EFFECTS OF CAPITAL STRUCTURE ON INSOLVENCY RISK AND COVID-19 PANDEMIC MODERATING EFFECT

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ABSTRACT

Studies on insolvency were developed mainly to elaborate on forecast models; however, identifying the determinant factors of insolvency risk contributes to understanding how this problem arises and helps with its prevention. A company's capital structure influences insolvency risk; however, different views of the effects of capital structure on the value and risk of the company are found. Additionally, when dealing with insolvency risk, the pandemic period can be considered a relevant event, because the consequences of COVID-19 impacted financial markets around the world. Therefore, the objective of this study was to analyze the influence of capital structure on the insolvency risk of nonfinancial Brazilian companies listed on B3 and the effects of the COVID-19 pandemic on this relationship. Multilevel regression of quarterly panel data from 2010 to 2021 was used to develop the study. The results showed that some of the indebtedness variables had significant positive effects, corroborating trade-off theory. The variable financial indebtedness and its quadratic term had significant results,

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confirming the existence of a quadratic relationship (U-shaped) between financial indebtedness and the insolvency risk. Regarding the moderating effect of the pandemic, the results show that in some cases the COVID-19 pandemic was relevant to relation between debt and insolvency risk.

Keywords: Indebtedness. Bankruptcy risk. COVID-19.

EFEITOS DA ESTRUTURA DE CAPITAL NO RISCO DE INSOLVÊNCIA E EFEITO MODERADOR DA PANDEMIA DE COVID-19

RESUMO

Os estudos sobre insolvência foram desenvolvidos principalmente para elaborar modelos de previsão; no entanto, identificar os factores determinantes do risco de insolvência contribui para compreender como este problema surge e ajuda na sua prevenção. A estrutura de capital de uma empresa influencia o risco de insolvência; no entanto, encontram-se diferentes visões sobre os efeitos da estrutura de capital sobre o valor e o risco da empresa. Adicionalmente, tratando-se do risco de insolvência, o período da pandemia pode ser considerado um evento relevante, pois as consequências da COVID-19 impactaram os mercados financeiros ao redor do mundo. Portanto, o objetivo deste estudo foi analisar a influência da estrutura de capital no risco de insolvência das empresas brasileiras não financeiras listadas na B3 e os efeitos da pandemia nesta relação. Para desenvolver o estudo foi utilizada regressão multinível de dados em painel trimestrais de 2010 a 2021. Os resultados mostraram que algumas variáveis de endividamento tiveram efeitos positivos significativos, corroborando a teoria do trade-off. A variável endividamento financeiro e o seu termo quadrático tiveram resultados significativos, confirmando a existência de uma relação quadrática (em forma de U) entre o endividamento financeiro e o risco de insolvência. Relativamente ao efeito moderador da pandemia, os resultados mostraram que em alguns casos a pandemia de COVID-19 foi relevante para a relação entre endividamento e risco de insolvência.

Palavras-chave: Endividamento. Risco de falência. COVID-19.

1 INTRODUCTION

Capital structure is understood as the long-term financing structure of companies. Companies are financed by their own or third-party capital. Thus, a company's capital structure shows the sources of funds used to finance its assets (Bittencourt & Albuquerque, 2018; Myers, 1984). The literature points to the existence of different capital structure theories. Among them are advocates that state that capital structure is irrelevant to the value of the company (Modigliani & Miller, 1958) and advocates that state that capital structure is relevant to the value of the company (Durand, 1952).

Among capital structure theories, *trade-off* theory stands out. According to this theory, capital structure is a relevant factor, as there is an optimal level

between own and third-party capital at which the costs of bankruptcy and the tax benefits arising from the use of debt (third-party capital) are balanced. This balance occurs because of the interest in third-party capital, which decreases taxable income, consequently decreasing the taxes paid and guaranteeing a tax benefit (Myers, 1984; Prado, 2019).

Different factors influence the insolvency risk, including capital structure. Since the capital structure represents a company's form of financing and, thus, its level of indebtedness, it is considered one of the determining factors of such risk. Thus, an inadequate capital structure influences the insolvency risk and company performance (Tao et al., 2020).

Another relevant factor that impacted the economy and that may have affected the influence of capital structure on the insolvency risk was the COVID-19 pandemic. According to CNN Brasil (2021), a survey conducted by Economatica found that among the 218 publicly traded nonfinancial companies analyzed, there was an 81.9% reduction in net income during the first half of 2020 compared to the same period in 2019. These results highlight the effects of the pandemic on the economy and, specifically, publicly traded nonfinancial Brazilian companies, which are the focus of this study.

Additionally, due to the impacts of COVID-19, attention from the public and researchers has been higher in recent years (Huang & Ye, 2021). Specifically, when dealing with insolvency risk, the pandemic period can be considered a relevant event, because the consequences of COVID-19 impacted financial markets around the world, increasing risk levels worldwide (Ali et al., 2020). In this sense, to deal with the consequences of this scenario, some companies resorted to increasing debt. However, increased debt can lead to an increased insolvency risk and subsequent bankruptcy of companies. An example of this were the results obtained by Arianpoor and Naeimi Tajdar (2024), that, considering the period of the COVID-19 pandemic, identified that underleveraged firms presented a lower total risk, and overleveraged firms presented a higher risk.

Additionally, Huang and Ye (2021) concluded that companies with excessive debt presented greater risk. In other words, companies with debt beyond the optimal level presented greater risk, while companies below the optimal level were self-protected. Therefore, there is evidence that the COVID-19 pandemic led to an increased insolvency risk for companies with higher debt levels.

Despite the relevance of the topic and the existence of evidence that capital structure can influence the insolvency risk, and that this risk may have intensified during the pandemic period, no studies were identified that jointly analyzed the effects of debt on the risk of insolvency and the moderating effect of the COVID-19 pandemic.

Thus, due to the relevance of the topic, identifying the factors that determine the insolvency risk contributes to understanding how this problem arises and assists in its prevention. However, the literature in the field has primarily focused on predictive studies (Altman, 1968; Costa et al., 2023; Elizabetsky, 1976; Matias, 1978; Ohlson, 1980; Prado et al., 2020). Additionally, company's capital structure can influence the insolvency risk, as the amount of indebtedness can indicate

financial problems. Nonetheless, different views exist in the literature about the effects of capital structure on the value and risk of a company.

To fill this gap, we aim to deepen the knowledge by analyzing the impact of capital structure on insolvency risk. In this context, the objective of this study was to analyze the influence of capital structure on the insolvency risk of publicly traded Brazilian nonfinancial companies traded on B3, also analyzing the COVID-19 pandemic moderating effect on the previously relation.

Importantly, theories on capital structure have been widely researched in relation to developed countries (Oz & Simga-Mugan, 2018). However, despite the importance of these theories, emerging countries have peculiarities that can be relevants to the definition of capital structure and to the insolvency risk. Specifically, Latin American countries have characteristics that differ from other countries, such as political uncertainty, violence, pro-market reforms and reversals, and geographic isolation (Cuervo-Cazurra, 2016). These differences make specific analyses of these countries necessary.

Therefore, the analysis of emerging economies, such as Brazil, is relevant to expand the knowledge. Specifically, in this study, knowledge of capital structure and insolvency risk was expanded considering the unique context of a Latin American country. Brazil was chosen because it is an important emerging economy in Latin America, with a GDP that represents the highest percentage (33.25%) of the region's total GDP, according to Economic Commission for Latin America and the Caribbean (Cepal, 2021) data. In addition, Brazil was chosen due to the availability of the data necessary to perform the analyses proposed in this study.

Thus, academic, managerial, political, and social contributions can be mentioned. Regarding academic contributions, it is worth noting that it was possible to expand knowledge about insolvency risk. The contribution of the study in this sense was twofold, because the effect of the capital structure on insolvency risk was analyzed, also considering the moderating effect of the COVID-19 pandemic on this relationship. Managerial contributions can also be mentioned, because greater knowledge about insolvency risk helps decision-makers, who will outline strategies to prevent the company bankruptcy. Regarding political contributions, it is mentioned that knowledge about the factors that influence insolvency risk can be used to define public policies that will mitigate this risk, and to adapt legislation on judicial, extrajudicial recovery and bankruptcy. Finally, regarding social contributions, the company non-bankruptcy brings benefits to society as a whole, since it benefits organization's stakeholders, such as suppliers and employees.

2 THEORETICAL FRAMEWORK

2.1 Trade-off theory and studies on capital structure

Trade-off theory reflects two views on the optimal level of indebtedness. Static trade-off theory reflects the idea that companies must achieve an optimal indebtedness point. In dynamic trade-off theory, the optimal level of indebtedness

also depends on factors in the external environment and may vary over time (Lott, 2019).

Thus, despite the initial idea that an equilibrium exists that maximizes the value of the company, companies may deviate from their leverage goals (Ricca et al., 2021). Such deviations can cause a static capital structure to give way to a dynamic capital structure.

In a complementary way, most models that address capital structure consider the level of indebtedness as a static decision. However, in the real world, the level of indebtedness is adjusted by companies depending on the changes that influence its value (Nenu et al., 2018).

In Hovakimian et al. (2012), the authors tested static *trade-off* theory by analyzing the probability of default, which plays a central role in the theory. The results were contrary to the predictions of the theory, indicating that companies with higher bankruptcy costs (which are smaller and have fewer tangible assets) tend to have capital structures that reflect a greater risk of bankruptcy.

Nenu et al. (2018) analyzed the factors that impact the leverage, profitability and risk of companies listed on the Bucharest Stock Exchange. The authors found a positive relationship between financial leverage and company size (consistent with *trade-off* theory) but also that capital structure impacted companies' performance in a different way. They also identified a negative relationship between profitability and short- and long-term debt.

In Ricca et al. (2021), the authors analyzed the degree of conservatism of companies in relation to their capital structure and sought to understand why companies do not fully use the tax benefits of debt. The evidence showed that the amount of financial leverage of Brazilian companies was not optimal, even if the benefits of debt outweighed the costs of bankruptcy.

Haron et al. (2021) considered companies in Indonesia. In their study, firm- and industry-level factors and the effect of the degree of ownership concentration on decisions about dynamic capital structure were analyzed. The authors concluded that, consistent with *trade-off* theory, companies that are growing rapidly and that operate in highly concentrated industries have more leveraged capital structures and benefit from the tax shield generated from using third-party capital. In contrast, companies with more time on the market and with high liquidity, profits and tangible and intangible assets and that operate in dynamic markets have lower indebtedness to avoid the risk of bankruptcy and its consequences.

Pamplona et al. (2020) analyzed the influence of capital structure on financial distress, considering both family and non-family Brazilian companies. As a result, they identified that total debt positively affected the probability of financial distress in both family and non-family Brazilian companies, whereas long-term debt had a negative influence on the probability of financial distress. However, when considering onerous liability, the results showed that it negatively affected the probability of financial distress in family Brazilian companies, but positively affected the probability of financial distress in non-family Brazilian companies. Therefore, different types of debt can impact financial distress in different ways.

2.2 Insolvency risk

Defining what the risk is can be considered an important aspect for its assessment (Horváthová & Mokrišová, 2018). According to Horváthová and Mokrišová (2018), risk can be understood as the occurrence of an unexpected event, being treated as something undefined and unstable, which causes a disturbance in the behavior of a certain phenomenon. Therefore, risk can be treated as uncertainty, characterized by the probability of deviation from expected values, whether this deviation is positive or negative. However, it is necessary to highlight that in practice the risk is considered as a negative deviation (Horváthová & Mokrišová, 2018).

The insolvency risk, also known as bankruptcy risk, can be understood as the probability that a company will go into insolvency, a fact that could culminate in its bankruptcy. In other words, the insolvency risk can be understood as the probability that a company will not be able to pay off its obligations as they fall due (Mateus, 2010). Given the possible consequences of the insolvency risk, this field has attracted the attention of scholars over the last few decades. According to Bryan et al. (2013), bankruptcy is an important event in the modern business environment, as it can trigger a negative effect on its stakeholders. According to the same authors, bankruptcy occurs when a company requests a period in court so that it can reorganize itself financially or close its activities.

2.3 Capital structure and insolvency risk in periods of crisis

According to Zeitun et al. (2017) the existence of economic crises constitutes a challenging aspect for financial theories, including capital structure theories. According to the authors, in periods of crisis, the resources destined for loans tend to be reduced. However, at the same time, companies may need to use debt to make it through these periods of crisis, making it difficult to generate cash flow.

The literature also indicates that external factors impact the insolvency risk (Hackbarth et al., 2006; Tinoco & Wilson, 2013). Evidence shows that companies' capital structure changes after economic crises (Alves & Francisco, 2015; Duran & Stephen, 2020; Tsoy & Heshmati, 2019). In addition to the capital structure, in periods of crisis, the risk of company bankruptcy can also be influenced because during recessions, companies' economic and financial performance tends to be compromised, a fact that makes the increased insolvency risk common in these periods (Chaia, 2003).

Thus, since the supply of credit is generally reduced in times of crisis and some companies need credit to continue their operations (Zeitun et al., 2017), such companies may opt for short-term debt, which may increase the risk of rollover and, consequently, insolvency risk (Alves & Francisco, 2015). Additionally, there is evidence that COVID-19 can impact the relationship between capital structure and risk (Huang & Ye, 2021).

Specifically regarding the COVID-19 pandemic, the restrictive measures had a direct impact on the economy. Since the reduced circulation of people led to a slowdown in sales and, consequently, a reduction in profitability, companies

increased their level of debt, since this was an alternative to keep payments up to date, for example (Avelar et al., 2021). In this sense, although necessary, the increase in debt, especially short-term debt in times of crisis, generates consequences for companies, such as increased risk, resulting from the greater probability of debt rollover risk (Alves & Francisco, 2015), as well as worse economic and financial performance (Machado & Freitas, 2023).

Some studies have analyzed the effects of the pandemic on the level of debt of companies in different countries. Considering Chinese companies, Gao and Tsusaka (2023) identified that during the COVID-19 pandemic there was an increase in the leverage of the companies analyzed. In the study by Azharl et al. (2022), the authors identified an increase in long-term debt in Malaysian companies, while short-term and total debt showed a slight decrease. Similarly, Ahmed et al. (2024) identified that non-financial companies present in Gulf Cooperation Council (GCC) countries presented greater debt financing and transferred short-term debt to long-term debt.

Complementarily, Shaari and Kamarudin (2024) concluded that total debt negatively affected the performance of Malaysian companies during the COVID-19 pandemic period, however long-term debt positively affected performance, since it ensured greater liquidity for companies during the crisis period. Alhajjeah and Besim (2024) analyzed the capital structure of UK companies during the COVID-19 pandemic, and concluded that contrary to expectations, companies reduced their exposure to debt

2.4 Hypotheses related to debt and insolvency risk

Decisions related to companies' capital structure are complex and can influence the financial health of these organizations (Brito et al., 2007; Nenu et al., 2018; Pamplona et al., 2020). Such an impact can be explained by *trade-off* theory, which defends the existence of a tax benefit derived from the use of third-party capital, although bankruptcy costs require attention, as they may become higher than recommended if indebtedness increases, reducing the effectiveness of the tax benefit (Myers, 2001).

In this sense, there is evidence of a positive relationship between capital structure and insolvency risk (Lott et al., 2021). Specifically, the evidence suggests that as indebtedness increases, there is an increase in insolvency risk, since companies may experience financial difficulties if they become excessively leveraged (Huang & Ye, 202; Pamplona et al., 2020). Therefore, companies can opt for lower leverage levels to avoid the risk of insolvency (Haron et al., 2021).

Furthermore, we can mention the tax benefit proposed by trade-off theory. The tax benefit proposed arises from the financial expenses levied on third-party capital. However, not all components of the liability generate interest payments. According to Machado et al. (2010), liabilities are divided into onerous and nononerous liabilities. Interest-bearing liabilities correspond to the portion of the liability on which interest is levied, that is, the portion that generates financial expenses that provide the tax benefit from using third-party capital.

Noninterest-bearing liabilities arise from the company's operating activities; i.e., as the name suggests, this type of liability generates no financial expenses. Therefore, it is important to take into account this difference when analyzing the effects of indebtedness on the level of insolvency risk since the tax benefit generated from using third-party capital is expected to be derived from onerous liabilities.

Despite such tax benefits, companies should be aware that their debt does not reach high levels. This concern is necessary because bankruptcy costs can increase to the point that the tax benefit of indebtedness becomes insufficient (Myers, 2001). Thus, companies should seek a balance between the use of equity and debt capital to ensure a structure that minimizes costs (capital and bankruptcy).

Given the possible effect of indebtedness on bankruptcy costs, the increased risk of bankruptcy may result from high indebtedness. As already mentioned and according to *trade-off* theory, if indebtedness exceeds the ideal level, bankruptcy costs may exceed the tax benefit, which arises from onerous liabilities. This situation puts the company more at insolvency risk. These assumptions lead to the expectation that increases in companies' debt in general positively influences the insolvency risk since the tax benefit is not derived from any type of third-party capital but only from capital that generates interest payments. Therefore, the first hypotheses of this study were proposed:

Hypothesis 1a: Short-term net debt positively influences the insolvency risk.

Hypothesis 1b: Short-term indebtedness positively influences the insolvency risk.

Hypothesis 1c: Long-term indebtedness positively influences the insolvency risk.

Since interest is levied on only part of the liability—the so-called onerous liability (Machado et al., 2010)—the tax benefit, defended by the trade-off theory, is expected to be generated only for a part of the liability. Therefore, due to the tax benefit, onerous liability can impact insolvency risk differently (Pamplona et al., 2020).

However, according to *trade-off* theory, when the use of third-party capital is excessive, the bankruptcy costs may outweigh the effects of the tax benefit. Thus, given the tax benefit derived from onerous liabilities, a quadratic relationship (U-shaped) is expected between the indebtedness arising from onerous liabilities (total gross financial debt) and the insolvency risk. Thus, the tax benefit of interest is expected to decrease the insolvency risk to a certain point (optimal debt level), beyond which bankruptcy costs are expected to exceed the tax benefit, increasing the risk of bankruptcy of the organization. Therefore, hypothesis 1d of this study was proposed:

Hypothesis 1d: Financial indebtedness has a U-shaped relationship wich the insolvency risk.

In this sense, the hypotheses 1a, 1b and 1c argue that different forms of debt increase the insolvency risk. However, the hypothesis 1d suggests a U-shaped relationship between debt and the insolvency risk. In other words, initially, increasing debt may reduce risk, but it may increase it due to the bankruptcy risk.

2.5 Hypotheses related to the COVID-19 pandemic effect

Additionally, the COVID-19 pandemic may have had a moderating effect on the effect of capital structure on insolvency risk. As previously mentioned, evidence shows that external factors influence the insolvency risk of companies (Carvalho et al., 2022; Huang & Ye, 2021; Tinoco & Wilson, 2013). The COVID-19 pandemic can be considered an adverse factor in the external environment that has had major impacts on the world economy, affecting companies and the economy globally (The World Bank, 2022).

Given the effects of the COVID-19 pandemic on the world economy, as well as several companies stopping operations due to social isolation (Fahlenbrach et al., 2021), companies are expected to have needed third-party resources to maintain their payments up to date. This idea is based on the fact that during crises, given the commitment of their cash flow, companies resort to higher use of third-party capital (Zeitun et al., 2017). Thus, in general, the relationship between indebtedness and insolvency risk is expected to have been strengthened during the pandemic period (Huang & Ye, 2021), leading to the first hypotheses of the second part of this study:

Hypothesis 2a: The COVID-19 pandemic strengthens the positive influence of short-term net debt on the insolvency risk.

Hypothesis 2b: The COVID-19 pandemic strengthens the positive influence of short-term debt on the insolvency risk.

Hypothesis 2c: The COVID-19 pandemic strengthens the positive influence of long-term indebtedness on the insolvency risk.

As already mentioned, the tax benefit is expected to lead to a quadratic relationship between the book value of financial indebtedness and insolvency risk. The initially negative relationship between financial indebtedness and the COVID-19 pandemic is expected to weaken, especially for companies with less financial flexibility since indebtedness incurred due to the need for funds for a company's going concern can increase the risk of debt rollover (Fahlenbrach et al., 2021), also increasing bankruptcy costs—a fact that can minimize the effects of the tax shield and weaken the initially negative relationship of financial indebtedness to insolvency risk. Thus, hypothesis 2d of this study was proposed:

Hypothesis 2d: The COVID-19 pandemic weakens the negative influence (up to a certain point) of financial indebtedness on the insolvency risk.

Nevertheless, it is argued that, given the possible need to use third-party capital to keep payments up to date (Zeitun et al., 2017), the pandemic is expected to strengthen the positive influence (from a certain point, due to the quadratic term) of the book value of financial indebtedness on the insolvency risk. Thus, as the book value of financial indebtedness (quadratic term) is expected to positively influence the insolvency risk, from a certain point, according to trade-off theory, this relationship is expected to have been strengthened by the COVID-19 pandemic, as proposed in hypothesis 2e.

Hypothesis 2e: The COVID-19 pandemic strengthens the positive influence (from a certain point) of financial indebtedness (quadratic variable) on insolvency risk.

Therefore, Hypotheses 2a, 2b, 2c: state that the pandemic strengthened the positive influence of debt on insolvency risk. Additionally, hypotheses 2d and 2e refer to the U-shaped relationship mentioned in Hypothesis 1d, suggesting that the pandemic weakened the initial negative influence of financial debt on insolvency risk (up to a certain point) and strengthened the positive influence of financial debt beyond that point.

As proposed by the hypotheses, based on *trade-off* theory, the relationship between the capital structure variables and insolvency risk is expected to be generally positive. However, considering *trade-off* theory, which defends the existence of a tax benefit provided by the so-called onerous liabilities, a quadratic relationship is expected between the book value of financial indebtedness and the insolvency risk. In addition, the COVID-19 pandemic is expected to have influenced the relationship between the capital structure and insolvency risk variables.

3 METHODOLOGICAL PROCEDURES

3.1 Sample, collection and processing of data

In the analysis of this study, we used quarterly information from the financial statements of Brazilian companies with shares traded on B3. Inflation-adjusted data were collected from the Economatica database. The period of analysis chosen was from January 2010 to December 2021. The year 2010 was the initial year due to changes in accounting legislation by Laws 11,638/07 and 11,941/09 that, according to Freire *et al*. (2012), amended the Brazilian Corporate Law (Law 6,404/76) to standardize Brazilian accounting standards to international law. The year 2021 was the year of closure, as it was the last year with data available at the time of the data collection.

The sample used in this study consisted of publicly traded Brazilian nonfinancial companies with shares traded on B3. From the Economática database, companies in Brazil that trade shares on B3 and are active were filtered. During the initial filtering, companies from the financial sector were also excluded due to their specificities. After filtering and excluding companies with missing data for all analyzed periods, the total number of companies was 510. Also noteworthy

is that unbalanced panel data were used in the analysis, totaling 15,582 observations. In addition, company quarterly data were analyzed from 48 quarters in the period from 2010 to 2021.

For the analysis proposed in this study, the multilevel regression technique of panel data was used. Panel data represent a data set containing observations of time series and several individuals at the same time (Hsiao, 2007). Different types of models exist for performing panel data analyses. In this study, we chose a multilevel model. According to Fávero and Belfiore (2017), multilevel models are used to consider the groups among the observations with common characteristics, such as sectors. The multilevel regression technique was chosen because companies in different sectors can present sector-specific characteristics that can impact insolvency risk. Specifically, there is evidence that the sector may be a debt determinant (Campos & Nakamura, 2013), thus it is important to consider it as a level of analysis.

Additionally, we aimed to analyze the impact of COVID-19 on the relationship between capital structure and insolvency risk, that is, to analyze the variation in the relation between capital structure and insolvency risk in a given periodThe choice of the multilevel model was based on the analyses specified by Fávero and Belfiore (2017). The null model, one with random intercepts and a model with random intercepts and slopes, were developed. After attaining the results of these analyses, a hierarchical three-level linear model with intercepts and random slopes was chosen. Three levels were determined because the data vary over time (level 1), between companies (level 2) and between sectors (level 3).

3.2 Variables and econometric models

To prepare the study, the economic-financial indicators were obtained through Economática. The variable data were winsorized up to 5% (Fávero et al., 2009; Rosa et al., 2022), to eliminate *outliers* that could affect the analysis (Hair et al., 2006). In addition, to avoid the occurrence of multicollinearity between the model variables, the variance inflation factor (VIF) was used. According to Gujarati and Porter (2011), VIF values greater than 10 indicate the existence of multicollinearity.

The dependent variable chosen was the *Z score* from Altman et al. (1979) study. In this study, Altman et al. (1979) developed a model for classifying and predicting financial problems for Brazilian companies.Specifically, the authors used the model by Altman (1968), but adapted it to Brazilian conditions. Altman's model, adapted to the Brazilian scenario, was chosen because the original model proposed by Altman (1968) is a relevant tool for predicting insolvency. Altman's study can be considered the most influential in the field of insolvency prediction and was the first to use multivariate analysis for such predictions (Prado et al., 2016). Therefore, insolvency risk was calculated considering the parameters of Equation 1:

$$Z_1 = -1{,}44 + 4{,}03X_2 + 2{,}25X_3 + 0{,}14X_4 + 0{,}42X_5 \quad (1)$$

where:

$$X_2 = \frac{Not\ required - Shareholder's\ Capital}{Total\ Asset} \quad (2)$$

$$X_3 = \frac{Earnings\ before\ interest\ and\ taxes}{Total\ Asset} \quad (3)$$

$$X_4 = \frac{Total\ equity}{Total\ liabiities} \quad (4)$$

$$X_5 = \frac{Revenue}{Total\ Asset} \quad (5)$$

According to the authors, the critical point of separation of companies with and without problems (value of Z_1) is zero; that is, companies with Z_1 less than zero to have a greater probability of bankruptcy, and companies with Z_1 greater than zero have a lower probability of bankruptcy. In this case, as proposed, the higher Z_1 is, the lower is the probability of bankruptcy. For a better understanding and to ensure that a higher value of Z_1 is associated with a greater probability of insolvency, Z_1 was multiplied by negative one (-1). Thus, through this transformation, the greater is Z_1, the greater is the risk of bankruptcy of the companies in the analysis.

For the analysis, indebtedness variables were considered explanatory to analyze the effects of capital structure on insolvency risk. The indebtedness variables used and the expected signs of their coefficients are detailed in Figure 1.

AUTORS	**Indicator**	**Formula**	**Acronym**	**Expected signal**
Dependent variable				
Altman et al. (1979)	Insolvency risk	$-1{,}44 + 4{,}03X_2 + 2{,}25X_3 + 0{,}14X_4 + 0{,}42X_5$	Risk	
Independents variables				
Fahlenbrach et al. (2021).	Total short-term net debt	Current Liabilities – (Cash and cash equivalent + Financial investments)	*DIV_LIQ_CP*	+
Baker and Wurgler (2002), Albanez (2012), Prado (2019), Pamplona et al., (2020).	Financial indebtedness	$\frac{\text{Total gross financial debt}}{\text{Total Assets}}$ (Total gross financial debt = onerous liability)	*END_C_DF*	U
			END_C_DF_2	
Bastos and Nakamura (2009), Prado (2019).	Short-term debt	$\frac{\text{Current liabilities}}{Total\ Asset}$	*END_C_CP*	+
Bastos and Nakamura (2009), Prado (2019), Pamplona et al., (2020).	Long-term indebtedness	$\frac{\text{Non} - \text{current liabilities}}{Total\ Asset}$	*END_C_LP*	+

Figure 1 – Study variables
Source: Prepared by the authors

Notably, for the financial indebtedness variable, the financial expenses arising from onerous liabilities is expected to initially negatively influence the risk of bankruptcy, which is consistent with *trade-off* theory that postulates the existence of the tax benefit. However, this influence is expected to be only up to a certain point because of bankruptcy costs; therefore, there is a U-shaped quadratic relationship, as proposed in hypothesis 1d. Thus, the variable was squared to verify the quadratic relationship. According to hypothesis 1d, the book value of financial indebtedness is expected to have a significantly negative coefficient, and the quadratic term of this variable is expected to have a significantly positive coefficient.

Since the literature suggests that external environmental factors of the organization influence its capital structure and bankruptcy risk (Carvalho et al., 2022; Hackbarth et al., 2006; Tinoco & Wilson, 2013), a dummy variable for the COVID-19 pandemic was also considered in the model. The first recorded case of the COVID-19 disease was on February 26, 2020 (Governo do Brasil, 2020); therefore, the *dummy* variable received the value one (1) for the quarters in 2020 and 2021 and zero (0) for the other quarters in the sample.

To analyze the effect of the COVID-19 pandemic on the relationship between capital structure and insolvency risk, interaction variables were created by multiplying the dummy variable and the capital structure variables. Therefore, interaction variables with significant results indicate that the COVID-19 pandemic influenced the relationship between capital structure and bankruptcy risk, where positive coefficients indicate a strengthening of this relationship and negative coefficients indicate a weakening of this relationship.

The model estimated is represented in Equation 6:

$$\begin{aligned} Risk_{tjk} = {} & \gamma_{000} + \gamma_{100}.Quarter_{jk} + \gamma_{010}.DIV\_LIQ\_CP_{jk} + \gamma_{010}.END\_C\_CP_{jk} \\ & + \gamma_{010}.END\_C\_LP_{jk} + \gamma_{010}.END\_C\_DF_{jk} \\ & + \gamma_{010}.END\_C\_DF\_2_{jk}\gamma_{010}.KI_{jk} + \gamma_{110}.DIV\_LIQ\_CP_{jk}.Quarter_{jk} \\ & + \gamma_{110}.END\_C\_CP_{jk}.Quarter_{jk} + \gamma_{110}.END\_C\_LP_{jk}.Quarter_{jk} \\ & + \gamma_{110}.END\_C\_DF_{jk}.Quarter_{jk} + \gamma_{110}.END\_C\_DF\_2_{jk}.Quarter_{jk} \\ & + u_{00k} + u_{10k}.Quarter_{jk} + r_{0jk} + r_{1jk}.Quarter_{jk} + e_{tjk} \end{aligned} \quad (6)$$

Where:

$Risk_{tjk}$ = dependent variable (insolvency risk);
γ_{000} = general intercept (constant that does not vary among individuals);
u_{00k} = random effects of level 3 – sector;
r_{0jk} = random effects of level 2 – company;
e_{tjk} = level 1 error terms – time (quarter);
$\tau_{u000}\, e\, \tau_{r000}$ = variances in the error terms;
DIV_LIQ_CP = short-term net debt;
END_C_CP = short-term debt;
END_C_LP = long-term debt;
END_C_DF = financial indebtedness;

$END\_C\_DF\_2$ = financial debt squared.

4 RESULTS

Before starting the multilevel regression analysis of the panel data, the data were winsorized. Table 1 shows the descriptive statistics of the study variables, the skewness and kurtosis values and the VIF of each variable after data processing.

Table 1
Descriptive statistics and VIF of independents variables (complete period)

Variables	Average	Maximum	Minimum	Standard deviation	Variance	Asymmetry	Kurtosis	VIF
DIV_LIQ_CP	1,016,	7,700	-4,100	2,025,	4.10e+92	1.997	7.142	1.04
END_C_CP	0.295	1.629	0.005	0.301	0.090	2.830	12.136	1.09
END_C_LP	0.427	2.173	0	0.390	0.152	2.765	12.510	1.36
END_C_DF	0.337	1.189	0	0.258	0.066	1.066	4.637	1.41

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt (in R$ millions); END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness.

In addition, Table 2 shows the descriptive statistics for the pandemic period. Specifically, short-term net debt decreased, while long-term debt increased. Short-term debt and financial indebtedness remained close to the mean of the total sample, indicating no major changes.

Table 2
Descriptive statistics of independents variables (pandemic period)

Variables	Average	Maximum	Minimum	Standard deviation	Variance	Asymmetry	Kurtosis
DIV_LIQ_CP	879.912	7,700	-4,100	2,048.64	4.20e+9	2.018	7.471
END_C_CP	0.30	1.628	.005	0.309	0.096	2.797	11.708
END_C_LP	0.450			0.384	0.147	2.619	11.933
END_C_DF	0.337	1.189	0	0.258	0.067	1.037	4.396

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt (in R$ millions); END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness.

Next, the best fit of the multilevel model was verified. To visually show the comparison of a traditional model (OLS, ordinary least squares) with the multilevel model (HLM3), the graph shown in Figure 2 was prepared.

As can be observed in Figure 2, the multilevel model (HLM3) was closer to the observed values. This figure visualizes the superiority of the linear trend model with explanatory variables and intercepts and random slopes at levels 2 and 3 (HLM3), in contrast to the multiple linear regression model estimated by OLS. Thus, the relevance of considering the random effects components in nested data structures is mentioned.

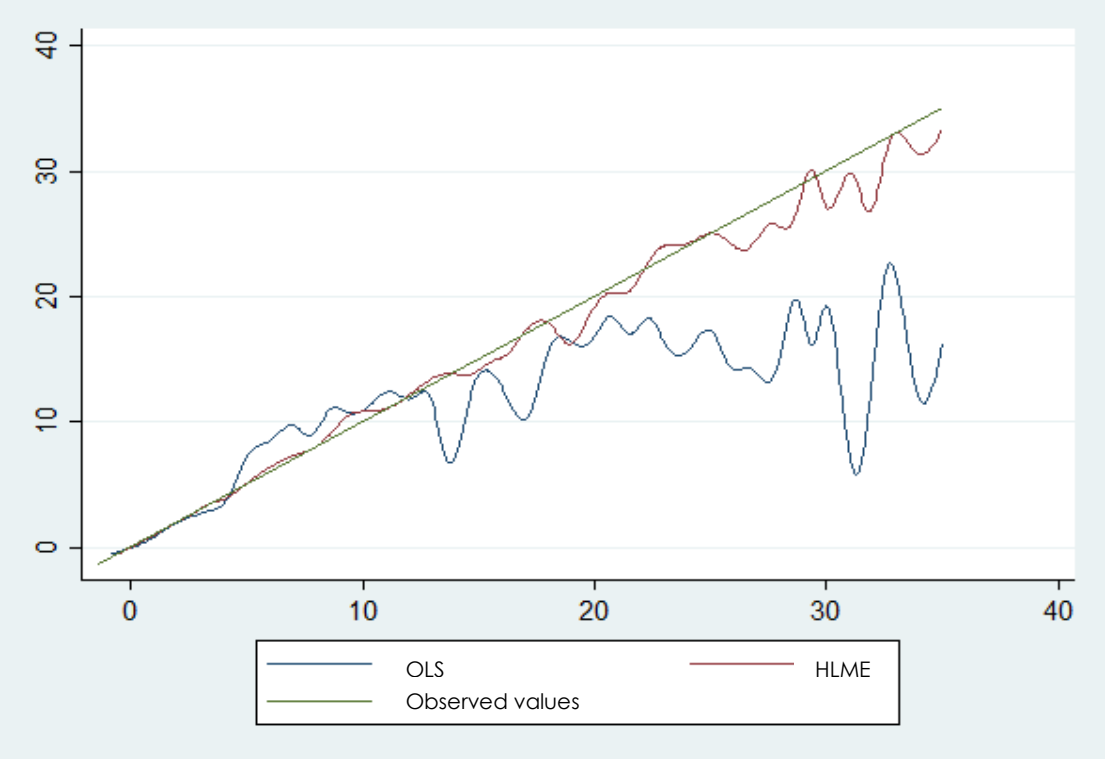

Figure 2 - Comparison of OLS (ordinary least squares) and HLM3 (multilevel model)
Source: Prepared by the authors.

The explanatory variables indicate the capital structure of companies to verify the effect on insolvency risk. Table 3 shows the results of the complete model. For the analysis of hypothesis 1a (short-term net debt positively influences the insolvency risk), the results of the short-term net debt (DIV_LIQ_CP) variable were observed. The results for the variable are significant (p value = 0.001) and negative, which differed from the expectation. Thus, hypothesis 1a of this study was rejected, indicating that short-term net debt negatively influences the insolvency risk of nonfinancial Brazilian companies with shares traded on B3.

This result can be considered consistent with the idea defended by Miller (1977). According to the author, bankruptcy costs exist but may be proportionally irrelevant compared to the tax benefit of indebtedness. Thus, the tax benefit resulting from onerous short-term liabilities, which are included in current liabilities, may be responsible for offsetting the bankruptcy costs associated with higher short-term net debt, reducing the risk of bankruptcy.

The analysis of hypothesis 1b (short-term indebtedness positively influences the insolvency risk) was based on the results of the short-term indebtedness (END_C_CP) variable. As shown in Table 3, the result for this variable was significant (p value=0.000) and positive. This result does not reject hypothesis 1b, indicating the positive influence of short-term debt on the insolvency risk of Brazilian nonfinancial companies with shares traded on B3, a result consistent with trade-off theory.

The analysis of hypothesis 1c (long-term indebtedness positively influences the insolvency risk) was based on the results of the long-term indebtedness

(END_C_LP) variable. The results for the was significant (p value = 0.000) and positive, as expected. Thus, the result does not reject hypothesis 1c and indicated the positive influence of short-term debt on the insolvency risk of nonfinancial Brazilian companies with shares traded on B3, as expected.

As proposed by trade-off theory, the indebtedness was expected to positively influence the risk of bankruptcy due to an increase in bankruptcy costs from greater indebtedness (Myers, 2001). The short-term debt (END_C_CP) and long-term debt (END_C_LP) variables showed significant positive effects, corroborating the theory proposed and confirming hypotheses 1b and 1c.

Table 3
Results of the complete model

Fixed effects	Coefficient	Standard error	P-value
Constant	-1.227	0.408	0.003
Quarter	-0.006	0.010	0.552
DIV_LIQ_CP	-2.12e-07	3.77e-08	0.000
END_C_CP	5.848	0.244	0.000
END_C_LP	4.937	0.220	0.000
END_C_DF	-3.756	0.899	0.000
END_C_DF_2	4.014	0.854	0.000
DIV_LIQ_CP_TRIM	2.48e-09	1.17e-09	0.033
END_C_CP_TRIM	0.043	0.008	0.000
END_C_LP_TRIM	0.051	0.007	0.000
END_C_DF_TRIM	-0.050	0.027	0.064
END_C_DF_2_TRIM	-0.021	0.026	0.426
Random effects	**Coefficient**	**Standard Error**	**Txxxx/ Standard Error**
Tu000 for Sector	0.157	0.368	0.430
Tu100 for sector	0.000	0.000	0.215
Tr000 for company	45.112	3.726	12.107
Tr100 for company	0.024	0.010	12.349
σ^2	2.779	0.032	8.52E-06
Intraclass Correlation(ICC)	**Value**	**Standard Error**	
rhocompany|sector	0.942	0.005	
rhosector	0.003	0.008	
Lrtest	χ^2	**P-value**	
	27695.06	0.000	

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt; END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness; $END\_C\_DF\_2$ = financial debt squared; $\tau_{u000}\, e\, \tau_{r000}$ = variances in the error terms; $rho_{company/sector}$= level 2 intraclass Correlation; rho_{sector}= level 3 intraclass Correlation; $\sigma^2 var(Residual)$= residual variance in error terms; ICC= intraclass Correlation.

For the analysis of hypothesis 1d (the book value of financial indebtedness negatively influences the insolvency risk to some extent), the results of the book value of financial debt (END_C_DF) and the book value financial debt squared (END_C_DF_2) variables were analyzed. This analysis accounted for the existence of a U-shaped quadratic relationship between the book value of financial indebtedness and the insolvency risk according to the assumptions of *trade-off* theory, which mentions the tax benefit arising from a reduction in tax due payments of financial expenses, affecting the so-called onerous liabilities.

The analysis showed that the variable and its quadratic term had significant results (p value = 0.000). As expected, the book value of financial debt variable had a negative coefficient, while the quadratic term of the variable had a positive coefficient, which indicates the expected U-shaped relationship. Thus, the results does not reject hypothesis 1d, indicating that the tax benefit deriving from onerous liabilities negatively influences the insolvency risk to some extent, with the optimal point being the value of financial indebtedness (END_C_DF) equal to 0.4679. This value was determined by dividing the coefficient of the financial indebtedness (END_C_DF) variable by twice the coefficient of the quadratic variable of financial indebtedness (END_C_DF_2).

These results indicate that financial indebtedness negatively influences to some extent (END_C_DF = 0.4679) the insolvency risk. Importantly, financial indebtedness (END_C_DF) considers the amounts on which interest is levied and, thus, the higher its value is, the greater the tax benefit provided by the interest paid tends to be. According to *trade-off* theory, indebtedness generates a tax benefit due to a reduction in taxes paid from a reduction given by the interest paid; however, bankruptcy costs must also be considered.

This result can be considered partially consistent with that proposed by Miller (1977). According to the author, bankruptcy costs exist but may be proportionally irrelevant compared to the tax benefit of indebtedness. Thus, the tax benefit resulting from the use of third-party capital may be responsible for offsetting the bankruptcy costs associated with greater indebtedness, reducing the risk of bankruptcy.

The significance of the quadratic term, however, reinforces the existence of an optimal indebtedness point (Brito et al., 2007; Durand, 1959) and the existence of the tax benefit as proposed by trade-off theory (Modigliani & Miller, 1963). This is because although the tax benefit results in a decrease in the insolvency risk, there is an optimal point that maximizes the effects of the tax benefit and minimizes the effects of bankruptcy costs (DeAngelo & Masulis, 1980; Miller, 1977; Scott, 1976).

Unlike the proposal in Miller (1977), the tax benefit offsets the bankruptcy costs arising from indebtedness only to a certain extent. This finding indicates that although the use of third-party capital, specifically onerous liabilities, is beneficial for companies, its use should not be excessive, as doing so may in fact result in excessive bankruptcy costs for the company. Thus, companies should use financial debt moderately (Durand, 1959) to minimize their insolvency risk and maximize their value.

To analyze the effect of the COVID-19 pandemic on the relationship between capital structure and insolvency risk, the moderating variables obtained through the product of the capital structure variables and the *dummy* variable that represented the period were added to the previous model (value of 1 for the four quarters of 2020 and 2021; value of zero for the other quarters). Table 4 shows the results considering the moderating variables.

Table 4
Results of the complete model including the moderating variables and COVID-19 pandemic

Fixed effects	**Coefficient**	**Standard error**	**P-value**
Constant	-1.200	0.414	0.004
Quarter	0.001	0.009	0.913
DIV_LIQ_CP	-2.22e-07	3.98e-08	0.000
END_C_CP	5.22	0.266	0.000
END_C_LP	5.243	0.233	0.000
END_C_DF	-3.739	0.946	0.000
END_C_DF_2	4.147	0.920	0.000
DIV_LIQ_CP_COVID	-2.33e-08	2.39e-08	0.331
END_C_CP_COVID	-0.947	0.163	0.000
END_C_LP_COVID	0.568	0.148	0.000
END_C_DF_COVID	-0.405	0.483	0.402
END_C_DF_2_COVID	0.522	0.492	0.289
DIV_LIQ_CP_TRIM	3.19e-09	1.33e-09	0.016
END_C_CP_TRIM	0.070	0.009	0.000
END_C_LP_TRIM	0.039	0.008	0.000
END_C_DF_TRIM	-0.048	0.030	0.105
END_C_DF_2_TRIM	-0.030	0.029	0.307
COVID	0.031	0.121	0.798

Random effects	**Coefficient**	**Standard Error**	**Txxxx/ Standard Error**
Tu000 for Sector	0.148	0.179	0.827
Tu100 for sector	0.000	0.000	0.716
Tr000 for company	45.799	3.763	12.169
Tr100 for company	0.024	0.020	12.388
σ^2	2.767	0.032	85.187

Intraclass Correlation(ICC)	**Value**	**Standard Error**
rhocompany|sector	0.943	0.004
Rhosector	0.003	0.004

Lrtest	χ^2	**P-value**
	27719.67	0.000

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt; END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness; $END\_C\_DF\_2$ = financial debt squared; τ_{u000} e τ_{r000} = variances in the error terms; $rho_{company/sector}$= level 2 intraclass Correlation; rho_{sector}= level 3

intraclass Correlation; $\sigma^2 var(Residual)$= residual variance in error terms; ICC= intraclass Correlation.

The analysis of hypothesis 2a (the COVID-19 pandemic strengthens the positive influence of short-term net debt on insolvency risk) showed that the short-term net debt X COVID-19 (DIV_LIQ_CP_COVID) moderating variable was not significant (p value=0.773) and negative. Thus, hypothesis 2a of this study was reject.

The analysis of hypothesis 2b (the COVID-19 pandemic strengthens the positive influence of short-term indebtedness on the insolvency risk) was performed by observing the short-term indebtedness X COVID-19 (END_C_CP_COVID) moderating variable. Table 4 shows that the variable had a significant (p value = 0.000) but negative result, indicating that the COVID-19 pandemic weakened the positive influence of short-term indebtedness on the insolvency risk. Therefore, this result rejected hypothesis 2b.

This result may have been caused by some companies having to stop their operating activities due to distancing during the COVID-19 pandemic. In addition, given the state of the calamity, several companies may have renegotiated their debts (especially short-term debts), as cash generation was compromised during the pandemic, and specific regulations were proposed for the pandemic period.

Hypothesis 2c (the COVID-19 pandemic strengthens the positive influence of long-term indebtedness on the insolvency risk) was verified by analyzing the moderating variable long-term debt X COVID-19. The coefficient of the variable was significant (p value = 0.000) and positive, indicating that hypothesis 2c was not reject. Thus, regarding the effect of long-term indebtedness on insolvency risk, the COVID-19 pandemic indeed strengthened this relationship, a fact that may be due to the need to use third-party capital, which was probably negotiated for the long term given the possible difficulties in generating cash flow associated with the COVID-19 pandemic.

To analyze hypotheses 2d and 2e (the COVID-19 pandemic weakens the negative influence (to some extent) of the book value of financial indebtedness on insolvency risk, and the COVID-19 pandemic strengthens the positive influence (from a certain point) of the book value of financial indebtedness (square term) on insolvency risk), the moderating variables of the book value of financial indebtedness X COVID-19 and the book value of financial indebtedness squared X COVID-19 were observed. The coefficients of these variables were not significant (p-value=0.402; p-value=0.289). Therefore, these results do reject hypotheses 2d and 2e. Thus, the Hypothesis that thepandemic weakened the initially negative relationship between the book value of financial indebtedness and the insolvency risk was reject, as insolvency risk could rise due to factors such as the risk of debt rollover. Furthermore, was not possible confirming that the pandemic strengthened the positive relationship beyond a certain point between the book value of financial indebtedness and the insolvency risk, as proposed by hypothesis 2e.

For all these reasons, it is clear that the results corroborate previous studies, which showed that capital structure and insolvency risk are related (Haron et al., 2021; Hovakimian et al., 2012). It is worth noting that the results corroborate the trade-off theory, which indicates the existence of an optimal level of capital

(Myers, 1984; Ricca et al., 2021). Therefore, the results reinforce the importance of companies being aware of their debt levels, so that they do not exceed the optimal level, which can lead to insolvency problems.

When considering specifically the pandemic period, the results showed that the relationship between capital structure and insolvency risk was strengthened only in the case of long-term debt. This result may be an indication that companies avoided other types of financing during the pandemic, a fact that may be due to organizations' greater caution regarding the increased risk of insolvency resulting from excessive debt (Haron et al., 2021). In addition, it is worth noting that studies considering other contexts identified a reduction in companies' short-term debt during the pandemic period, while they showed an increase in long-term debt (Azhari et al., 2022; Gao & Tsusaka, 2023).

4.1 Robustness test

To confirm the results of the study, a robustness test was also performed. For this purpose, the analysis was performed again, but this time considering another variable to measure the risk of insolvency. The variable used was from another Brazilian insolvency prediction model, developed by Elizabetsky, (1976). Formula 7 indicates the model used.

$$Z = 1{,}93X_{32} - 0{,}20X_{33} + 1{,}02X_{35} + 1{,}33X_{36} - 1{,}12X_{37} \quad (7)$$

Where:

$$Z = score\ total \quad (8)$$

$$X_{32} = \frac{Net\ profit}{Sales} \quad (9)$$

$$X_{33} = \frac{Available}{Non - current\ assets} \quad (10)$$

$$X_{35} = \frac{Accounts\ receivable}{Total\ assets} \quad (11)$$

$$X_{36} = \frac{Stock}{Total\ assets} \quad (12)$$

$$X_{37} = \frac{Current\ Liabilities}{Total\ assets} \quad (13)$$

In this case, high Z values indicate a lower insolvency risk, so the variable was also multiplied by minus one (-1), so that higher values indicate a higher risk of insolvency. Thus, the two models were estimated again, now using the Z value proposed by Elizabetsky (1976). Table 5 shows the results for the first block of hypotheses.

Table 5

Results of the complete model

Fixed effects	Coefficient	Standard error	P-value
Constant	-0.499	0.195	0.011
Quarter	0.002	0.005	0.751
DIV_LIQ_CP	-4.93e-08	2.02e-08	0.014
END_C_CP	2.751	0.157	0.000
Fixed effects	**Coefficient**	**Standard error**	**P-value**
END_C_LP	2.008	0.151	0.000
END_C_DF	-2.528	0.475	0.000
END_C_DF_2	1.378	0.468	0.003
DIV_LIQ_CP_TRIM	1.81e-09	6.21e-10	0.004
END_C_CP_TRIM	-0.0258	0.005	0.000
END_C_LP_TRIM	-0.044	0.004	0.000
END_C_DF_TRIM	0.071	0.014	0.000
END_C_DF_2_TRIM	-0.014	0.014	0.306

Random effects	Coefficient	Standard Error	Txxxx/ Standard Error
Tu000 for Sector	0.333	0.185	1.78
Tu100 for sector	0.0001	0.00008	1.25
Tr000 for company	1.327	0.135	9.82
Tr100 for company	0.001	0.0001	10
σ^2	0.976	0.012	81.33

Intraclass Correlation(ICC)	Value	Standard Error
rhocompany | sector	0.630	0.031
rhosector	0.126	0.062

Lrtest	χ^2	P-value
	6501.15	0.000

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt; END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness; $END\_C\_DF\_2$ = financial debt squared; τ_{u000} e τ_{r000} = variances in the error terms; $rho_{company/sector}$= level 2 intraclass Correlation; rho_{sector}= level 3 intraclass Correlation; $\sigma^2 var(Residual)$= residual variance in error terms; ICC= intraclass Correlation.

The results of the first block of hypotheses were all consistent with the previous results of the study. In this case, hypotheses 1b, 1c and 1d of the study were confirmed, as proposed by the Trade-off theory.

Again, the model for the second block of hypotheses was estimated, as shown in Table 6. In this case, the results confirmed only hypothesis 2e, which indicated a strengthening of the positive relationship between financial debt and insolvency risk, from a certain point (2e). The other hypotheses, however, were not confirmed.

Despite presenting significant results, short-term and long-term debt presented negative results, indicating that the positive relationship between debt and insolvency risk in these cases was weakened. In this case, the possibility that Brazilian companies have been more cautious regarding their level of debt during the pandemic is once again highlighted, in order to avoid an excessive increase in their insolvency risk, that is, reinforcing that Brazilian companies can adopt a conservative stance regarding their capital structure (Ricca et al., 2021). Additionally, it is worth noting that the chosen Z-score may be a determinant of the weakening or strengthening of the relationship between different types of debt and insolvency risk, especially considering crisis periods.

Table 6
Results of the complete model including the moderating variables and COVID-19 pandemic

Fixed effects	**Coefficient**	**Standard error**	**P-value**
Constant	-0.287	0.199	0.149
Quarter	-0.008	0.005	0.139
DIV_LIQ_CP	-3.88e-08	2.14e-08	0.070
END_C_CP	2.285	0.174	0.000
END_C_LP	1.844	0.165	0.000
END_C_DF	-3.089	0.511	0.000
END_C_DF_2	2.515	0.518	0.000
DIV_LIQ_CP_COVID	1.57e-08	1.42e-08	0.269
END_C_CP_COVID	-0.660	0.103	0.000
END_C_LP_COVID	-0.287	0.099	0.004
END_C_DF_COVID	-0.890	0.316	0.005
END_C_DF_2_COVID	1.737	0.326	0.000
DIV_LIQ_CP_TRIM	1.40e-09	7.23e-10	0.054
END_C_CP_TRIM	-0.005	0.006	0.368
END_C_LP_TRIM	-0.036	0.005	0.000
END_C_DF_TRIM	0.094	0.016	0.000
END_C_DF_2_TRIM	-0.063	0.017	0.000
COVID	0.339	0.081	0.000
Random effects	**Coefficient**	**Standard Error**	**Txxxx/ Standard Error**
Tu000 for Sector	0.321	0.181	1.773
Tu100 for sector	0.0001	0.00008	1.25
Tr000 for company	1.357	0.138	9.833
Tr100 for company	0.001	0.0001	10
σ2 var(Residual))	0.970	0.012	80.833
Intraclass Correlation(ICC)	**Value**	**Standard Error**	
rhocompany | sector	0.633	0.030	
rhosector	0.121	0.060	
Lrtest	χ^2	**P-value**	

	6528.76	0.000

Source: Prepared by the authors.
Note: DIV_LIQ_CP = short-term net debt; END_C_CP = short-term debt; END_C_LP = long-term debt; END_C_DF = financial indebtedness; $END\_C\_DF\_2$ = financial debt squared; $\tau_{u000}\, e\, \tau_{r000}$ = variances in the error terms; $rho_{company/sector}$= level 2 intraclass Correlation; rho_{sector}= level 3 intraclass Correlation; $\sigma^2 var(Residual)$= residual variance in error terms; ICC= intraclass Correlation.

In addition, the moderation result, analyzed for hypothesis 2d, presented a significant and negative result, which indicates that the initially negative relationship between financial debt and insolvency risk was strengthened by the pandemic, once again indicating the relevance of the pandemic in the relationship between capital structure and insolvency risk. Therefore, it is highlighted the importance of companies trying to seek the optimal level of debt, so that they do not incur high insolvency risks resulting from excess debt.

It is also noteworthy that, in the robustness test, the variable indicating the COVID-19 pandemic presented a significant and positive result. Therefore, this result indicates that the crisis caused by COVID-19 had a positive impact on the insolvency risk of Brazilian companies. This result is consistent with other studies that verified the influence of COVID-19 on aspects such as indebtedness (Azhari et al., 2022; Gao & Tsusaka, 2023) and performance (Shaari & Kamarudin, 2024), which may affect the risk of these companies.

5 FINAL CONSIDERATIONS

We aimed to analyze the impact of capital structure on the insolvency risk of publicly traded Brazilian nonfinancial companies traded on B3. Quarterly data from the financial statements obtained through Economática, considering the period from January 2010 to December 2021, were considered. We chose to use multilevel regression of the panel data for the analysis.

The results showed that some of the capital structure variables had significant results, which confirmed some of the initially proposed hypotheses. Specifically, the short-term indebtedness (END_C_CP) and long-term indebtedness (END_C_LP) variables showed significant positive effects, corroborating trade-off theory, which proposes that the use of third-party capital increases bankruptcy costs and, therefore, the insolvency risk (Myers, 2001). These results does not reject hypotheses 1b and 1c.

The result of the short-term net debt (DIV_LIQ_CP) variable, in turn, was significant but negative—different from expectations. Thus, hypothesis 1a was not confirmed, indicating that short-term net debt negatively influenced the insolvency risk of the companies analyzed.

The book value of financial indebtedness (END_C_DF) and its quadratic term (END_C_DF_2) variables had significant results, with END_C_DF having a negative coefficient and END_C_DF_2 having a positive coefficient. These results does not reject the hypothesis 1d, which expected a quadratic (U-shaped) relationship between the book value of financial indebtedness and the insolvency risk. Such a result was expected due to the tax benefit derived from onerous liabilities that offsets, to some extent, the bankruptcy costs associated with the use of debt. The

book value of financial debt (END_C_DF) is composed of the so-called onerous liabilities; i.e., it considers third-party capital on which there is interest.

Since trade-off theory postulates about the tax benefit arising from the use of third-party capital (Modigliani & Miller, 1963), this result indicates that the tax benefit provided by the interest paid exceeded, to a certain extent, bankruptcy costs and, thus, initially negatively influenced the insolvency risk. This result can be considered consistent with trade-off theory as proposed, which recognizes the existence of bankruptcy costs but defends the existence of an optimal capital structure (Brito et al., 2007; Durand, 1959; Modigliani & Miller, 1963). Thus, the tax benefit is considered to decrease the insolvency risk to some extent; however, if the use of third-party capital is excessive, the bankruptcy costs exceed this tax benefit.

When considering the effects of the COVID-19 pandemic on the influence of the capital structure variables on bankruptcy risk, some of the results were not significant or rejected the hypotheses. Specifically, on the first model only hypothesis 2c (the COVID-19 pandemic strengthened the positive influence of long-term indebtedness on the insolvency risk) was not reject. This result suggests that the COVID-19 pandemic strengthened the influence of long-term indebtedness on the insolvency risk and may indicate that, faced with the need to use third-party capital, companies mainly opted for long-term debt due to the possible difficulties arising from the COVID-19 pandemic. The result may also reflect the effect of the possible renegotiations of short-term debts carried out during the pandemic period.

However, considering the robustness test, the result of the COVID-19 moderation in the relationship between long-term debt showed a negative result, indicating a weakening of the relationship. Thus, we note that the moderating effect of the pandemic presented significant results for both cases, indicating its relevance for the relationship between long-term debt and insolvency risk. However, it is worth noting that the result can be considered inconclusive, requiring specific investigations related to the effects of COVID-19 on long-term debt to be carried out.

One possible explanation for the different results is that the Altman (1979) and Elizabetsky (1976) Z-scores present different calculation methods. It is worth noting that only the Elizabetsky (1976) model considers the differentiation between current liabilities and total liabilities, while the Altman et al. (1979) model considers only total liabilities, without distinguishing between current and non-current liabilities. Therefore, the choice of the model used may influence the intensity relationship between debt and insolvency risk in crisis periods, such as the COVID-19 pandemic.When considering short-term debt, despite a significant result, the coefficient was negative, indicating that the COVID-19 pandemic weakened the positive influence of short-term indebtedness on the insolvency risk, possibly because of the need to renegotiate short-term debts, mainly given companies' cash generation problems, as many had to pause their activities due to the social isolation imposed to contain the virus.

Specifically, the results of the robustness test indicate that Brazilian companies may be conservative in relation to debt during crisis periods, precisely to avoid an increase in the insolvency risk. Also, the use of long-term debt may

help the companies with their liquidity, weakening their insolvency risk, especially in the short term. In addition, the robustness test showed that the relationship between financial debt and insolvency risk was impacted, highlighting the importance of companies not exceeding the optimal level of financial debt, especially in crisis periods.

The results of this study have clear academic, managerial, social and political implications. Regarding academic implications, we extend the literature on the insolvency risk, identifying factors that may influence this risk. Unlike most studies, which are usually concerned with the development of predictive models, in this study, we focused on the effects of capital structure. The results led to the conclusion that *trade-off* theory can explain the influence of debt on the insolvency risk. Thus, through this study, we observed an optimal point that maximizes the effects of the tax benefit arising from onerous liabilities and minimizes the risk of the insolvency of nonfinancial Brazilian companies with shares traded on B3.

Regarding the managerial implications, in this study, verifying that capital structure is relevant to the insolvency risk of the analyzed companies was possible. Such knowledge provides decision makers with evidence of the existence of an optimal capital structure that minimizes bankruptcy risk. Thus, decision makers can adopt strategies that favor the financial health of companies and can opt for a capital structure that does not put the company at risk, ultimately favoring its financial health.

The social implications of this study refer to the benefits generated for society while a company remains in the market. Through greater knowledge of the factors that influence the insolvency risk, decision makers will have knowledge that can help them adopt more assertive strategies. Thus, all *stakeholders* linked to the organization benefit, such as investors, employees and suppliers, since the discontinuity of a company that goes bankrupt harms all agents involved, a fact that can trigger a systemic effect.

Finally, political implications are mentioned. As already mentioned, studies on insolvency risk have focused mainly on forecasting models; however, understanding the factors that influence this risk is also relevant. Thus, through this knowledge, more appropriate public policies can be formulated, especially those related to judicial and extrajudicial reorganization and bankruptcy, to make judicial and extrajudicial reorganization more efficient and effective and to enable companies to actually recover and become competitive in the market.

Despite the relevance of this study, some limitations are mentioned. First, data from publicly traded companies with shares traded on B3 were considered. Therefore, the sample did not include companies not listed on Be, which can be a limitation. For future studies, it is suggested that samples considering different companies be used, such as small and medium-sized companies. This analysis will help improve knowledge of the determinants of insolvency risk, allowing a more comprehensive view of the effects of capital structure on the insolvency risk of smaller companies; the analysis will also be relevant to analyzing the influence of the pandemic on these companies.

Another limitation of this study was that only Brazilian companies were considered. Given the institutional differences that can influence the capital structure and the insolvency risk, studies considering companies from other developing countries should be considered, such as companies from Latin American countries. Such analysis may increase the knowledge by showing whether the influence of capital structure in different institutional contexts presents results that corroborate or contradict those found in the present study. The effects of the pandemic on the relationship and insolvency risk of companies from different countries can also be analyzed.

Finally, this study did not consider issues related to legislation on judicial reorganization, extrajudicial reorganization and bankruptcy. For future studies, it is suggested that this aspect be considered because such analysis will make it possible to identify how the current legislation and the changes that have occurred over the years influence the relationship between capital structure and bankruptcy risk. Thus, a new perspective of the factors that determine the risk of bankruptcy can be analyzed, also expanding the knowledge on the subject.

REFERENCES

Albanez, T. (2012). *Efeitos do market timing sobre a estrutura de capital de companhias abertas brasileiras*. (Tese de Doutorado) Universidade de São Paulo, São Paulo, 251.

Ahmed, A. M., Nugraha, D. P., & Hágen, I. (2024). Assessing the Impact of COVID-19 on Capital Structure Dynamics: Evidence from GCC Economies. In *Economies* (Vol. 12, Issue 5). https://doi.org/10.3390/economies12050103

Alhajjeah, D., & Besim, M. (2024). Firms' Capital Structure during Crises: Evidence from the United Kingdom. In *Sustainability* (Vol. 16, Issue 13). https://doi.org/10.3390/su16135469

Ali, M., Alam, N., & Rizvi, S. A. R. (2020). Coronavirus (COVID-19)-an epidemic or pandemic for financial markets. *Journal of Behavioral and Experimental Finance*, *27*. https://doi.org/10.1016/j.jbef.2020.100341.Altman, E. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance*, *23*(4), 589–609.

Altman, E. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance*, *23*(4), 589–609.

Altman, E. I., Baidya, T. K. N., & Dias, L. M. R. (1979). Previsão de problemas financeiros em empresas. In *Revista de Administração de Empresas, 19*(1), 17-28. https://doi.org/10.1590/S0034-75901979000100002

Alves, P., & Francisco, P. (2015). The impact of institutional environment on the capital structure of firms during recent financial crises. *The Quarterly Review of Economics and Finance*, *57*, 129–146. https://doi.org/https://doi.org/10.1016/j.qref.2014.12.001

Arianpoor, A., & Naeimi Tajdar, S. S. (2024). The relationship between firm risk, capital structure, cost of equity capital, and social and environmental sustainability during the COVID-19 pandemic. *Journal of Facilities Management*, *22*(2), 234–255. https://doi.org/10.1108/JFM-11-2021-0148

Avelar, E. A., Ferreira, P. O., Silva, B. N. E. R., & Ferreira, C. O. (2021). Efeitos Da Pandemia De Covid-19 Sobre A Sustentabilidade Econômico-Financeira De Empresas Brasileiras. *Revista Gestão Organizacional*, *14*(1), 131–152. https://doi.org/https://doi.org/10.22277/rgo.v14i1.5724

Azhari, N. K. M., Mahmud, R., & Shaharuddin, S. N. H. (2022). Capital Structure Of Malaysian Companies: Are They Different During the COVID-19 Pandemic? *The Journal of Asian Finance, Economics and Business*, *9*(4), 239–250. https://doi.org/https://doi.org/10.13106/JAFEB.2022.VOL9.NO4.0239

Baker, M., & Wurgler, J. (2002). Market Timing and Capital Structure. *The Journal of Finance*, *57*(1), 1–32. https://doi.org/https://doi.org/10.1111/1540-6261.00414

Bastos, D. D., & Nakamura, W. T. (2009). Determinantes da estrutura de capital das companhias abertas no Brasil, México e Chile no período 2001-2006. *Revista Contabilidade & Finanças*, *20*(50), 75–94. https://doi.org/10.1590/s1519-70772009000200006

Bittencourt, W. R., & Albuquerque, P. H. M. (2018). Estrutura de capital: uma revisão bibliográfica das publicações dos periódicos nacionais. *Revista Contemporânea de Contabilidade*, *15*(34 SE-Artigos), 94–114. https://doi.org/10.5007/2175-8069.2018v15n34p94

Brito, G. A. S., Corrar, L. J., & Batistella, F. D. (2007). Fatores determinantes da estrutura de capital das maiores empresas que atuam no Brasil. *Revista Contabilidade & Finanças*, *18*(43), 9–19. https://doi.org/10.1590/s1519-70772007000100002

Bryan, D., Dinesh Fernando, G., & Tripathy, A. (2013). Bankruptcy risk, productivity and firm strategy. *Review of Accounting and Finance*, *12*(4), 309–326. https://doi.org/10.1108/RAF-06-2012-0052

Campos, A., & Nakamura, W. T. (2013). Folga Financeira Avaliada como Endividamento Relativo e Estrutura de Capital. *Revista de Finanças Aplicadas*, 1–19.

Carvalho, P. V, Curto, J. D., & Primor, R. (2022). Macroeconomic determinants of credit risk: Evidence from the Eurozone. *International Journal of Finance & Economics*, *27*(2), 2054–2072. https://doi.org/https://doi.org/10.1002/ijfe.2259

Cepal. (2021). *Anuario Estadístico de América Latina y el Caribe*.

https://statistics.cepal.org/yearbook/2021/statistics.html?lang=es&theme=economicas

Chaia, A. J. (2003). *Modelos de gestão do risco de crédito e sua aplicabilidade ao mercado brasileiro.* Universidade de São Paulo.

CNN. (2021). *Lucro das empresas de capital aberto cai 82% no segundo trimestre*. CNN Brasil. https://www.cnnbrasil.com.br/business/lucro-das-empresas-de-capital-aberto-cai-81-no-segundo-trimestre/

Costa, T. R., Prado, J. W., Guimarães, P. H. S., Andrade, L. P., & Ávila, E. S. (2023). Risco de Insolvência: Uma Análise Comparativa de Diferentes Técnicas de Previsão para o Período de Pandemia. *23º USP International Conference on Accounting*.

Cuervo-Cazurra, A. (2016). Multilatinas as sources of new research insights: The learning and escape drivers of international expansion. *Journal of Business Research*, *69*(6), 1963–1972. https://doi.org/https://doi.org/10.1016/j.jbusres.2015.10.142

DeAngelo, H., & Masulis, R. W. (1980). Optimal capital structure under corporate and personal taxation. *Journal of Financial Economics*, *8*(1), 3–29. https://doi.org/https://doi.org/10.1016/0304-405X(80)90019-7

Duran, M. M., & Stephen, S. A. (2020). Internationalization and the capital structure of firms in emerging markets: Evidence from Latin America before and after the financial crisis. *Research In International Business And Finance*, *54*. https://doi.org/10.1016/j.ribaf.2020.101288

Durand, D. (1952). Costs of Debt and Equity Funds for Business: Trends and Problems of Measurement. In *Conference on Research in Business Finance* (pp. 215–262). National Bureau of Economic Research, Inc. https://econpapers.repec.org/RePEc:nbr:nberch:4790

Durand, D. (1959). The Cost of Capital, Corporation Finance, and the Theory of Investment: Comment. *American Economic Review.*, *49*(4), 639–655.

Elizabetsky, R. (1976). *Um modelo matemático para decisão no banco comercial*. Universidade de São Paulo.

Fahlenbrach, R., Rageth, K., & Stulz, R. M. (2021). How Valuable Is Financial Flexibility when Revenue Stops? Evidence from the COVID-19 Crisis. *The Review of Financial Studies*, *34*(11), 5474–5521. https://doi.org/10.1093/rfs/hhaa134

Fávero, L. P. L., Belfiore, P. P., Silva, F. L. da, & Chan, B. L. P. P.-R. de J. (2009). *Análise de dados: modelagem multivariada para tomada de decisões*. Elsevier.

Fávero, L. P., & Belfiore, P. (2017). *Manual de análise de dados: estatística e modelagem multivariada com Excel, SPSS e Stata* (1st ed.). Elsevier.

Freire, M. D. de M., Machado, M. R. R., Machado, L. S., Souza, E. S., & de Oliveira, J. J. (2012). Aderência às normas internacionais de contabilidade pelas empresas brasileiras. *Revista de Contabilidade e Organizações*, *6*(15 SE-), 3–22. https://doi.org/10.11606/rco.v6i15.52654

Gao, C., & Tsusaka, T. W. (2023). Economic Uncertainty and Firms' Capital Structure: Evidence from China. *In Risks* (Vol. 11, Issue 4). https://doi.org/10.3390/risks11040066

Governo Do Brasil. (2020). *Brasil confirma primeiro caso do novo coronavírus*.. https://www.gov.br/pt-br/noticias/saude-e-vigilancia-sanitaria/2020/02/brasil-confirma-primeiro-caso-do-novo-coronavirus#:~:text=O Brasil confirmou%2C nesta quarta,para Itália%2C região da Lombardia.

Gujarati, D. N., & Porter, D. C. (2011). *Econometria Básica* (5th ed.). McGraw Hill Brasi.

Hackbarth, D., Miao, J., & Morellec, E. (2006). Capital structure, credit risk, and macroeconomic conditions. *Journal of Financial Economics*, *82*(3), 519–550. https://doi.org/https://doi.org/10.1016/j.jfineco.2005.10.003

Hair, J., Black, W., Babin, B., Anderson, R., & Tatham, R. (2006). *Análise Multivariada de Dados* (6ª edição). Bookman Companhia Editora.

Haron, R., Nomran, N. M., Abdullah Othman, A. H., Md Husin, M., & Sharofiddin, A. (2021). The influence of firm, industry and concentrated ownership on dynamic capital structure decision in emerging market. *Journal of Asia Business Studies*, *15*(5), 689–709. https://doi.org/10.1108/JABS-04-2019-0109

Horváthová, J., & Mokrišová, M. (2018). Risk of Bankruptcy, Its Determinants and Models. In *Risks* (Vol. 6, Issue 4). https://doi.org/10.3390/risks6040117

Hovakimian, A., Kayhan, A., & Titman, S. (2012). Are Corporate Default Probabilities Consistent with the Static Trade-off Theory? *The Review of Financial Studies*, *25*(2), 315–340. https://doi.org/10.1093/rfs/hhr101

Hsiao, C. (2007). Panel data analysis—advantages and challenges. *TEST*, *16*(1), 1–22. https://doi.org/10.1007/s11749-007-0046-x

Huang, H., & Ye, Y. (2021). Rethinking capital structure decision and corporate social responsibility in response to COVID-19. *Accounting & Finance*, *61*(3), 4757–4788. https://doi.org/https://doi.org/10.1111/acfi.12740

Lott, V. F. (2019). *Fatores Determinantes do Endividamento e Predição de Insolvência: Um Estudo Comparativo entre Brasil e Estados Unidos*. (Dissertação de mestrado), Universidade Federal de Minas Gerais, Belo Horizonte, 86.

Lott, V. F., Tenenwurcel, D. R., & Camargos, M. A. de. (2021). Determinants of indebtedness of Brazilian companies listed in B3 with and without insolvency risk. *Revista de Administração Da UFSM*, *14*(1 SE-Articles), 79–99. https://doi.org/10.5902/1983465933892

Machado, K. G., & Freitas, T. R. (2023). Impacto Da Alavancagem Financeira No Desempenho Das Empresas Brasileiras Durante A Pandemia Da Covid-19. *Revista Liceu On-Line*, *13*(1), 75–95. https://liceu.emnuvens.com.br/LICEU_ON-LINE/article/view/1918

Machado, M. A. V., Medeiros, O. R. de, & Eid Júnior, W. (2010). Problemas na mensuração da estrutura de capital: evidências empíricas no Brasil. *BBR - Brazilian Business Review*, *7*(1), 24–47. https://www.redalyc.org/articulo.oa?id=123016768002

Mateus, R. (2010). *Análise de insolvência empresarial: uma abordagem financeira fundamentalista com aplicação do método estatístico multivariado e da técnica discriminante*. Universidade Federal de Sergipe, São Cristóvão.

Matias, A. (1978). *Contribuição às técnicas de análise financeira: um modelo de concessão de crédito*. Universidade de São Paulo.

Miller, M. H. (1977). Debt and taxes. *The Journal of Finance*, *32*(2), 261–275. https://doi.org/https://doi.org/10.1111/j.1540-6261.1977.tb03267.x

Modigliani, F., & Miller, M. H. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. *The American Economic Review*, *48*(3), 261–297. http://www.jstor.org/stable/1809766

Modigliani, F., & Miller, M. H. (1963). Corporate Income Taxes and the Cost of Capital: A Correction. *The American Economic Review*, *53*(3), 433–443. http://www.jstor.org/stable/1809167

Myers, S. (1984). The capital structure puzzle. *Journal of Finance*, *39*(3), 575–592.

Myers, S. C. (2001). Capital structure. *The Journal of Economic Perspectives*, *15*(2), 81–102.

Nenu, E. A., Vintilă, G., & Gherghina, Ş. C. (2018). The Impact of Capital Structure on Risk and Firm Performance: Empirical Evidence for the Bucharest Stock Exchange Listed Companies. In *International Journal of Financial Studies* (Vol. 6, Issue 2). https://doi.org/10.3390/ijfs6020041

Ohlson, J. A. (1980). Financial Ratios And The Probabilistic Prediction Of Bankruptcy. *Journal Of Accounting Research*, 18(1), 109–131. Https://Doi.Org/10.2307/2490395

Oz, I. O., & Simga-Mugan, C. (2018). Bankruptcy prediction models'

generalizability: Evidence from emerging market economies. *Advances in Accounting*, *41*(September 2017), 114–125. https://doi.org/10.1016/j.adiac.2018.02.002

Pamplona, E., Ames, A. C., & Silva, T. P. da. (2020). Estrutura de capital e financial distress em empresas familiares e não familiares brasileiras. *Revista Contemporânea de Contabilidade*, *17*(44), 17–32. https://doi.org/10.5007/2175-8069.2020v17n44p17

Prado, J. W., Alcântara, V. C., Carvalho, F. M., Vieira, K. C., Machado, L. K. C., & Tonelli, D. F. (2016). Multivariate analysis of credit risk and bankruptcy research data: a bibliometric study involving different knowledge fields (1968–2014). *Scientometrics*, *106*(3), 1007–1029. https://doi.org/10.1007/s11192-015-1829-6

Prado, J. W. do. (2019). *Determinantes e implicações da estrutura de capital, da estrutura de propriedade e da governança corporativa: um modelo multiteórico de análise*. (Tese de Doutorado), Universidade Federal de Lavras, Lavras,194.

Prado, J. W., Vilamaior, A. G., Campos, A. C., & Nascimento, T. B. P. (2020). Previsão da Insolvência Eemresarial Utilizando Redes Neurais Artificiais. *Revista Gestão e Desenvolvimento*, 17(2 SE-Artigos Livres), 136–162. https://doi.org/10.25112/rgd.v17i2.1777

Ricca, L. T., Jucá, M. N., & Hadad Junior, E. (2021). Tax benefit and bankruptcy cost of debt. *The Quarterly Review of Economics and Finance*, *81*, 82–92. https://doi.org/https://doi.org/10.1016/j.qref.2021.05.003

Scott, J. H. (1976). A Theory of Optimal Capital Structure. *Bell Journal of Economics*, *7*(1), 33–54. https://econpapers.repec.org/RePEc:rje:bellje:v:7:y:1976:i:spring:p:33-54

Rosa, A. A. S., Forti, C. A. B., & Dias, V. F. M. B. (2022). Impact of internationalization on the working capital requirement of Brazilian companies. *RAM. Revista de Administração Mackenzie*, 23(4), eRAMF220017. https://doi.org/10.1590/1678-6971/eRAMF220017.en

Shaari, S. N. M., & Kamarudin, N. (2024). The Moderating Effect of the Pandemic on Capital Structure and Firm Performance in Malaysia. *Asia-Pacific Management Accounting Journal*, *19*(1), 25-49. https://www.doi.org/10.24191/APMAJ.V19i1-02

Tao, Q., Zahid, Z., Mughal, A., & Shahzad, F. (2020). Does operating leverage increase firm's profitability and bankruptcy risk? Evidence from China's entry into WTO. *International Journal of Finance and Economics*, *November*, 1–17. https://doi.org/10.1002/ijfe.2395

The World Bank. (2022). *O crescimento global deve desacelerar até 2023, aumentando o risco de um declínio rápido e indesejado nas economias em*

desenvolvimento. COMUNICADO À IMPRENSA Nº 2022/038/EFI.

Tinoco, M. H., & Wilson, N. (2013). Financial distress and bankruptcy prediction among listed companies using accounting, market and macroeconomic variables. *International Review of Financial Analysis*, *30*, 394–419. https://doi.org/10.1016/j.irfa.2013.02.013

Tsoy, L., & Heshmati, A. (2019). Impact of Financial Crises on the Dynamics of Capital Structure: Evidence from Korean Listed Companies. *The Singapore Economic Review*, *68*. https://doi.org/10.1142/S0217590819500498

Zeitun, R., Temimi, A., & Mimouni, K. (2017). Do financial crises alter the dynamics of corporate capital structure? Evidence from GCC countries. *The Quarterly Review of Economics and Finance*, *63*, 21–33. https://doi.org/https://doi.org/10.1016/j.qref.2016.05.004