by the Federal Reserve during the stock market bubble burst aimed at the technical field. The reduction in interest rates, combined with the development of securitization methods and financial innovation introduced during that period, made the real estate market boom a true illusion, with an average annual growth rate of home prices of 6.4% between 2000/2005.

Lima (2014) pointed out that in 2003, the interest rate on a 30-year mortgage was below 6% per year, the lowest level since the 1960s. Moreover, since 1994, the number of families who own their own homes has increased drastically. In 2006, this number represented about 69%.

According to Farhi's study (2009), between 2001 and 2006, the mortgage market moved about \$3 trillion in new business each year, focusing on 2003, which reached nearly \$4 trillion. These substantial increases in value consider important factors such as the rapid expansion of the US mortgage market and the increase in the securitization of subprime mortgages.

In mid-2002, the competition among financial agents operating in the mortgage market led to various disclosure contracts to attract borrowers with higher risk and, consequently, higher profitability.

These loan portfolios were quickly securitized and combined with a series of financial assets (CDOs), which were resold. Cintra & Cagnin (2007) mention that CDOs include mortgages with diverse risks, such as mortgages charged on credit cards. Investment banks organize these operations and consist of various batches of operations with different levels of risk, which were classified by credit rating agencies.

As highlighted by Cintra & Cagnin (2007), from 2006 onwards, the US real estate market began to show signs of price and volume decline. Moreover, the depreciation of properties occurs rapidly each year.

These influences have greater expressive power in the riskier segments of the housing finance market. The increase in delinquency of high-risk borrowers is evident due to the shrinking real estate market, which impacts the global financial system due to its scope.

Cintra & Cagnin (2007) reported that approximately 90% of subprime mortgages involve some fraud: "More than half of borrowers overestimate their savings by more than 50%". In addition, financial agents falsify information in the electronic scoring system ("credit scoring") to facilitate operations and subsequently charge appropriate commissions (Cintra & Cagnin, 2007).

In 2006, delinquency rates increased, and real estate prices dropped. As a result of the shrinking MBS market, the original banks' investment portfolios continued to accumulate. At the same time, many financial institutions providing insurance for these securities (including many of the originating banks themselves) were forced to increase their reserves for losses and face margin calls. In other words, instead of falling on investors as in the hypothetical securitization model, these losses accumulated in financial institutions, primarily in MBS underwriters and companies offering insurance against capital losses for these securities (Dulci, 2009, p. 25).

Farhi (2008) reported that due to the collateral requirement, the property's value was lower than the value of the mortgage debt. As a result, in the first month of 2008, there was a market with approximately 4 million unsold homes, including 2.9 million vacant homes. The significant increase in housing supply led to a price drop, while uncollectible debts increased. This fact caused unrecoverable mortgage market losses, which led to a collapse in the US banking sector, directly impacting the global economy.

The subprime mortgage crisis became an international financial crisis in 2008, damaging the global economy. In the years leading up to the financial crisis, the world went through a cycle of international liquidity. For example, in Brazil, according to Giambiagi et al. (2011), there was a significant increase in Gross Domestic Product (GDP) between 2004 and 2008. Similarly, the decrease in unemployment during this period was one of the factors that contributed to a 21.5% increase in consumption.

In addition, the investment rate increased by 44.8%, followed by increased exports of goods and services. Freitas (2008) pointed out that one of the underlying factors was the abundance of capital flows (related to the liquidity cycle for emerging countries between 2003 and 2007) and the positive results of trade and current transactions between Brazil and the rest of the world.

It is observed that the impact of the international financial crisis on the Brazilian economy reached its peak, completing six consecutive quarters of accelerated growth. At this time, these companies were in a good moment, producing and planning new investments. Therefore, bank credit was essential. However, as the crisis unfolded, the first impact that Brazil felt was the shortage of international credit. Given the expected fundamental role of agents, the banking sector reacted cautiously and greatly reduced credit in the Brazilian economy, causing companies to re-examine their production and investment plans.

The strong contraction of bank credit supply in the domestic market and the rupture of external credit lines were enough to trigger a reduction in domestic demand and anchor inflation expectations, as they caused a strong slowdown in economic activity in the last three months. As a result, the last quarter of 2008 was characterized by a rapid deceleration of economic activity (Freitas, 2009). In addition to the impact on credit availability, the impact of the 2008 crisis on prices of national currency and capital flows traded in the country is also evident in Brazil.

According to Prates & Farhi (2009), the Real is still appreciating one year after the crisis that originated in the US economy. For example, between July 2007 and July 2008, the Brazilian currency appreciated by 17%. However, since August 2008, with the bankruptcy of Lehman Brothers and the deepening of the international financial crisis, risk aversion has intensified strongly, triggering a widespread capital flight and a sharp currency devaluation in peripheral economies, including Brazil. In this case, the Brazilian asset and currency were combined as targets for deleveraging and investor flight, as shown in Figure 1.

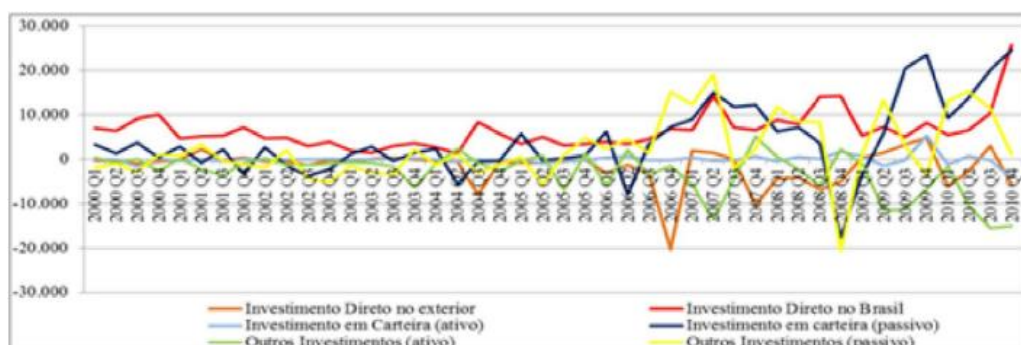


Figure 1. Financial account of Brazil's balance of payments from 2000 to 2010
Source: Freitas (2009).

In Figure 1, it is clear from the analysis of the flow of resources in Brazil's balance of payments financial account that there was a massive flight of capital during the height of the crisis, especially from typically speculative investments (other investments and portfolio investments).

The rapid and disorderly depreciation of the exchange rate caused severe instability in the Brazilian economy. The Real devaluation severely affected several companies in the productive sector, especially exporters. The decline in exports forced some companies to turn to the foreign market and made segmentation in the pre-crisis period. This type of financial market corresponds to currency derivatives and is characterized by the classic operation of selling dollars in the forward market, betting on currency appreciation to earn interest from the operation (Freitas, 2009).

Since July 2008, Brazilian exports have fallen sharply, with declines in production and sales in the automotive, construction, agriculture, furniture, and home appliance sectors (TCU, 2009). As a result, GDP fell 3.6% in October-December, after growing at an annual rate of 6.8% in the first nine months. The reversal is brutal and is reflected in the generation of new jobs: 61,401 in October 2008, compared to the 205,260 generated a year earlier.

COVID-19 CRISIS

The health crisis caused by the Covid-19 outbreak is one of the biggest challenges in modern human history. As research from various institutions such as the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), the European Union, the International Monetary Fund (IMF), and many multilateral organizations have shown, its socioeconomic impacts are unparalleled by any other event of planetary proportions, such as the Great Depression of 1929 and the international economic and financial crisis of 2007-2008 (Biernath, 2020).

The health crisis affects the economy through multiple channels. On the one hand, there are supply-side factors related to the negative impact of infectious diseases and public health measures (movement restrictions, temporary closure of businesses, etc.) aimed at reducing the virus's spread (flattening the curve). These can be subdivided into three different effects (Biernath, 2020).

Firstly, there is job generation due to the reduction in the hiring of employees and working hours. Secondly, there is work efficiency resulting from the physical impact of disease symptoms, the psychological impact of social isolation, unemployment, and/or loss

of skills due to prolonged absence from the workplace. Declining productivity is also a result of the chaotic flow of work in the company and the decline in economic activity since productivity is pro-cyclical. Finally, the supply chain is related to interrupting input flows between the domestic and international sectors (Biernath, 2020).

On the other hand, demand factors are related to the negative impact of epidemics on three different factors. First, household consumption is affected by the loss of current income due to reduced working hours, unemployment and/or reduced real wages. Social distancing measures also negatively affect consumption, which reduces spending by restricting mobility (out of fear or coercion by the state), even if income is not necessarily reduced. In addition, expectations of future income decline also limit household spending (Biernath, 2020).

Private investment is related to the immediate reduction in profitability due to reduced demand (accelerator effect) and the expectation of future profitability deterioration. Moreover, foreign trade is related to the interruption of input and final product production in some countries, as well as a decrease in international demand, but also related to non-cooperative and protectionist practices (confiscation of national production and exclusive sales in the country) of market and inputs (Biernath, 2020).

On the demand side, it is particularly noteworthy that the volatility and fall in asset prices have had a negative impact on the balance sheet and investment decisions of companies and households, mainly given the social isolation and the reduction in working hours caused by the pandemic. In addition, the negative impact of exchange rate fluctuations on international trade was also very important. As for liquidity issues, the focus is on the shortage of working capital, especially wages and payments to suppliers (OECD, 2020).

Since the first case was confirmed and until the beginning of December 2020, Brazil recorded 6.9 million cases and 181,000 deaths, one of the highest numbers in absolute terms and to the population among the countries affected by the pandemic (BACEN,2020c).

Figure 2 shows that Brazil's GDP contracted by 4.1% in 2020. In addition, the unemployment rate in the third quarter was 14.6% for the economically active population, leading it to 14 million people. A similar economic situation was verified in 2015 and 2016 (BACEN, 2020b).



Figure 2. GDP Evolution - Year by Year, in %

Source: IBGE (2020)

Given the necessary physical distancing to protect the population and avoid the saturation of the health system, state and municipal governments applied restrictions of varying degrees and periods regarding the opening of businesses and the number of people allowed in a given space, according to the evolution of COVID-19, throughout the territory (BACEN, 2020c).

The federal government implemented actions and programs to protect individuals and corporate revenues from ensuring business continuity. Regarding income transfers, the emergency assistance program reached 66 million people, with payments totalling 280 billion reais, or about 3.9% of GDP. Federal government spending until November 2020 (including tax relief and increased spending) reached around 615 billion reais, or about 8.6% of GDP (ME, 2020a).

The central bank also supported the expansion of credit in the financial system, which sustained an increase of more than 37%, equivalent to 1.7% of GDP, in loans to micro, small, and medium-sized enterprises compared to 2019. As a result, between fiscal and credit measures, 12% of GDP resources were allocated in response to COVID-19 (BACEN, 2020b).

As a result of these resources, more than 40% of households, representing more than 50% of the Brazilian population, received assistance to compensate for the decrease in their income resulting from the loss of 10 million jobs in the first four months of the pandemic (ME, 2020b).

For the poorest segment of the population, the monthly assistance of 600 reais (almost US\$120) for five months (April-August 2020) and an additional 300 reais until the end of 2020 increased resources by more than 200% (ME, 2020b).

A study by the Getulio Vargas Foundation (2020) using poverty and extreme poverty lines (US\$5.50 and US\$1.90 per day, respectively) estimated a reduction of 5.3 percentage points in poverty (from 23.7% in May to 18.4% in August 2020) and a 45% decrease in the number of extremely poor people (from 4.2% to 2.3%).

In the poorest regions, such as the country's North and Northeast, emergency programs helped protect the revenue levels of local businesses, especially those in the food industry and domestic construction sector, particularly the materials segment (BACEN, 2020d).

In the third quarter of 2020, the effects of COVID-19 combat policies began to be felt, with GDP growing by about 7.7% compared to the second quarter, with a cumulative production decline of 5.0% for the year (ME, 2020a).

Although the recovery did not reach pre-pandemic levels, sectors such as industry and commerce, whose activities fell by 19.1% and 13.7%, respectively, compared to the previous quarter, grew by 23.7% and 15.9%, respectively, in the third quarter (ME, 2020a).

The service sector, the largest employer in the Brazilian economy, recorded a variation of 6.3% in the third quarter after contracting by 9.4% in the second quarter. The sector's biggest impact was on food services, personal services, tourism, and air transport. On the demand side, household consumption grew by 7.6% in the third quarter after falling by 11.3% in the second quarter.

To sustain public policies to combat the COVID-19 crisis, in the early months of the year, Congress approved a constitutional amendment suspending the application of fiscal rules in 2020 (ME, 2020a).

Thus, by the end of November, the Treasury had spent 494.4 billion reais (6.4% of GDP), and the projection is to reach 674.6 billion reais (7.4% of GDP) by the end of 2021. In addition to emergency assistance, this spending included a transfer of 79.2 billion reais (1.0% of GDP) to states and municipalities to partially compensate for the tax drop (ME, 2020b).

Around 50 billion reais were allocated for extra expenses of the Ministry of Health and other agencies combating Covid-19, acquiring medical devices, medicines, and support for vaccine development (ME, 2020b).

The Treasury also provided 40 billion reais for creating a loan guarantee fund for micro and small enterprises. With these additional real expenses (an increase of 42.7%) and real losses in tax revenue (-11.5%) compared to the same ten months of 2019, as shown in Figure 3, the federal government's fiscal accounts recorded an increase in debt (ME, 2020b).

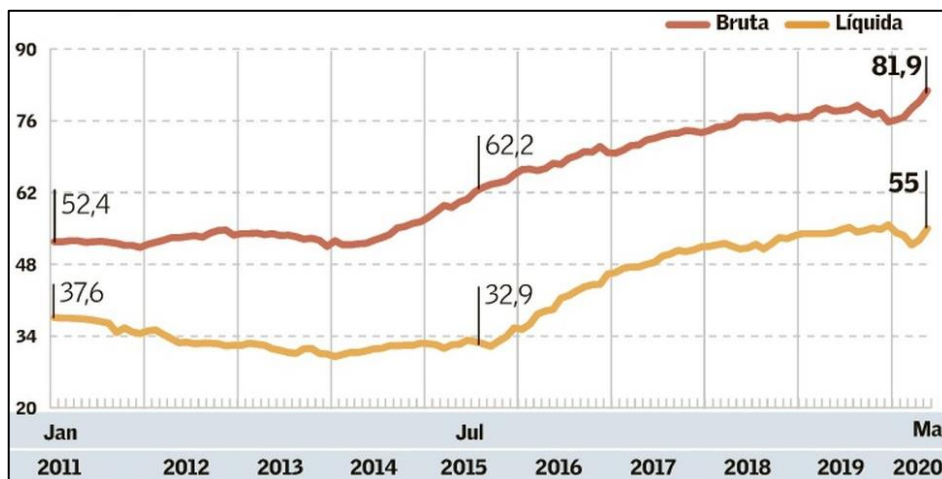


Figure 3. Evolution of Net and Gross Debt - % of GDP

Source: BACEN (2020a)

The federal government's primary deficit was 725.6 billion reais (9.8% of GDP) until October, and the projection is to reach 12.7% of GDP by the end of 2021 (ME, 2020b). The primary deficit for the public sector, which includes state governments and state-owned companies, was 10.6% of GDP from January to October 2020. However, with the addition of interest payments (4.8% of GDP, slightly below the 5.1% of the previous year), the nominal deficit reached 15.4%, 2.75 times higher than the previous year. In turn, gross public debt reached 90.7% of GDP, or about US\$1.3 trillion, an increase of 14.2% compared to 2019 (ME, 2020b).

On the monetary policy front, in August 2020, the central bank cut the basic interest rate (SELIC) from 4.5% to 2.0% per year, the lowest nominal rate since the Real Plan (BACEN, 2020d).

The pandemic-induced drop in production and consumption brought the inflation rate below target, and the central bank's decisions were guided by the objective of stimulating spending and the evolution of asset purchases. However, as a result of some expansion in the real estate business and new domestic investors entering the stock market, stock market indices showed some peaks, and the interest rate on public securities fell, generating pressure to change the structure of these securities by reducing their maturities or increasing future interest rates (BACEN, 2020d).

On the external front, the pandemic affected Brazil's balance of payments. Goods trade generated a surplus of US\$51 billion in November 2020, up 21.2% from the same period in 2019, and exceeded the total of US\$48 billion. The main factor was a sharp drop in imports (-14.7%), with fuels (-39.9%) standing out. Meanwhile, exports fell by 7.4%, given the weak performance of Brazilian exports in the manufacturing industry (-13.5%), while the agricultural sector increased by 6.8% in value (BACEN, 2020d).

Services fell by 42% in the first ten months of 2020 compared to the previous year. This reduction mainly reflected the paralysis of tourism and the decline in personal transportation. As a result, the deficit in travel services decreased from US\$9.8 billion in 2019 to US\$2.1 billion in 2020 and transportation services from US\$5 billion to US\$2.5 billion (BACEN, 2020d).

Net outflows of foreign exchange in external interest payments and profit and dividend remittances fell (-17% and -37%, respectively), with outflows of these items totalling US\$13.3 billion in the first ten months of 2020. Consequently, the current account deficit of the balance of payments decreased from US\$42.9 billion, at the end of 2019, to US\$7.6 billion between January and October 2020 (i.e., from -2.8% to -0.65% of GDP). The capital and financial account were influenced by the greater instability of currency flows (BACEN, 2020d).

Foreign direct investment in Brazil fell by 44.6% from January to October 2020, reaching US\$31.9 billion. Net loans increased by US\$22.3 billion in the first ten months of 2019, while in the same period of 2020, there were net outflows of US\$17.3 billion. The capital market and securities saw an outflow of foreign investment equivalent to US\$15 billion from January to October. International reserves fell by US\$12.3 billion at the end of October (BACEN, 2020d).

In addition to financing the balance of payments, international resources played an important role in the central bank's measures in the Brazilian foreign exchange market. The real depreciated by 44.2% against the dollar in the 12 months until October 2020. The complex and volatile global scenario, due to the pandemic and the responses to it by the major economies, combined with the country's efforts, along with a larger fiscal deficit and lower interest rates, pushed up the dollar exchange rate in Brazil and other emerging markets (BACEN, 2020d).

However, in November, the result of the presidential election in the United States and the prospect of COVID-19 vaccination in the short or medium-term sustained

investment in the Brazilian foreign exchange market. It provoked a 7.6% appreciation of the Real in that month. The currency's depreciation directly impacted domestic prices of food and fuel (BACEN, 2020d).

On the other hand, the sharp decline in the service sector had the effect of containing prices in that sector. Thus, the wholesale price index (IPA-DI) showed a variation of 33.7% in the 12 months up to November, with a 60.5% increase in agricultural food prices. Meanwhile, the Broad Consumer Price Index (IPCA) varied by 4.3%. The central bank and the government consider the impact on agricultural prices to be temporary, given the exchange rate depreciation (ME, 2020a).

However, the general price index (IGP-M), the main index for adjusting contracts over one year, such as property rentals, and includes the total sales price index, rose by 24.3% in the 12 months up to November (ME, 2020a).

The job market was restructured by the pandemic in 2020. In general terms, lockdown measures and emergency aid reduced the participation rate in July. As a result, the number of formal workers included in the general register of employees and unemployed (CAGED) was almost 39 million, with a net loss of 1.4 million jobs between March and June 2020. However, from July to October, the economy responded with a net creation of 1.1 million jobs. So, 300,000 had already been recovered (IBGE, 2020a).

The loss of formal jobs compared to October 2019 was 613,500. On the other hand, the average wages (the average value of all those with a contract in the job market) were 1,691.92 reais in October 2020, a real increase of 1.0% compared to October 2019 (IPEA, 2020).

Chapter 3. Methodology

In this chapter, we will develop the methodology used in this study, seeking to delve into the method used, classifying this research as qualitative and quantitative. Then, we will discuss the data collected, including the variables used and their sources, and finally, we will present the econometric model developed, presenting the results obtained after the econometric application of the data and the topic under study.

3.1. Method

It is considered that for the realization of this study, bibliographic and exploratory research were used, where bibliographic research, according to (Lakatos, 1991), is characterized by the data collection source being "restricted to documents, written or not, constituting what is called primary sources. This bibliographic research was relevant to understand the subject better and seeking information from different authors that substantiated the study.

Exploratory research, according to (Gil, 2009), "has the main objective of improving ideas or discovering institutions." In most cases, these researches involve (a) a bibliographic survey; (b) interviews with people who have practical experience with the researched problems; and (c) analysis of examples that stimulate understanding.

Regarding the approach to the problem, this research is classified as qualitative and quantitative. According to (Lakatos, 2017), qualitative research establishes some objectives about the chosen theme, thus collecting information necessarily in textual form, as well as texts, tables, and graphics, subsequently creating hypotheses that will be important for explaining the highlighted problem.

Quantitative research applies mainly to data collection for testing the hypotheses raised, thus performing statistical analysis, seeking to confirm the theories. As for the procedures, this research can be classified as bibliographic and documentary. According to (Pereira, 2016), documentary research is developed from materials that have not yet undergone analysis treatment, thus being characterized as primary sources.

3.2. Data

The main objective of this study is to evaluate the impact of economic crises on the suicide rate in the Brazilian states. To achieve this goal, we used annual data from 2004 to 2020 for a panel of 26 states plus the Federal District, totalling 27 federative units: Acre (AC), Alagoas (AL), Amapá (AP), Amazonas (AM), Bahia (BA), Ceará (CE), Espírito Santo

(ES), Goiás (GO), Maranhão (MA), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Pará (PA), Paraíba (PB), Paraná (PR), Pernambuco (PE), Piauí (PI), Rio de Janeiro (RJ), Rio Grande do Norte (RN), Rio Grande do Sul (RS), Rondônia (RO), Roraima (RR), Santa Catarina (SC), São Paulo (SP), Sergipe (SE), Tocantins (TO), and the Federal District (DF). It is important to highlight that the criteria for choosing the period and states were based solely on data availability. The econometric analysis was conducted using STATA 17.

The dependent variable to be studied is the number of suicide deaths, and the independent variables include per capita GDP, the Gini index, the unemployment rate, the default rate, the literacy rate, the number of divorces, and the GDP-equality relationship. Data on the number of deaths by suicide were exported from the DATASUS platform. To classify the deaths, we selected the CID10 Group - Intentional self-harm. We then filtered the data by state. Further detail can be found in Figure 4. Regarding the Gini index, we obtained data from two different sources, IBGE and IPEADATA. This was because the data provided by IBGE had a limitation regarding the period, as no value was provided for this index in the year of the 2010 census. Therefore, we had to resort to IPEADATA to complement it. For unemployment, we collected annual data up to 2014 from the IPEADATA platform. To obtain the remaining data, we exported table 4100 from IBGE and made an adjustment by calculating the annual average rate per federative unit since the data was quarterly. Additionally, it was necessary to obtain the demographic census for the year 2010, as was done for the Gini index. For the default rate, we obtained monthly data from the Central Bank of Brazil. However, in order to work with the same period, we calculated the annual average rate according to the researched literature.

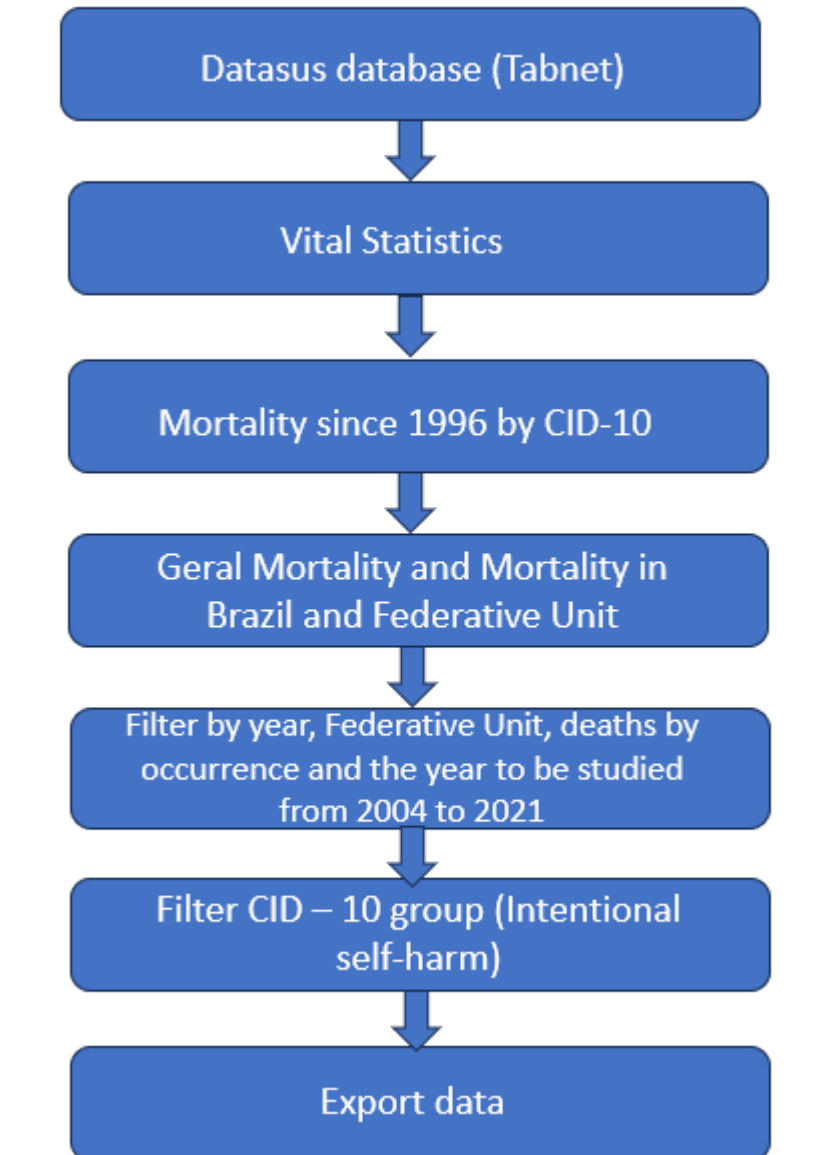


Figure 4 - Flow to extract death data from DATASUS.
Source: Own elaboration.

The data for the literacy rate were obtained from IBGE. To obtain the complete data, it was necessary to work with data regarding the illiteracy rate covering a 4-year period (2016-2019) and then with the literacy rate covering a 12-year period (2004-2015). For this, we subtracted 1 from the illiteracy rate to find the closest result to the literacy rate. Additionally, we observed that the variation was very low between the periods. For the divorce, population, and GDP data, we obtained data from IBGE and IPEADATA, and no adjustments were needed for the data treatment.

Table 1 presents the name, units of measurement, definition, and sources of the raw variables used.

Table 1. Variables used in the econometric model.

Variables	Measurement Units	Source	Description	Expected relationship with the dependent variable.
Suicide deaths. (Deaths)	unit	DATASUS	The number of deaths recorded by suicide in a certain period.	Null
Divorce	unit	IBGE	The number of divorces recorded in a certain period.	+
Gini	%	IPEADATA and IBGE	The Gini coefficient is an index that measures income inequality in a country. The closer it is to 0, the more equal the income distribution is. The closer it is to 1, the more unequal the income distribution is.	+
Default	%	BRAZILIAN CENTRAL BANK	Default is the proportion of loans that are not paid on time. This indicator measures the ability of individuals and companies to honour their debts.	-
Per Capita GDP (gdp)	R\$	IPEADATA	Gross Domestic Product (GDP) is the sum of all the wealth produced in a country during a certain period. GDP per capita is obtained by dividing GDP by the number of inhabitants in the country.	-
Literacy	%	IBGE	The illiteracy rate is the ratio between the number of people in a certain age group who cannot read and write a simple message or note in their known language and the total number of people in that same age group.	-
Unemployment	%	IPEADATA and IBGE	The unemployment rate is the proportion of the economically active unemployed population during a specific period.	+

Source: Own elaboration.

To estimate the model, some changes and transformations were made to the variables mentioned earlier, and these adjustments will be mentioned. The population was divided by one million, clarifying the reading of the information. A variable called "PIB_equality" was created, which is the product of GDP and the adjusted Gini index. To achieve this, we adjusted the Gini index on a new scale by multiplying it by 100. Then we transformed it into a variable that has an equivalent relationship to GDP when analysing both in relation to the number of suicides. Hence, we created a new variable called "equality," which is equal to 100 minus the Gini index. Finally, the product of GDP and "equality" becomes the new variable "pib_equality." Furthermore, the number of deaths was also divided by 1 million in order to enhance the visualization of the expected results.

As previously mentioned, the data for literacy were exported only until 2019, as there are no available data for the years 2020 and 2021. Therefore, was used the 2019 data since these values do not vary significantly from year to year, and it would not have a significant impact on our results. Thus, this adjustment was necessary to work with this variable. Additionally, two dummy variables were created for the Subprime and Covid crises. We assigned the value 1 to the years 2008 and 2020, respectively, and the remaining years were assigned the value 0 in order.

3.3. Econometric Model

To assess the effect of sociodemographic variables on the determination of suicides, a panel empirical equation, with random effects, is specified, as follows.

$$\begin{aligned} deaths_{it} = & \beta_0 + \beta_1 gdp_{it-1} + \beta_2 gini_{it-1} + \beta_3 unemployment_{it-1} \\ & + \beta_4 default_{it-1} + \beta_5 (gdp * equality)_{it-1} + \beta_6 divorce_{it-1} \\ & + \beta_7 literacy_{it-1} + \mu_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

β_0 is the intercept, the average value of deaths when all regressors are equal to zero;

β_k , with $k=1, \dots, 7$ are the parameters to be estimated that determine the partial correlations between the independent variables and the dependent variable;

μ_{it} , is the combined error of the time series and cross-sectional data, sometimes referred to as the idiosyncratic term, as it varies with the cross-sectional data (i.e., the individuals) and time;

ε_{it} , is the random error term with zero mean and normal distribution.

It is observed that the effect of wealth (GDP per capita) on deaths is given by:

$$\frac{\partial deaths}{\partial lgdp} = \beta_1 + \beta_5 equality \quad (2)$$

Therefore, we have:

- (a) If $\beta_1 > 0$ and $\beta_5 > 0$, wealth positively affects suicide, and equality factors increase this positive effect
- (b) If $\beta_1 > 0$ and $\beta_5 < 0$, wealth positively affects the growth of suicide, and equality factors have a negative impact on this positive effect (equality attenuates this positive effect).
- (c) If $\beta_1 < 0$ and $\beta_5 > 0$, wealth negatively affects suicide, and equality factors attenuate this negative effect.

(d) If $\beta_1 < 0$ and $\beta_5 < 0$, wealth negatively affects suicide, and equality exacerbates this negative effect.

From Equation (2), we can derive the threshold level of equality beyond which wealth could increase the growth of suicide. Based on the equation, the positive effect of wealth on suicide is found when the following conditions are met:

$\rho > 0 \leftrightarrow \beta_1 + \beta_5 \text{equality} > 0$. Therefore, the threshold level of equality beyond which wealth would increase suicide is achieved when $\text{equality} > -\beta_1 / \beta_5$.

For model estimation, a technique of distributed lag autoregression is used. This method is preferred by econometricians over other cointegration techniques due to its various merits, allowing for the estimation of long and short-term parameters.

Thus, we can modify Equation (1) to reveal the long-term relationship and the short-term relationship as presented below:

$$\begin{aligned}
 & d.deaths_{it} \\
 & = \beta_0 + \beta_1 d.deaths_{it-1} + \beta_2 d.gdp_{it} + \beta_3 d.gini_{it} + \beta_4 d.unemployment_{it} \\
 & + \beta_5 d.default_{it} + \beta_6 d.(gdp * equality)_{it} + \beta_7 d.divorce_{it} + \beta_8 d.literacy_{it} \quad (3) \\
 & + \beta_9 covid_{it} + \beta_{10} subprime_{it} + \beta_{11} l.what_{t-1} + \mu_{it} \\
 & + \varepsilon_{it}
 \end{aligned}$$

where d . represents the variable's first differences operator and l . represents the operator of variables' lags (here, lagged once).

Note that the constant is specified jointly with the dummies for financial crises, which will indicate the occurrence of a change in the intercept's mean.

Chapter 4. Results

In this chapter, we will provide an analysis of economic and social indicators in Brazil between 2004 and 2020, including suicide rates, HDI, Gini index, defaults, GDP per capita, inflation, and unemployment. The annual data indicate fluctuations and trends in each of the indicators, with some years showing improvements and others showing declines. We discuss the impact of financial crises on suicide rates and present a multiple regression model that explores the relationship between the number of suicides and several explanatory variables.

Descriptive Analysis and Model estimation

The descriptive statistics of the variables in the model are presented in Table 2. The number of observations for each series is 459, obtained by multiplying the number of Brazilian states (27) by the number of years (17). On average, approximately 400 people commit suicide annually in the Brazilian states over the study period. According to figure 5 and figure 6, we can observe the overall progress in the number of suicides in Brazil during the study period and the suicide deaths by states of the federation. We can observe that suicide deaths have been substantially increasing in Brazil over the past years. Particularly, there was a significant increase between 2007 and 2008 during the subprime crisis, and in 2020, while still facing the COVID-19 crisis, we see a marked rise.

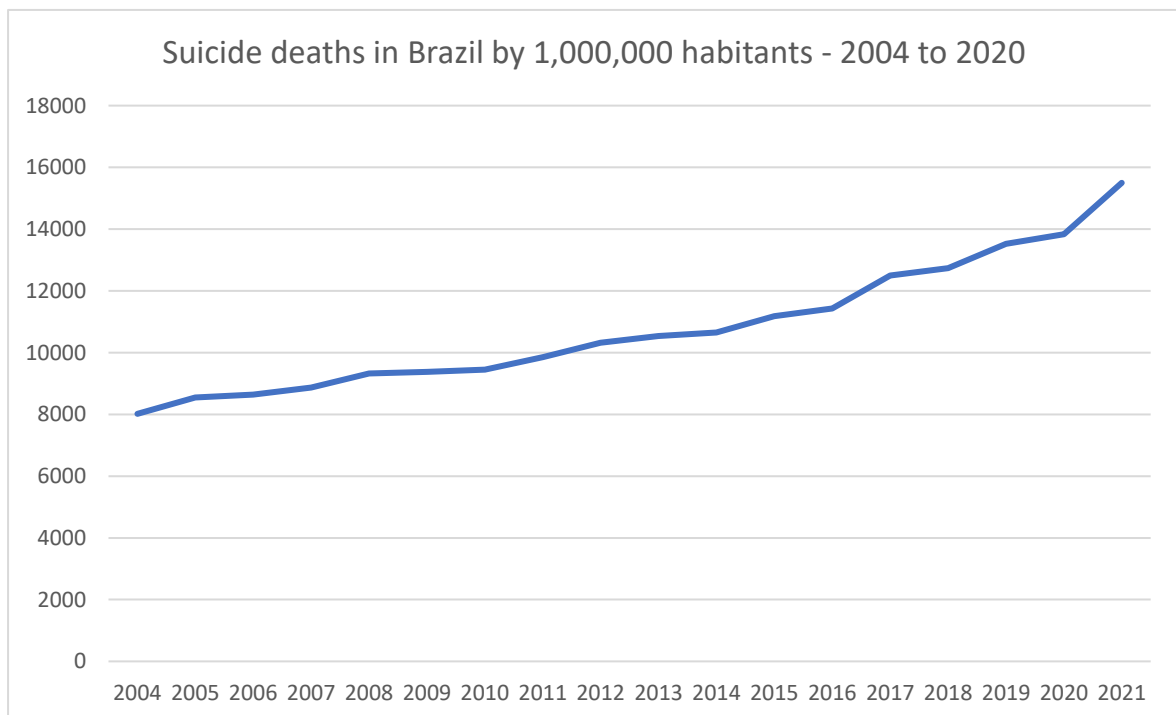


Figure 5. Suicide deaths in Brazil by 1,000,000 habitants – 2004 to 2020.

Source: Own elaboration.

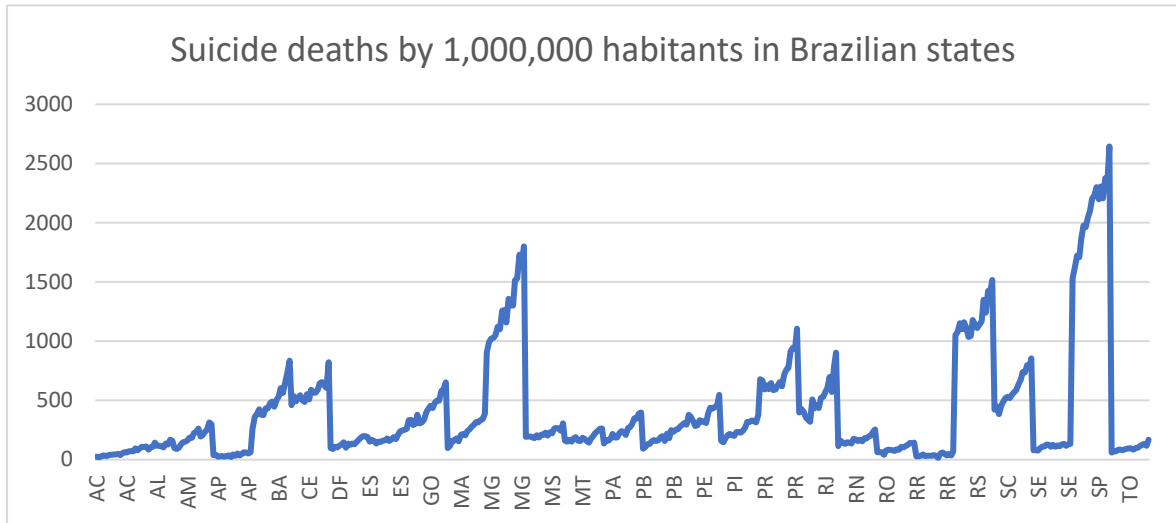


Figure 6. Suicide deaths by 1,000,000 in Brazilian states

Source: Own elaboration.

Additionally, we note that the states with the highest number of suicide deaths are São Paulo, Minas Gerais, Rio Grande do Sul, Paraná, and Rio de Janeiro. Additionally, the variance is quite large for the entire series, as indicated by substantial differences between the maximum and minimum values of the variables. This is further reinforced by the standard deviation statistic for each variable, indicating a potential case of heterogeneity among the sample states.

Table 2. Descriptive analysis of variables.

Variable	Obs.	Mean	SD	Min	Max
Suicide	459	399.745	466.308	15	2.645
Gini	459	0.523	0.040	0.421	0.629
Defaults	459	4.795	1.639	2.056	12.192
GDP per Capita	459	14.294	7.711	4.350	46.740
GDP*equality	459	6.844	3.507	1.780	20.072
Unemployment	459	10.139	3.941	3.134	25.525
Divorce	459	104.246	47.036	12.182	25.059
Literacy	459	89.320	6.282	70.500	98.600

Source: Own elaboration (using Stata16 software).

Notes: Obs, SD, Min, and Max denote observations, standard deviation, minimum, and maximum, respectively.

Although the ARDL cointegration procedure can be applied even if the variables are integrated of order zero, order one, or both orders, it is necessary to conduct unit root tests to ensure that no variable is I(2). In Table 3, we present the results of panel unit root tests by Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), and Augmented Dickey-Fuller (ADF) conducted on the series. An individual intercept was included in the test equation for each of the unit root tests, while the lag length for each variable was selected automatically using the Schwarz information criterion (SIC). As indicated in the table, the integration properties of the variables are close to I(1).

The LLC test, as well as the ADF and IPS tests, show that the Suicide and Unemployment variables are not stationary at the level, and the IPS and ADF tests show that the Literacy variable is also not stationary at the level. As the classical literature defines, all variables should be stationary. Therefore, we can conclude that the variables in our model are integrated of orders zero and one, which reinforces our choice of panel ARDL for estimating the model.

Table 3. Panel unit root test results. LLC—Levin, Lin, and Chu; IPS—Im, Pesaran, and Shin; ADF— Augmented Dickey-Fuller

Variable	Level			First Difference		
	LLC	IPS	ADF	LLC	IPS	ADF
Suicide	1.13	2.79	45.75	-24.14***	-20.77***	381.71***
GDP	-6.39***	-2.20**	6.84*	-12.01***	-9.67***	186.99***
Gini	-4.42***	-2.75***	8.7***	-19.06***	-17.62***	330.84***
Unemployment	5.66	6.00	12.986	-12.62***	-11.049***	212.93***
Default	-5.36***	-0.31	62.0661	-24.01***	-18.72***	334.531***
GDP_equality	-5.80***	-2.18***	75.01**	-16.42***	-12.46***	236.694***
Literacy	-2.76***	2.92	27.68	-21.30***	-19.10***	358.65***
Divorce	-2.29**	-1.64**	69.9*	-11.16***	-9.88***	197.14***

Source: Own elaboration (using EViews software).

Notes: *** and ** represent significance at 1% and 5%, respectively

Based on the provided results in table 4, the statistic for the Augmented Dickey-Fuller (ADF) test and the modified Dickey-Fuller test is -2.1491 and -4.7303, respectively, which is below the critical value determined. Additionally, the associated p-value is 0.0158 and 0.0000, respectively, which are smaller than the significance level of 5%. Therefore, based on these results, it can be concluded that the time series analysed in the Augmented Dickey-Fuller and Modified Dickey-Fuller tests is stationary, rejecting the null hypothesis of the presence of unit roots, indicating stationarity of the series. This suggests the presence of

cointegration among the series, meaning that they are linearly related and share a long-term trend.

Table 4. Cointegration test

	Augmented Dickey-Fuller		Modified Dickey-Fuller	
	Statistic	P-value	Statistic	P-value
KAO	-2.1491	0.0158	-4.7303	0.0000
Pedroni	-5.2031	0.0000	7.2280	0.0000

Source: Own elaboration (using Stata16 software).

The panel ARDL estimation technique provides the opportunity to estimate the model using fixed effects, random effects, and pooled estimators, each operating under different assumptions. Therefore, we conducted Chow, Breusch-Pagan, and Hausman tests to determine which of the three is more efficient for the analysis. The results of these tests are presented in Table 5.

Comparing fixed effects with pooled using the Chow test, we can observe from the table that the null hypothesis - that fixed effects are more efficient - cannot be rejected, given the insignificance of the chi-square coefficient. This implies that fixed effects are preferable to pooled effects.

Comparing random effects with the pooled, we find that the null hypothesis - that random effects are more efficient than pooled effects - is rejected due to the significance of the chi-square coefficient, as indicated in Table 5.

Finally, when comparing fixed effects with random effects, we also reject the null hypothesis. Therefore, the most efficient model is the fixed effects model, and thus, this will be adopted for the estimation of the long-term model.

Table 5. Choice tests for modelling the idiosyncratic term for the long-term model.

Tests		Statistics		Chosen model
		Chi-Square	Prob.	
Chow	Fixed effect vz Pooled	59.95	0.0000	Fixed effect
Breusch and Pagan	Random Effect vz Pooled	1373.37	0.0000	Random Effect
hausman	Fixed effect vz Random Effect	19.6	0.0065	Fixed effect

Source: Own elaboration (using Stata16 software).

To assess the statistical independence between different data sections, Pesaran and Frees's tests were conducted, as described in the text.

After analysing both tests, we concluded that they indeed support the presence of dependence between different sections for the variables. According to the Friedman test and the Frees test, as the p-value (0.6672) and p-value (0.2116), respectively, are larger than the common significance level (0.05), there is insufficient evidence to reject the null hypothesis of independence between the cross-sections in both tests. Therefore, there is no statistical indication that the sections are dependent on each other.

The modified Wald test for heteroscedasticity among groups was performed in the fixed effects regression model. The null hypothesis (H_0) tested is that the variance (σ^2) is the same for all groups ($\sigma(i)^2 = \sigma^2$ for all i). Based on the results, the chi-square test statistic is equal to 305.69 with 27 degrees of freedom, and the "Prob>chi2" value is 0.0000, indicating that the probability of obtaining a test statistic as extreme or more extreme than the observed, assuming the null hypothesis is true, is extremely low. Thus, we can reject the null hypothesis of equal variances among groups. This indicates the presence of heteroscedasticity among the groups, meaning that the error variances are not constant for all groups.

The Wooldridge test for autocorrelation in panel data was also examined. The null hypothesis (H_0) tested is that there is no first-order autocorrelation in the data. The F-statistic is calculated as 7.349 with 1 degree of freedom in the numerator and 26 degrees of freedom in the denominator, and the "Prob > F" value is reported as 0.0117, indicating the probability of obtaining an F-test statistic as extreme or more extreme than the observed, assuming the null hypothesis is true. Therefore, based on the "Prob > F" value (0.0117), there is statistical evidence to reject the null hypothesis of the absence of first-order autocorrelation in the panel data. This suggests that there is autocorrelation in the data, meaning that observations in one period are correlated with observations from the previous period.

Given the violation of assumptions and after the analyses and tests conducted, three models will be presented: Driscoll-Kraay with robust vce, Bootstrap, and Cluster. These models consider statistical corrections. According to Driscoll and Kraay, the xtsc, the STATA command is used to calculate Driscoll-Kraay standard errors in fixed effects regressions, combined OLS/WLS, or random effects GLS. It assumes a heteroscedastic error structure, autocorrelation up to a certain lag, and possible correlation between groups (panels). Driscoll-Kraay standard errors are robust to various forms of cross-sectional and temporal dependence, making them suitable for large samples. This nonparametric approach imposes no restrictions on the limiting behaviour of the number of panels, making it feasible

even with many groups. However, caution should be exercised when applying this estimator to panel datasets with few observations over time, which does not apply to this study. `xtscc` works for both balanced and unbalanced panels and can handle missing values.

We worked with robust VCE to estimate the variance-covariance matrix corresponding to the parameter estimates. According to Mooney and Duval, the "bootstrap" command is used to perform a nonparametric estimation of specific statistics or expressions for a command or a community-contributed program. It operates by resampling the data in memory with replacement, allowing for robust estimates. "Bootstrap" is particularly useful when applied to commands that do not directly involve coefficient estimation but rather the analysis of functions of these coefficients or additional programs. To estimate coefficients using bootstrap, we used the "vce (bootstrap)" option as allowed by the estimation command used.

According to Stata, cluster analysis procedures offer various hierarchical and partitioning clustering methods, as well as post-clustering summary methods. Hierarchical clustering methods can be applied to the data using a dissimilarity matrix. Therefore, such regression models are used to correct for variance, as the violation of the assumptions of homoscedasticity and autocorrelation in the Ordinary Least Squares (OLS) estimators maintains the property of being unbiased and consistent. However, they cease to be efficient, meaning they no longer have minimum variance.

For the short-term model, the Hausman test was conducted to determine which estimation to use, fixed effects or random effects. The obtained results were $\chi^2 = 74.49$ and $\text{Prob} > \chi^2 = 0.0000$. This implies that fixed effects are preferred over random effects, as the null hypothesis is not rejected. Therefore, the most efficient model is the fixed effects model, and it will be adopted for the estimation of the short-term model.

To assess the statistical independence between different data sections, Pesaran and Frees's tests were also performed, as described in the text. After analysing both tests, we concluded that they indeed support the presence of dependence between different sections for the variables. According to the Friedman test and the Frees test, as the p-value (0.3885) and p-value (0.2262), respectively are greater than the common significance level (0.05), there is insufficient evidence to reject the null hypothesis of independence between the cross-sections in both tests. Therefore, there is no statistical indication that the sections are statistically dependent on each other.

The modified Wald test for heteroscedasticity among groups was conducted in the fixed effects regression model. The null hypothesis (H0) tested is that the variance (σ^2) is the same for all groups ($\sigma(i)^2 = \sigma^2$ for all i). Based on the results, the chi-square test statistic is equal to 1102.56 with 27 degrees of freedom, and the "Prob>chi2" value is 0.0000, indicating that the probability of obtaining a test statistic as extreme or more extreme than the observed, assuming the null hypothesis is true, is extremely low. Thus, we can reject the null hypothesis of equal variances among the groups. This indicates the presence of heteroscedasticity among the groups, meaning that the error variances are not constant for all groups.

The Wooldridge test for autocorrelation in panel data was also conducted. The null hypothesis (H0) tested is that there is no first-order autocorrelation in the data. The result of the F-statistic was 76.686 with 1 degree of freedom in the numerator, and 26 degrees of freedom in the denominator, and the "Prob > F" value is 0.000, indicating the probability of obtaining an F-test statistic as extreme or more extreme than the observed, assuming the null hypothesis is true. Therefore, based on the "Prob > F" value (0.000), there is statistical evidence to reject the null hypothesis of the absence of first-order autocorrelation in the panel data. This suggests that there is autocorrelation in the data, meaning that observations in one period are correlated with observations from the previous period.

Given the violation of assumptions and after the analyses and tests conducted, three models will be presented: Driscoll-Kraay, Bootstrap, and Cluster. These models will consider statistical corrections, as shown in Table 6.

Table 6. Models' estimation results.

Variables	Driscoll-Kraay		Cluster		Bootstrap	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
Long run:						
Suicide						
IGDP	-2.947	0.014	-2.947	0.039	-2.947	0.246
IGini	0.976	0.009	0.976	0.009	0.976	0.100
lUnemployment	0.851	0.001	0.851	0.000	0.851	0.000
lDefault	-1.120	0.052	-1.120	0.010	-1.120	0.051
IGDP_equality	0.069	0.018	0.069	0.007	0.069	0.143
lLiteracy	1.591	0.000	1.591	0.000	1.591	0.000
lDivorce	0.000	0.805	0.000	0.815	0.000	0.846
Constant	-144.231	0.001	-144.231	0.000	-144.231	0.004
Short run:						
lSuicide	-0.080	0.39	-0.080	0.142	-0.080	0.373
dGDP	-1.915	0.134	-1.915	0.201	-1.915	0.360
dGini	0.559	0.027	0.559	0.144	0.559	0.375
dUnemployment	0.319	0.080	0.319	0.132	0.319	0.252
dDefault	-0.928	0.043	-0.928	0.041	-0.928	0.195
dGDP_equality	0.029	0.199	0.029	0.309	0.029	0.532
dLiteracy	-0.552	0.064	-0.552	0.147	-0.552	0.164
dDivorce	0.002	0.360	0.002	0.180	0.002	0.294
covid	1.469	0.331	1.469	0.373	1.469	0.273
subprime	2.630	0.002	2.630	0.083	2.630	0.012
lwhat	-0.539	0.001	-0.539	0.000	-0.539	0.000
Constant	1.222	0.081	1.222	0.007	1.222	0.605

Source: Own elaboration (using Stata16 software).

Chapter 5. Econometric Analysis and discussion

Upon analysing the long-term results obtained, we have observed that the Gini index exhibits a statistical significance of 95% in all three estimated models. This suggests that there is a statistically significant relationship between a higher income concentration and a 0.9755 increase in the deaths by suicide per 1,000,000 inhabitants. These findings support the studies conducted by Neumayer (2004), which examined the impact of recessions on mortality rates in Germany. Although the methodology applied in this study differs, the results for this variable are similar, indicating a positive but statistically insignificant relationship between the Gini index and suicide. However, the results from Jalles & Andresen (2015) are completely different as they show a negative and statistically insignificant relationship.

Regarding the short-term specifications, the Gini index is positive in all estimated models, but only the Driscoll-Kraay model (xtscc) demonstrates statistical significance. The impact of the unemployment rate on suicide is positive and statistically significant in all long-term specifications. This implies that when the unemployment rate increases by 1%, the deaths by suicide also increase by 0.85 per 1,000,000 inhabitants. These results are consistent with the study by Jalles & Andresen (2015), which examined ten Canadian provinces over an eight-year period (2000-2008) using a similar model (ARDL). In their conclusion, they define the relationship between the unemployment rate and suicide as positive and statistically significant. Other studies by Kuncze & Anderson (2002), Economou et al. (2008), and Noh (2009) have also reached the same conclusion, demonstrating a positive and significant relationship. However, studies by Neumayer (2004) indicate the opposite, where the relationship between the unemployment rate and the suicide rate is negative but still statistically significant. In terms of the short-term relationship, the unemployment rate is positive in all models, but it is only statistically significant in the Driscoll-Kraay model (xtscc).

Furthermore, it is important to note that the divorce variable does not exhibit statistical significance in all specifications, both in the short and long term, which is consistent with the studies conducted by Jalles & Andresen (2015) and Brainerd (2001). However, it is important to highlight that there may be other unmeasured factors related to divorce and suicide rates that were not considered in this study. For instance, stress and depression can be determinants of both suicide and divorce.

Evaluating the results found in the long-term relationship, we observe that the GDP rate is negative and statistically significant at a 95% confidence level in all three estimated models. This suggests that the lower the per capita GDP, the higher the suicide rate. Additionally, we can conclude that for every 1% increase in per capita GDP, there is a reduction of 2.95 in suicide deaths per 1,000,000 inhabitants in the Brazilian states. These results differ from the findings presented by Jalles & Andresen (2015), where their study demonstrates a positive and statistically significant relationship between these variables. However, they align with the results obtained by Okada & Samreth (2013), who studied the socioeconomic determinants of suicide in 13 European countries, specifically the OECD countries. The ARDL model was estimated, and the results showed that for most countries examined, an increase in GDP contributes to a reduction in suicide. However, despite the consistent outcome, the study by Noh (2009) argues that more developed countries tend to exhibit a reverse impact compared to the findings of this study.

In terms of the short-term relationship model, the results also show a negative impact, but statistically insignificant. Therefore, in the short term, the variable in question does not have a significant impact on the suicide rate.

The impact of the default rate on suicide is negative and statistically significant in all specifications in the long-term relationship. This indicates that a 1% increase in the default rate leads to a reduction of approximately 1.12 in suicide deaths per 1,000,000 inhabitants. In the short term, the default rate has a negative relationship in all results, but it is only statistically significant in the Driscoll-Kraay model (xtscc) and Cluster. This result is interesting because it suggests that the higher the number of indebted individuals, the lower the suicide deaths, both in the short and long term. This raises an intriguing question, considering that Brazil has one of the highest debt rates in the world. According to data from PEIC, the rate of delinquent individuals continues to rise and currently stands at an astonishing 78.3% of Brazilian households. Therefore, it is worth questioning why this phenomenon occurs in Brazil. Could it be a cultural factor where people are already accustomed to being in debt, and therefore, this behaviour leads to improved mental health? A better understanding of factors such as purchasing power, coupled with education and financial literacy, can help us gain a better understanding of this type of phenomenon.

Analysing the results found in the long-term relationship, we observe that the literacy rate is positive and statistically significant at a 95% confidence level in all three estimated models. These results demonstrate that for every 1% increase in the literacy rate, there is a

1.60 increase in suicide deaths per 1,000,000 inhabitants in Brazilian states. In other words, higher literacy rates are associated with higher suicide rates. These results do not align with the findings presented by Economou et al. (2008). In their study, the researchers found that higher education levels are associated with lower suicide mortality. Their study considered European Union countries and employed different models to determine the impact of crises and recessions on individuals' mental health. However, these findings align with the data from Figueiredo et al. (2022), where in the long-term effect, the relationship is positive and statistically significant. In their study, it is observed that individuals with higher levels of education are more likely to commit suicide during periods of recession. According to the author, the reason why individuals with higher education levels tend to commit suicide is due to significant income losses, loss of social status, and long-term economic well-being. Therefore, it is worth delving deeper into the reasons why individuals with higher education levels in Brazil tend to have higher suicide rates.

As for the short-term relationship, only the Driscoll-Kraay model (xtscc) shows statistical significance. However, this relationship becomes negative. In other words, for every 1% increase in the literacy rate, there is a 0.55 reduction in suicide deaths per 1,000,000 inhabitants. This indicates that in the short term, individuals with lower levels of education are more likely to commit suicide. This finding aligns with the results presented by Economou et al. (2008).

As verified earlier in the long-term relationship, it was observed that the GDP is negative and statistically significant at a 95% confidence level in all three estimated models, just like the Gini coefficient, which shows a positive relationship and is statistically significant in the estimated models, supporting the studies by Okada & Samreth (2013) and Neumayer (2004), respectively. In other words, when we examine these variables separately, we find that as the GDP increases, the number of suicide deaths decreases, and as income equality (equality being $100 - \text{Gini}$, as explained earlier) increases, the number of suicide deaths also decreases. However, the study reveals an improbable and intriguing outcome when we combine both variables. It shows that both GDP and income equality have a positive effect on suicide deaths. In other words, as income equality and GDP increase, the number of suicide deaths also increases. According to De Medeiros Alves et al. (2016), suicide may be directly related to people's quality of life, as well as stress and anxiety, which are contributing factors to such actions. Additionally, Floková et al. (2023) state that negative impacts on quality of life are associated with features of large cities, such as noise pollution, air pollutants, social

deprivation, among others. To better comprehend this result, further investigation into variables related to quality of life is necessary. In cities with higher GDP and greater income equality, they are usually large cities and, consequently, more affluent and developed in terms of urbanisation, as demonstrated in the study by Altinanahtar & Halicioglu (2009). The variable urbanization was used as an independent variable to examine its relationship with suicide deaths. The study found that a 1% increase in urbanization led to a 2.20% increase in the suicide death rate. Therefore, it is essential to include more variables related to quality of life, such as commuting time, safety, working hours, etc., to understand better the results obtained in this study.

Regarding the dummy variable that assesses the impact of the health crisis (COVID-19), we found that in the short-term relationship, it exhibits a positive but statistically insignificant association. This contradicts the results presented by Osaki et al. (2021) that showed a direct and significant impact of the COVID-19 crisis on suicide deaths. They also emphasized the need for preventive policies in such crisis scenarios. However, according to Soares et al. (2022), there was no evidence of an increase in the suicide rate compared to the expected number during the first year of the COVID-19 pandemic, neither in Brazil nor in the country's regions. This aligns with the data presented in this study.

Regarding the variable related to the subprime crisis, we find that the relationship is positive and statistically significant. This indicates that during the peak of the crisis in Brazil in 2008, there was a direct impact on the number of suicides. This finding corroborates the study by Figueiredo et al. (2022), which observed a significant increase in the risk of suicide following the economic recession, especially among the population with lower education levels. This also aligns with the results of this study, as the crisis, along with the lack of education (as measured by the literacy rate), are variables that impact the suicide rate in the short term. Therefore, we can deduce that crises directly related to people's financial situations tend to have a greater impact on mental health than other types of crises, such as the COVID-19 crisis, which, although it had an impact on the Brazilian economy, was not a crisis of the same magnitude as the 2008 crisis faced by Brazil and the world, a crisis that extended for several subsequent years.

Chapter 6. Conclusion

This work aimed to assess the impact of economic crises on the number of suicides in the Brazilian states. It can be concluded that suicide is a complex and multifactorial problem influenced by various factors, both economic and social. Furthermore, during periods of economic crisis, especially when unemployment and poverty rates are high, suicide rates tend to increase, which can be explained by income and job loss, financial insecurity, and difficulty accessing basic goods and services, among other factors.

Scientific literature indicates that economic crises significantly impact the number of suicides, with the most common economic variables related to this phenomenon being unemployment rates and default rates, which show statistically significant positive and negative relationships, respectively. This suggests that higher unemployment is associated with a higher suicide rate, while a higher default rate is associated with a lower suicide rate. Additionally, the literacy rate variable also proved to be highly relevant in the study. In the long term, higher literacy rates are associated with higher suicide deaths, whereas in the short term, the relationship is inverse, as lower literacy rates are associated with higher deaths. Therefore, the results presented confirm this assertion, showing that economic crises significantly impact the number of suicides in Brazilian states. However, it is important to emphasize that the crisis does not directly impact the number of suicides but rather the consequences it generates in the overall economy. For instance, according to the results proposed in this study, the subprime crisis had an impact on suicides, while the COVID-19 sanitary crisis showed no relationship with the dependent variable studied.

These results highlight the importance of public policies to improve the population's quality of life by increasing job opportunities and providing assistance in public health, thereby mitigating the risks of suicide in the population.

It is important to note one limitation of this research, which is the lack of success in extracting data on social and quality-of-life variables. These variables would have been crucial for supporting and analyzing the results of this study. This limitation arose due to the data sources, as, unfortunately, some data were incomplete or non-existent. Additionally, variables related to quality of life are still a significant challenge to overcome, as their scarcity of data led the study to focus solely on presenting variables directly related to economic and social factors. Furthermore, it is essential to better understand the reason why the short-term relationship in the literacy rate variable shows opposite results to the long-term relationship, seeking to comprehend if there are any behavioural and social factors

involved in this outcome. Therefore, for future research and studies, it is suggested to investigate and analyze more variables related to the quality of life and mental health of society to gain a clearer, more objective, and realistic understanding of the impacts that economic crises have on people's lives.

It is important to emphasize that this study does not conclude the discussion on the impact of economic crises on the number of suicides in Brazilian states. Therefore, further research is necessary to understand the topic under study better.

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