Is default risk affected by the debt structure of Brazilian firms?

O risco de *default* é afetado pela estrutura da dívida das firmas brasileiras?

Abstract

This article sought to analyze the relationship between the debt structure and the default risk of Brazilian companies during the subprime crisis. By debt structure, we understand both the composition of the typologies that compose it and the maturity structure of the debts, as well as the seniority structure of receipt. To analyze how the debt structure – specialization, maturity and seniority - are associated with the default risk of Brazilian firms listed on B3 during the subprime crisis, we used a descriptive research based on quantitative methods. The verification of our hypotheses followed the application of the Differences-in-Differences (DiD) estimator. Subsequently, this analysis took into account the fact that the treated and control firms have different observable characteristics. Thus, to solve this problem, we applied the Kernel Propensity Score Matching (K-PSM). Our results reveal behaviors unidentified in previous research. First, we identified that Brazilian companies are decreasing their specialization over time and that this specialization helped Brazilian companies to mitigate their default risk during the subprime crisis. Furthermore, we identified that Brazilian companies significantly reduced their long-term debt maturing in one year during the subprime crisis, trying to reduce their rollover risk since this increased the propensity to default risk of Brazilian companies during the crisis. Finally, we identified that companies mostly use senior debt and balance their seniority structure in secured and unsecured debt. Still, in the historical series, the secured debt reached their maximum values in 2009 during the crisis. Based on this, we identified that companies that have higher levels of subordinated (non-senior) debt increased their default risk as well as companies that have higher levels of secured debt mitigated their default risk during the crisis.

Keywords: Default risk. Debt structure. Subprime Crisis.

Resumo

O presente artigo buscou analisar a relação entre a estrutura de dívida sobre o *risco de default* das empresas brasileiras durante a crise *subprime*. Como estrutura de dívida entendemos tanto a composição das tipologias que a compõem quanto a estrutura de maturidade das dívidas e também a estrutura de prioridade de recebimento. Para analisar se a estrutura da dívida – especialização, maturidade e senioridade – está associada ao risco de *default* das empresas brasileiras listadas na B3 durante a crise *subprime,* utilizamos uma pesquisa descritiva baseada em métodos quantitativos. A verificação de nossas hipóteses seguiu a aplicação do estimador Diferenças em Diferenças (DiD). Posteriormente, esta análise teve em conta o fcto de as empresas tratadas e de controle apresentarem características observáveis diferentes. Assim, para resolver este problema, aplicamos o Kernel *Propensity Score Matching* (K-PSM). Nossos resultados demonstraram até então não identificados am pesquisas anteriores. Primeiramente, identificamos que as empresas brasileiras estão diminuindo a sua especialização ao longo do tempo e que essa especialização ajudou as empresas brasileiras a mitigar o seu risco de *default* durante a crise *subprime*. Ainda, identificamos que as empresas brasileiras diminuíram significativamente a sua dívida de

longo prazo a vencer em um ano durante a crise *subprime* tentando diminuir o seu risco de rolagem dado que este aumentou a propensão ao risco de *default* das empresas brasileiras durante a crise. Por fim, identificamos que as empresas utilizam majoritariamente dívida sênior e equilibram a sua estrutura de prioridade em dívidas seguradas e não seguradas. Ainda, na série histórica, a dívida garantida atingiu seus valores máximos em 2009 durante a crise. Com base nisso, identificamos que empresas que possuem altos níveis de dívidas subordinadas (não seniores) aumentaram o seu risco de *default*, bem como as empresas que possuem maiores níveis de dívidas controladas mitigaram seu risco de *default* durante uma crise.

Palavras-Chave: Risco de *default*. Estrutura de dívida. Crise *Subprime.*

1. Introduction

Capital structure has been one of the main topics researched in corporate finance, either by seeking to understand the optimal choice of capital structure, or by understanding its determinants (Póvoa & Nakamura, 2014). Likewise, Colla et al., (2013) point out that much attention has been devoted to questions related to why companies choose to issue debt over equity and how the ideal capital structure is designed to minimize the cost of financing a company.

Thus, most of the existing studies on capital structure deal with the choice of the company with regard to equity or debt capital to finance its activities, but this decision also involves the option of the type of debt resource to be used, that is, its debt structure. In this sense, when analyzing only third-party resources, most studies on capital structure directed their attention to the construction of theoretical models, as well as to the treatment considering that this source of capital was uniform, that is, it was formed by a single source of funds (Rauh & Sufi, 2010; Póvoa & Nakamura, 2014).

In this sense, when treating indebtedness with debt structure as a uniform source of funds, characteristics such as the origin of funds, contractual covenants, debt maturity, receipt seniority, transaction costs, incentives for managers, information asymmetries, among others (Barclay & Smith, 1995), which are potentially relevant for understanding the way in which companies structure their debt, as traditional studies of capital structure that ignore debt heterogeneity lose substantial variation in the capital structure (Rauh & Sufi, 2010).

Together with the debt structure, we have recently observed some studies seeking to relate how this structure can impact the default risk of companies given that different types of debt, different maturities and also different seniorities for receiving creditors have different levels of risk (Wang et al., 2017; Ivashina et al., 2016; Gopalan et al., 2014; Dudley et al., 2018; Bougheas & Kirman, 2018). Furthermore, these different risks arising from the debt structure can be increased or mitigated in contexts of high financial stress, as observed in financial crisis, directly impacting the default risk of companies (Wang et al., 2017; Almeida et al., 2011).

Based on these motivations, this article sought to analyze the relationship between the debt structure and the default risk of Brazilian companies during the subprime crisis. By debt structure, we understand both the composition of the typologies that compose it and the maturity structure of the debts, as well as the seniority structure of the firm. As far as we have identified, this article has one of the most comprehensive databases for the Brazilian context. In temporal terms, we can analyze the debt structure with a coverage of 17 years, between

2004 and 2020, allowing us to identify the relationship between the debt structure over time as well as analyze its relationship with the risk of default in a specific window that was the subprime crisis (2004 to 2010).

Based on this, our data allowed us to explore the debt structure in a substantial way, making it possible for the debt composition to break it down into seven different types of debt: a) bank debt; b) senior bonds and notes; c) subordinated bonds and notes; d) promissory notes; e) capital leasing; f) revolving credit; and, g) Other sources. This segregation is available in the Capital IQ database and allowed identifying which Brazilian firms specialization or diversify their debt composition.

Our historical evolution to debt structure composition reveal that Brazilian firms have an average Herfindahl–Hirschman Index (HHI) of 0.55 (higher HHI values indicate a tendency for specialization) for the general sample. However, when analyzing the debt structure over the years, as well as the types of debt, we can identify trends and issues revealed recently by Granzotto et al. (2023) in the literature on Brazilian firms. First, firms had an average overall HHI of 0.63 in 2004 and, after 17 years, the HHI dropped to 0.52 (-21.21%), demonstrating an expressive decline in the specialization of debt sources. Regarding the impact of debt composition (in terms of specialization) on the risk of default (z-score), we can observe lower propensities to default (positive impact on the z-score) justified by the fact that companies that specialize their debt composition seek to reduce expected bankruptcy costs. Therefore, our results show for Brazil that a high degree of debt specialization helps to minimize expected default costs. In this sense, we do not reject our hypothesis H1.

Additionally, our data make it possible to analyze the debt structure in relation to its maturity in detail, as it is possible to specifically analyze the maturity of debts in the following types: a) short-term debt; b) long-term debt maturing in $t + 1$; c) long-term debt maturing in $t + 2$; d) long-term debt maturing in $t + 3$; e) long-term debt maturing in $t + 4$; f) long-term debt maturing in $t + 5$; g) long-term debt maturing after *5 years*. Again, this segregation allows advances in the analyzes given the possibility of estimating the maturity of the debts in a more reliable way, compared to previous studies, in which they only segregate between short and long term debt. Thus, for example, we can measure the rollover risk (long-term debt maturing in $t + 1$) in a less endogenous way, given that long-term debt maturing in the coming years (instead of short-term debt) were financed in previous years, having a low relationship with the characteristics of firms in the contemporary period (Almeida et al. 2012). This lower endogeneity makes it possible to capture the effect of rollover risk on default risk more reliably.

Our results of the historical evolution of the debt maturity structure reveal that Brazilian companies have a certain stationarity in their average debt maturity, but we also identified that long-term debt maturing in $t + 1$ represent, on average, 34% of total debt outstanding, being possible to observe variations throughout the series in question. In 2009, for example, this representativeness has its maximum value, i.e. 37% and in the following two years, they have significant drops culminating in 25% in 2010 (representing a drop of 32.43%) and 28% (representing a drop of 17.64%) in 2011. Based on these results, we can understand that companies sought to renegotiate the portion of their long-term debt falling due in 2010 and 2011 as this increased their rollover risk. A possible justification for this is the subprime crisis of 2007/2008, in which rollover risk suggests that companies with high amounts of long-term debt payable in one year are more likely to suffer a deterioration in their credit quality.

After these descriptive statistics, our differences-in-differences models confirm the above given that we identified a negative impact of rollover risk on the z-score of Brazilian companies. Thus, companies that had high rollover risk during the subprime crisis increased their probability of default compared to Brazilian companies that did not have the same levels of rollover risk. Therefore, we identified that rollover risk was an additional source of credit risk for Brazilian firms given the increase in their default risk. In this sense, we do not reject our hypothesis H2

Finally, the data also allowed us to analyze the debt structure in relation to its debt structure seniority, as it can be analyzed in the following types: a) senior sebt; b) subordinated debt; c) convertible; d) secured debt; and, e) unsecured debt. Our historical evolution results revealed that Brazilian companies that, between senior debt and subordinated debt, on average, companies almost entirely have the senior debt. Still in relation to debt structure seniority, among secured, unsecured and convertible debts, Brazilian companies access the two prime modalities very similarly, with a slight tendency towards unsecured debt. Thus, on average, debts that have some collateral for the debt contract reach 41% while debts without any collateral reach 59%.

Regarding the regression differences-in-differences, we identified that companies that had a representative part of their subordinated debt negatively impacted their z-score, making them more prone to default during the subprime crisis. Thus, therefore, we do not reject our hypothesis H3. In relation to secured debts, that is, debts that have a collateral guarantee, we identified that companies that have significant portions of their secured debt distance themselves from a probable default during crises. Thus, therefore, we do not reject our hypothesis H4. Finally, regarding unsecured debts, despite observing the expected relationship that was hypothesized in our review, that is, a negative relationship between unsecured debts and the z-score (greater propensity to default), we did not observe statistical significance for the cutoffs tested, which does not allow us to reject (or not) our hypothesis H5.

This study is divided into the following five sections. The first section is the present introduction, the second section is about our literature review and hypothesis construction, the third section is about our methodological procedures, the fourth section is about our results and the fifth and last section is about the our conclusions.

2. Debt structure and default risk

This section is subdivided as follows: a) Debt specialization and default risk; b) Debt maturity and default risk; and, c) Debt seniority and default risk.

2.1 Debt specialization and default risk

The relationship between debt structure and default risk is seminally explored by Bolton and Scharfstein (1996), in which they propose an optimal debt structure model in which expected default costs should be minimized. The authors argue that debt contracts have an explicit trade-off, in which the benefits permeate the reduction of the incentive for strategic default (i.e. the default of companies given in order for managers to want to divert money to themselves), giving creditors the right to liquidate the company's assets during the

liquidation process. On the other hand, this right that gives the creditor the option to liquidate the company can also result in inefficiency costs.

To better understand this trade-off, Bolton and Scharfestein (1996) analyzed the influence of the number of creditors, bond interest and voting rights on the optimal debt contract. More specifically, the first causes the debt structure to affect the manager's incentive to default strategies and the expected liquidation value of the company. Thus, if there are many creditors in the composition of the debt structure, managers will have incentives not to enter into a strategic default justified by the fact of reducing their payoffs, however, on the other hand, the presence of many creditors may lead to a reduction in the value of debt. ex ante liquidation, since many creditors will have to sell the company's assets, creating inefficiencies.

Given this context, the main finding of the article is that it is optimal for companies with poor credit quality to borrow from just one lender to maximize the liquidation value (lower negotiation costs). Otherwise, if the company has high credit quality, it is optimal to borrow from many creditors to make strategic default less attractive (Bolton & Scharfstein, 1996).

In this context, after finding that most US companies (85% of the sample) borrow predominantly with one type of debt, thus showing a notable specialization, Colla et al., (2013, 2020) offer three possible explanations for this behavior: a) reduction of expected default costs; b) savings in information collection and monitoring costs; and, c) restricted access to capital. The first refers to the fact that an optimal debt structure should minimize the expected default costs due to debt specialization. The author identifies that his evidence is consistent with this prediction, that is, a high degree of debt specialization helps to minimize expected default costs.

Other evidence converging with Bolton and Scharfstein (1996) is the study by Ivashina et al., (2016), in which they found evidence that companies with a higher concentration of debt at the beginning of the default are more likely to file bankruptcy plans in advance. combined, move quickly through the restructuring process and successfully emerge as independent companies.

Therefore, following the literature, it is hypothesized that companies with higher debt specialization should have lower default risk during the subprime crisis given the low expected default costs and the possibility while companies with lower debt specialization should have higher risk of default given that the debt structure is not specialist.

H1: The specialization of the debt structure reduced the default risk of Brazilian companies during the subprime crisis.

2.1 Debt maturity and default risk

According to Tirole (2006) the loan can be short- or long-term, in which bank loans of less than one year are short-term and those greater than one year are long-term. Thus, short-term or long-term debt payable within a year exposes borrowers to rollover risk and, therefore, can cause and amplify financial crises (Gopalan et al., 2014), as documented by Almeida et al., (2012), in which the subprime crisis spread to the long-term corporate debt market in autumn 2007, making it difficult for companies to roll over their long-term obligations.

According to Wang et al., (2017) rollover risk or refinancing risk arises when a company's debt is close to maturity, but the company wants to refinance it. The collapse of financial institutions such as Bear Stearngs and Lehman Brothers during the recent financial crisis has refocused the risks arising from short-term debt (Gopalan et al. 2014). It is recognized that the immediate cause of the default of the two institutions was the excessive dependence on short-term debt, which could not be rolled over due to the fall in the values of the guarantees (Brunnermeier, 2009).

Some seminal studies such as Diamond (1991) and Titman (1992) have shown that, in the presence of frictions in the credit market, firms may face difficulties in rolling over short-term debt maturities, especially if refinancing coincides with a deterioration in the company's fundamentals or in the credit market (subprime crisis in the context of this article). The justification for this effect, according to Gopalan et al., (2014), is that rollover risk can be an additional source of credit risk, as it increases the possibility of the company exacerbating the conflict of interests between shareholders and creditors (He & Xiong, 2012; Morris & Shin, 2009).

Empirical evidence on the effect of rollover risk on default risk is in its early stages (Wang et al., 2017). Thus, Gopalan et al., (2014) argue that rollover risk suggests that companies with high amounts of long-term debt payable in one year are more likely to suffer deterioration in credit quality. In this context, to the extent that long-term creditors recognize the rollover risk arising from the maturity of a company's debt, they demand a premium for lending with greater exposure to rollover risk.

In this sense, one of the most recent articles that investigated this research problem was Wang et al., (2017). The authors empirically examine rollover risk using a comprehensive dataset of industrial companies in the US market from 1986 to 2013. Thus, Wang et al., (2017) provide new evidence, exploring whether a company's financing structure drives that risk. The main result of the study is that the rollover risk significantly increases the default risk, mainly for companies dependent on banks, because such companies suffer from significant increases in default rates when the risk of rollover increases.

A key implication of these theoretical contributions is that the amount of firm debt maturing in the short term increases the firm's overall probability of default, in addition to the traditional default risk factors that cause the effect of rollover risk (Wang et al., 2017), the company's credit quality, the cost of long-term borrowing (Gopalan et al., 2014) as well as investment and valuation (Almeida et al., 2012). Therefore, the rollover risk exacerbated the default risk justified by the deterioration of liquidity in the debt markets, affecting the main channel used by companies that need to refinance their maturing debts (Wang et al., 2017).

The following hypothesis directly follows theoretical predictions that greater exposure to rollover risk makes a firm more likely to default on its debt obligations, especially in the context of a financial crisis:

H2: Brazilian companies with high rollover risk increased their default risk during the subprime crisis.

2.3 Debt Seniority and Default Risk

During the last decades, researchers in law, economics and finance have theorized about debt seniority in corporate finance (Adler & Triantis, 2017). Attention was directed

because seniority is one of the main characteristics of debt contracts and the capital structure of firms, given that the borrower structures seniority to mitigate agency problems, as well as its cost of capital (Adler & Triantis, 2017).

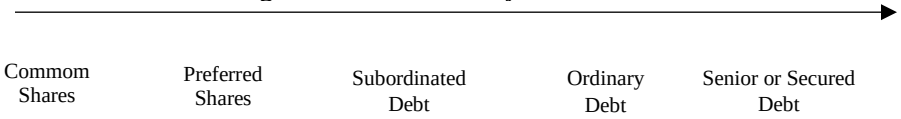
Several theories have emerged to explain the debt seniority structure, which can be summarized into two categories: a) the static theory that focuses on the allocation of debt seniority among creditors to exploit comparative advantages in filtering, monitoring and enforcing debts; and, b) dynamic theory, which focuses on the allocation of debt seniority among creditors over time to regulate their financial slack as well as their liquidity and influence investment policy (Adler & Triantis, 2017; Dudley & Yin , 2018).

Within the static theory, according to Rauh and Sufi (2010), it can be segregated into two groups: a.a) the first states that firms should finance themselves with non-bank debt, as their credit quality increases, that is, its reputation (Diamond 1991); and, a.b) the second seeks to explain why firms have multiple seniority classes, types and maturities of debt (Besanko & Kanatas, 1993; Diamond, 1993; Park 2000).

Thus, an important issue that the definition of any default procedure must resolve is the allocation of seniority rights among the various creditors of the correspondent entity. By definition, the value of a firm's assets in default is less than the value of its liabilities, and therefore a rule is needed to allocate these assets to different creditors. Seniority assignment often gives rise to a complex hierarchy among creditors, with secured and/or senior debt holders at the top and capital providers of capital (equity) (Tirole, 2006; Bougheas & Kirman, 2018).

The lower the creditor is in the debt seniority structure, the less likely it is to receive its compensation in case of default and, therefore, the stronger its incentives to ensure that the borrower does not take excessive risks (Adler & Triantis, 2017). In this context, the debt contract contains provisions that specify the seniority of credit in case of default (Tirole, 2006). In this context, Figure 1 illustrates a debt seniority structure.

Figure 1 - Debt Seniority Structure



Source: Tirole (2006)

The seniority of the secured or senior creditors means that it is repaid first in case of default (Tirole, 2006). Subordinated or junior debt generally specifies that, upon the occurrence of a stipulated event, such as default, its rights holders are paid only after senior debt holders are paid in full (Tirole, 2006).

For larger proportions of subordinated debt, it resembles equity, i.e., a severely undercapitalized (i.e., highly leveraged) company is unlikely to produce much profit for its shareholders, so subordinated debt holders are almost residual claimants, since that senior debt is repaid. Subordinated debt must, therefore, generate a higher yield than senior debt, to compensate for the higher default risk (Tirole, 2006). Therefore, a subordinated debt, whose payment will only take place if the debts with payment preference are settled, presents a greater risk than debts with the same payment seniority as the others and, therefore, must be

negotiated with a premium to compensate the investor. by the greater risk (Securato et al., 2004).

Securato et al, (2004) sought to estimate the premium charged by creditors as a result of the subordination of financial liabilities to seniority liabilities, imposed by the current Law 11,101 of February 9, 2005 (Bankruptcy Law in Brazil). The authors identified that, on average, the subordination premium is 0.30% per year, indicating that companies pay, on average, a premium of 0.30% per year when contracting loans and financing, due to the subordination of these liabilities to labor and social security issues, established by this law.

Other types of seniority involve types of secured and unsecured debt (Rauh & Sufi, 2010). According to Tirole (2006), creditors can grant loans 'against assets' or 'against cash flow'. According to the author, lending 'against cash flow' simply means that your loan is unsecured, so the expectation of getting the money back is purely based on the assessment that the borrower will be able to generate sufficient cash flow. 'Lending against assets' means that creditors are partially protected against non-repayment of interest or principal by pledging assets, i.e. creditors can repossess (seize) the specified assets in the event of default. Loans are then 'secured' (Tirole, 2006).

Therefore, secured debt gives creditors title to the pledged assets until the bonds are paid in full. In liquidation, secured creditors have seniority over the pledged assets, unlike creditors, who have no collateral. If the value of assets pledged as collateral is less than the amount owed, secured creditors have a claim on the company's other assets for the shortfall (Barclay & Smith, 1995). Therefore, the definition of the debt seniority structure can affect firms in different ways, among them, having an impact on the risk of default, given its differentiated seniority, as well as the costs and guarantees related to it.

Thus, the following hypotheses directly follow the theoretical predictions that a debt seniority concentrated on subordinated debt as well as on unsecured debt, because they have higher interest rates to compensate for the higher risk of default, makes the firm more prone to default on its debt obligations, especially in the context of a financial crisis:

H3: Brazilian companies that have more subordinated debt increased their default risk during the subprime crisis.

H4: Brazilian companies that have more secured debt have reduced default risk during the subprime crisis.

H5: Brazilian companies that have more unsecured debt increased their default risk during the subprime crisis.

3. Methodological Aspects

Basic data relating to balance sheet, income statement and debt structure were taken from Capital IQ in which breaks down the debt structure into three possible layers: (i) debt structure composition, (ii) debt structure maturity, and, (iii) debt structure seniority. The composition of debt structure is broken down into seven mutually exclusive types, as follows: (i) commercial papers; (ii) revolving credit lines; (iii) bank debt; (iv) senior bonds and notes; (v) subordinated bonds and notes; (vi) capital leases; and, (vii) others. This segregation is available in the Capital IQ database and allows identifying which Brazilian firms specialize or diversify their debt composition.

Analogously, the data make it possible to analyze the debt structure in relation to its maturity in the following types: (i) short-term debt; (ii) long-term debt maturing in *t + 1*; (iii) long-term debt maturing in *t + 2;* (iv) long-term debt maturing in *t + 3*; (v) long-term debt maturing in *t + 4*; (vi) long-term debt maturing in *t + 5*; (vii) long-term debt maturing after *5 years.*

As mentioned, this segregation allows advances in the analyzes given the possibility of estimating the maturity of debts more reliably, compared to previous studies in which they only segregate between short and long term debt. Thus, for example, one can measure the rollover risk in a less endogenous way, given that long-term debt maturing in the coming years (instead of short-term debt) was financed in previous years, having a low relationship with the characteristics of the firms. in the contemporary period. Finally, the data also make it possible to analyze the debt structure in relation to its receipt seniority in the following types: (i) Senior Debt; (ii) Subordinated Debt; (iii) Convertible Debt; (iv) Secured Debt; (v) Unsecured Debt;

The sample considered firms that have shares traded on B3, covering the period available from 2004 to 2020 (17 years). After applying some filters used by Almeida et al. (2012) (withdrawal from the financial sector, utilities sector and public sector companies), traditional filters (firms with negative equity, negative sales and negative total assets) as well as the maintenance of only leveraged firms, that is, which would have a higher probability of default. The final sample consisted of 373 companies.

To analyze whether the debt structure – specialization, maturity and seniority - are associated with the default risk of Brazilian firms listed on B3 during the subprime crisis, we used a descriptive research based on quantitative methods. To test this relationship, companies were identified based on their debt specialization (composition), on their debt rollover risk (maturity) and on their debt seniority. Initially, to achieve the proposed objective, we built groups that reflect the debt structure such as: (i) firms with high debt specialization (DS); (ii) firms with high rollover risk (RR); (iii) firms with high seniority (high secured debt - SED) and firms with low seniority (high subordinated debt – SUD - or high unsecured debt - UND). Thus, when comparing the default risk between the groups mentioned, it is possible to test the impact of debt specialization (H1), the rollover risk effect (H2) and the seniority effect (H3, H4 e H5) during the subprime crisis.

The use of the Z-score as an indicator of default risk allows analyzing changes in the time series over the period before and during the crisis, that is, varying during the credit cycle, and therefore making this measure more appropriate and more comprehensive than others used in the literature, such as ratings, which are a relative and discrete measure of the probability of default. Second, Altman et al., (2017) the model is applicable internationally to both publicly and privately held businesses and to all types of non-financial businesses as well as manufacturing and non-manufacturing industries

Afterwards, the calculation of $Z - Score_{i,t}$ is shown in Equation 1.

$$Z - Score_{i,t} = 1,2 * \left(\frac{CA - CL}{TA}\right)_{i,t} + 1 * \left(\frac{RE}{TA}\right)_{i,t} + 2,2 \left(\frac{EBIT}{TA}\right)_{i,t} + 0,6 \left(\frac{MV}{TL}\right)_{i,t} + 1 * \left(\frac{Net\ Sales}{TA}\right)_{i,t} \quad (1)$$

Where, CA is current assets, CL is the current liabilities, TA is the total assets, LR it the retained earning, EBIT is the earning befores interest and taxes, MV is the Market value, TL is the total liabilities. As for the dependent variable, the Z-score creates three distinct result ranges. According to Altman (1968), if the final result is in the following ranges, it indicates, therefore, the following situation of the company: if the Z-score > 2.99, the company is in a safe zone with low risk of default ; on the other hand, if the company has 2.99 > Z > 1.81, the company is in a gray area where it is not possible to say what its real situation is, but it is more sensitive to bankruptcy; and, finally, if the Z-score < 1.81 the company is in a danger zone and with a high risk of default.

After these definitions, the verification of the hypotheses (H1, H2, H3, H4 and H5) followed by the application of the Differences-in-Differences (DiD) estimator. This estimator allows us to capture whether, in fact, debt structure companies suffered a greater impact on default risk than other similar companies without the same level of debt composition, or rollover risk or seniority during the subprime crisis. Subsequently, this analysis took into account the fact that the treated and control firms have different observable characteristics. Thus, to solve this problem, we applied the Kernel Propensity Score Matching (K-PSM), as suggested by Leuven and Sianesi (2014), in which, through a set of covariates, we identified companies from the control group that are similar to the treatment group, except for the variable that distinguishes both groups (debt structure).

Therefore, the DiD with K-PSM was estimated by creating two main variables in the model. The first, called 'crisis', refers to the global financial crisis, which represents a quasi-natural experiment to identify the exogenous effect of a banking supply shock (Fernandéz et al., 2018). Based on this shock, the time period considered was from 2004 to 2010, with 2004 to 2006 being the 'pre-crisis' period, in which the value '0' is assigned; and from 2007 to 2010 the period during the crisis, in which the value '1' is assigned.

The other variable created, called 'treatment' refers to the treatment and control groups, which was assigned, for Hypothesis H1, the value '1' for Brazilian firms that presented high debt specialization (DS) and '0' for companies that did not have high debt specialization. On the same way, for Hypothesis H2, the value '1' for Brazilian firms that presented high rollover risk (RR) and '0' for companies that did not have high rollover risk. Still, for Hypothesis H4 (H3 and H5), the value '1' for Brazilian firms that presented high (low) seniority debt (SD) and '0' for companies that did not have high (low) seniority debt (SD). In addition, total assets, net sales and sector were considered as covariates of the model. The interaction of these two variables, 'crisis' and 'treatment', generate the variable DiD, shown in Equation (2).

$$y_{i,t} = \delta_0 + \delta_1 crisis_t + \delta_2 treatment_i + \delta_3 (crisis_t x treatment_i) + \varepsilon_{i,t} \quad (2)$$

Where i represents the firm; t the time; $y_{i,t}$ the dependent variable, δ_1 captures aggregate factors that could cause changes in y over time, even in the absence of the subprime crisis; δ_2 captures possible differences between treatment and control groups before the crisis (shock); δ_3 captures the coefficient of interest and $\varepsilon_{i,t}$ is the error term. The δ_3 coefficient was calculated by the difference between the treatment group before and after the shock minus the difference between the control group before and after the shock, as shown in Equation (3).

$$\hat{\delta}_3 = (\hat{y}_{treatment,crisis=1} - \hat{y}_{treatment,crisis=0}) - (\hat{y}_{control,crisis=0} - \hat{y}_{control,crisis=0}) \quad (3)$$

With regard to H1, DiD sought to compare the default risk of firms that had a high debt specialization (DS) (treatment group) with firms that did not have high debt specialization (control group). This analysis allowed us to verify whether the debt specialization decrease the default risk in the subprime crisis. Then, through these groups, it is possible verify whether firms with high debt specialization mitigated the default risk during the subprime crisis.

To achieve debt specialization, first, we measured the degree of debt specialization among companies considering the aforementioned debts. For this purpose, the methodology of Colla et al. (2013, 2020) were applied, based on the Herfindahl–Hirschman Index (HHI), which is normalized by the type of debt. Thus, the calculation basically follows two steps.

$$SSI_{i,t} = \frac{CP_{i,t}}{TD_{i,t}} + \frac{RC_{i,t}}{TD_{i,t}} + \frac{SEBN_{i,t}}{TD_{i,t}} + \frac{SUBN_{i,t}}{TD_{i,t}} + \frac{BD_{i,t}}{TD_{i,t}} + \frac{CL_{i,t}}{TD_{i,t}} + \frac{Others_{i,t}}{TD_{i,t}} \quad (4)$$

Where $SSI_{i,t}$is the sum of the squared debt type indices for firm i in year t; $CP_{i,t}$, $RC_{i,t}$, $SEBN_{i,t}$, $SUBN_{i,t}$, $BD_{i,t}$, $CL_{i,t}$ e $Others_{i,t}$,refer to commercial paper, revolving credit, senior bonds and notes, subordinated bonds and notes, bank debt, capital leasing and others debts, respectively; and, finally, $TD_{i,t}$ refers to the total debt. Afterwards, the calculation of $IHH_{i,t}$ is shown in Equation 5.

$$HHI_{i,t} = \frac{SSI_{i,t} - \frac{1}{7}}{1 - \frac{1}{7}} \quad (5)$$

If a Brazilian firm exclusively employs a single type of debt, the HHI is equal to one, while if a company simultaneously employs all the seven types of debt in equal proportion, the HHI is equal to zero (Colla et al., 2013, 2020). Consequently, higher HHI values indicate a tendency for firms to specialize in fewer types of debt (Colla et al., 2013, 2020).

Then, to measure debt specialization we used the HHI. Addicionally, to measure high debt specialization we are based on the *cutoff* of Póvoa and Nakamura (2014) which created a dummy variable which takes value 1 if a firm has a HHI more 0.7 (specialist) and 0 if a firm has a HHI less than 0.4 (diversified). Then, the treated firms are firms that have one HHI greater than or equal 0.7 (HHI>=0.7) and the control firms are firms that have one HHI less than or equal to 0.4 (HHI<=0.4).

With regard to H2, DiD sought to compare the default risk of firms that had a high rollover risk (RR) (treatment group) with firms that did not have high rollover risk (control group). This analysis allowed us to verify whether the rollover risk effect increase the default risk in the subprime crisis. Then, through these groups, it is possible to verify whether firms with high rollover risk increased the default risk during the subprime crisis.

To achieve rollover risk effect, Capital IQ provides information on the amount of debt in 6 maturity categories: debt due in less than 1 year (dlc), which is the sum of long-term debt due in 1 year (dd1) and other short-term debt; debt due in years two to five years (dd2, dd3, dd4, and dd5); and debt due in more than 5 years, computed as long-term debt due in more than 1 year (dltt) minus the sum of long-term debt due in years two to five (dd2 + dd3 + dd4 + dd5). In the same way as Wang et al. (2017) and Almeida et al. (2012) our measure

of rollover risk is the ratio between the total long-term debt due within one year (dd1) and the total long-term debt (dd1/dltt), where dd1 and dltt are based on the fiscal year t - 1 balance sheet information.

Table 1 – Definition of the variables

Dependent Variable - Default Risk

Variables	Formula	Description
Z-Score	$Z - Score = 1{,}2 * \left(\frac{CA - CL}{TA}\right) + 1 * \left(\frac{RE}{AT}\right) + 2{,}2 \left(\frac{EBIT}{TA}\right) + 0{,}6\left(\frac{MV}{PL}\right) + 1 * \left(\frac{Net\ Sales}{TA}\right)$	A firm with a lower z-score has more probability to default Z > 2,99 = a empresa encontra-se em uma zona segura; 2,99 > Z > 1,81 = a empresa encontra-se em uma zona cinzenta; 1,81 < Z = a empresa encontra-se numa zona de perigo e com risco de falência;

Debt Structure variables – specialization, maturity and seniority

Variables	Formula	Description	Signal
Debt Specialization Herfindahl–Hirschman Index (HHI)	$HHI_{i,t} = \frac{SSI_{i,t} - \frac{1}{7}}{1 - \frac{1}{7}}$	HHI is equal to zero, if a company simultaneously employs all seven types of debt in equal proportion, otherwise, if a company employ just one type of debt the HHI is equal to one.	+
Debt Maturity - Rollover Risk Effect (RR)	$RR_{i,t} = \frac{dd1_{i,t}}{dltt_{i,t}}$	dd1 is the sum of long-term debt due in 1 year and debt due in more than 5 years, computed as long-term debt due in more than 1 year (dltt) minus the sum of long-term debt due in years two to five (dd2 + dd3 + dd4 + dd5).	-
Debt Maturity	$DM_{i,t} = (rdd1_{i,t} * 0{,}5) + (rdd2_{i,t} * 1{,}5) + (rdd3_{i,t} * 2{,}5) + (rdd4_{i,t} * 3{,}5) + (rdd5_{i,t} * 5{,}5)$	Weighted global maturity rdd1 is the ratio between the dd1 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd2 is the ratio between the dd2 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd3 is the ratio between the dd3 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd4 is the ratio between the dd4 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd5 is the ratio between the dd5 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5);	+
Seniority Risk Effect (SR)	$SUD_{i,t} = \frac{Sub_{i,t}}{(Sub + Sen)_{i,t}}$	Sud is the subordinated debt that is the ratio between the subordinated debt to the sum of subordinated debt and senior debt	-
	or		
	$SED_{i,t} = \frac{Sec_{i,t}}{(Sec + Uns + Conv)_{i,t}}$	Sed is the secured debt that is the ratio between the secured debt to the sum of secured debt, unsecured debt and convertible debt	+
	or		
	$UND_{i,t} = \frac{Uns_{i,t}}{(Sec + Uns + Conv)_{i,t}}$	Und is the unsecured debt that is the ratio between the unsecured debt to the sum of secured debt, unsecured debt and convertible debt	-

Covariates

Profitability	Net Sales	Almeida et al. (2012)	Net Sales
Size	Ln(Total Assets)	Matenda et al., (2021)	Natural Logarithm of Total Assets

Sector Fixed Effects (SFE)	Categorical variable	Tristão & Sonza (2021)	Variable encoding in numerical order

Source: Elaborated by the authors (2023).

Then, to measure rollover risk effect we used the amount of a firm's long-term debt outstanding at the end of year t − 1 due for repayment in year t (i.e., dd1 in year t − 1), scaled total debt. This measure illustrates the mechanism through which greater the rollover risk greater will be the default risk. Additionally, to measure high rollover risk effect we are based on the cutoff of Almeida et al (2012) which created a dummy variable which takes value '1' if a firm needs to refinance more than 20% of its long term debt during the crisis and '0' othewise. Then, the treated firms are firms that have more than 20% long-term debt maturing in subprime crisis (dd1>20%) and the non-treated firms are firms that have less than or equal to 20% (dd1<=20%) long-term debt maturing in subprime crisis.

As we will observe in the discussion of our results, the average long-term debt of Brazilian companies in 2008 was around 35%, so we used two other cutoffs in addition to the 20% suggested above, that is, we tested our hypothesis by generating the treatment groups in which the firms owned more than 30% or more than 40% of their long-term debt maturing in subprime crisis (dd1>30% or dd1>40%) and the control group firms are firms that have less than or equal to 30% or 40% (dd1<=20% or dd1<=40%) long-term debt maturing in subprime crisis. These alternative cutoffs are necessary to contemplate the Brazilian context of debt maturity.

In the case of seniority debt structure, to achieve seniority risk effect, Capital IQ provides information on the amount of debt in two categories: the first one provides senior debt and subordinated debt and the second one provides secured debt, unsecured debt and convertible debt. Then, to the first category, we measure seniority risk using the amount of a firm's subordinated debt scaled to the sum of senior debt and subordinated debt. Then, to test H3, DiD sought to compare the impact on default risk of firms with low seniority debt (high suborinated debt - SUD) (treatment group) with firms with low seniority effect (low subordinated debt - SUD) (control group). Through these groups, it is possible to verify whether the debt structure affects the default risk during the subprime crisis.

This measure illustrates the mechanism through which greater the subordinated debt of the company greater will be the default risk. How we didn't find a reference of cutoff to seniority risk, on the same way of rollover risk, to measure high seniority risk we are based on the cutoff of 20% of its subordinated debt. Then, the treated firms are firms that have more than 20% of their debt in subordinated debt (SUD>20%) and the control group firms are firms that have less than or equal to 20% (SUD<=20%) of their debt in subordinated debt. We also used two robustness cutoffs of 30% and 40% to subordinated debt.

On the way of second category, to measure seniority risk we used the amount of a firm's secured debt scaled to the sum of secured, unsecured and convertible debt. This measure illustrates the mechanism through which greater the secured debt of the lower company will be the default risk. How we didn't find a reference of cutoff to seniority risk, on the same way of rollover risk, to measure high seniority risk we are based on the cutoff of 20% of its secured debt. Then, the treated firms are firms that have more than 20% of their debt in secured debt (SED>20%) and the control group firms are firms that have less than or equal to 20% (SED<=20%) of their debt in subordinated debt. We also used two robustness cutoffs of 30% and 40% to secure debt.

Still, we used the amount of a firm's unsecured debt scaled to the sum of secured, unsecured and convertible debt. This measure illustrates the mechanism through which greater the unsecured debt of the greater will be the default risk. How we didn't find a reference of cutoff to seniority risk, on the same way of rollover risk, to measure high seniority risk we are based on the cutoff of 20% of its unsecured debt. Then, the treated firms are firms that have more than 20% of their debt in secured debt (UND>20%) and the control group firms are firms that have less than or equal to 20% (UND<=20%) of their debt in subordinated debt. We also used two robustness cutoffs of 30% and 40% to secure debt.

4. Results

The following section is divided into two parts, as follows: (i) Descriptive statistics and historical evolution of the debt structure of Brazilian companies; and, (ii) Influence of the debt structure on default risk.

4.1 Descriptive statistics and historical evolution of the debt structure of Brazilian companies

Before starting the analysis, descriptive statistics were estimated in order to demonstrate the consistency of the data and also to present some important measures for the study. In Table 1, we can observe the descriptive statistics of the three debt structure layers of Brazilian companies, that is, debt specialization (composition), debt maturity and debt seniority, both in general terms and over the series 17 year history (2004 to 2020).

As shown in Table 1, for the debt structure composition, Brazilian firms have an average HHI of 0.55 (higher HHI values indicate a tendency for specialization) for the general sample. Specifically, this debt structure is mainly driven by the high representation of bank debt (45%), senior bonds and notes (27%) and also by revolving credit (16%) on total debt. These three types of debt are responsible for the formation of at least 88% of all externally raised financing.

However, when analyzing the debt structure over the years, as well as the types of debt, we can identify trends and issues revealed recently by Granzotto et al. (2023) in the literature on Brazilian firms. First, firms had an average overall HHI of 0.63 in 2004 and, after 17 years, the HHI dropped to 0.52 (-21.21%), demonstrating an expressive decline in the specialization of debt sources. The authors explain that this trend can be justified by a mechanism to reduce financial constraints (cost of debt) as the reduction of dependence on a single creditor.

Basically, two reasons can explain this trend. In 2004, the Brazilian firms had a share of their bank debt in 66% of the total and in 2020 this share dropped to 35% (a drop of approximately 50%). Together with this fact, we can observe that Brazilian companies began to structure their debts much more by senior bonds and notes, and in 2004 this debt represented only 15% and in 2020 it represented 31% (an increase of more than 100%).

Another factor that draws attention is the significant increase in capital leasing debt in 2019 and the justification for this increase is in CPC 06 (R2) that required firms to recognize in balance Sheet the leasing contracts (Granzotto et al. 2023). Thus, part of the variation in capital leasing in 2019 is a purely accounting and bureaucratic issue, not related to the greater use of this instrument (Granzotto et al. 2023).

In relation to the debt maturity of companies, as shown in Table 1, Brazilian companies have an average maturity of their debts of 1.55 years. This variable reveals that

the average maturity of Brazilian companies is stable over time, given that in 2004 the average maturity of companies was also 1.55 years. Thus, throughout the series we observe small variations in the average maturity of Brazilian companies.

In addition, a look at the maturity structure reveals some significant variations. The first of these is found in long-term debt maturing in one year (dd1), which represents a significant part of the debts due by Brazilian companies. In general, long-term debts maturing in one year represent 34% of total debts maturing, with variations being possible over the series in question. In 2009, for example, this representativeness has its maximum value, i.e. 37% and in the following two years, they have significant drops culminating in 25% in 2010 (representing a drop of 32.43%) and 28% (representing a drop of 17.64%) in 2011.

Based on these results, we can understand that companies sought to renegotiate the portion of their long-term debt falling due in 2010 and 2011 as this increased their risk of debt rollover. A possible justification for this is the subprime crisis of 2007/2008, in which rollover risk suggests that companies with high amounts of long-term debt payable in one year are more likely to suffer a deterioration in their credit quality. In this context, to the extent that long-term creditors recognize the rollover risk arising from the maturity of a company's debt, they demand a premium for lending with a greater exposure to rollover risk (Wang et al., 2017, Gopalan et al. al., 2014). We cannot categorically conclude that the subprime crisis is the factor causing this drop because it is a univariate analysis.

Together, we can also observe that, hierarchically, the long-term debts of Brazilian companies are concentrated in long-term debts that mature in two years, as these debts represent, on average, 20% of all long-term debts outstanding. After two years, the portion of debt maturing gradually decreases, culminating in 14% for long-term debts maturing in three years, 10% for long-term debts maturing in four years, 7% for long-term debts term debt maturing in five years and, finally, 15% for long-term debt maturing after the fifth year.

From now on, regarding debt seniority, we can see in Table 1 that between senior debt and subordinated debt, companies almost entirely have the senior modality. As highlighted in the literature review, senior creditor seniority means that the senior creditor is repaid first in the event of default (Tirole, 2006). Subordinated or junior debt generally specifies that, upon the occurrence of a stipulated event, such as default, its rights holders are paid only after senior debt holders are paid in full (Tirole, 2006).

Still in relation to debt structure seniority, we have that between secured, unsecured and convertible debt, Brazilian companies access the first two modalities in a very similar way, with a slight tendency towards unsecured debt. Thus, on average, debts that have some collateral for the debt contract reach 41% while debts without any collateral reach 59%. Again, as highlighted in our review, lenders can lend 'on assets' or 'on cash flow'.

Table 1 - Descriptive Statistics

Debt Structure – Composition																		
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Geral**
HHI	0.63	0.63	0.57	0.57	0.51	0.54	0.55	0.55	0.54	0.54	0.53	0.55	0.56	0.55	0.56	0.54	0.52	**0.55**
CP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
RC	0.04	0.04	0.12	0.11	0.17	0.17	0.19	0.17	0.15	0.18	0.18	0.18	0.20	0.20	0.18	0.13	0.15	**0.16**
DB	0.66	0.66	0.49	0.51	0.49	0.49	0.48	0.49	0.47	0.43	0.44	0.44	0.46	0.40	0.42	0.34	0.35	**0.45**
SEBN	0.15	0.15	0.23	0.20	0.20	0.20	0.21	0.24	0.27	0.29	0.29	0.27	0.27	0.32	0.32	0.33	0.31	**0.27**
SUBN	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	**0.01**
CL	0.03	0.03	0.01	0.03	0.03	0.05	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.17	0.15	**0.05**
Others	0.12	0.12	0.14	0.15	0.11	0.09	0.07	0.07	0.08	0.05	0.05	0.06	0.04	0.04	0.03	0.03	0.03	**0.07**
Debt Structure – Maturity																		
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Geral**
DM	1.55	1.48	1.52	1.73	1.61	1.58	1.92	1.75	1.54	1.64	1.59	1.50	1.46	1.47	1.52	1.56	1.54	**1.55**
rdd1	0.34	0.33	0.27	0.31	0.35	0.37	0.25	0.28	0.33	0.29	0.34	0.38	0.39	0.38	0.37	0.30	0.30	**0.34**
rdd2	0.20	0.15	0.19	0.17	0.19	0.18	0.22	0.23	0.19	0.23	0.21	0.19	0.23	0.19	0.20	0.17	0.20	**0.20**
rdd3	0.14	0.16	0.15	0.15	0.15	0.18	0.22	0.16	0.14	0.16	0.15	0.16	0.13	0.14	0.14	0.14	0.13	**0.14**
rdd4	0.10	0.11	0.10	0.12	0.11	0.09	0.12	0.11	0.10	0.10	0.10	0.09	0.08	0.08	0.09	0.10	0.10	**0.10**
rdd5	0.07	0.05	0.07	0.10	0.07	0.06	0.09	0.09	0.07	0.07	0.07	0.06	0.06	0.06	0.07	0.08	0.08	**0.07**
rdd+5	0.15	0.19	0.22	0.15	0.13	0.11	0.09	0.14	0.17	0.15	0.14	0.12	0.11	0.14	0.14	0.20	0.20	**0.15**
Debt Structure – Seniority																		
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Geral**
SND	0.98	0.99	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.98	0.99	0.99	0.99	**0.98**
SUD	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	**0.01**
COND	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
SED	0.41	0.26	0.31	0.45	0.56	0.52	0.54	0.49	0.42	0.42	0.41	0.40	0.39	0.36	0.34	0.40	0.38	**0.41**
UND	0.59	0.74	0.69	0.55	0.44	0.48	0.46	0.51	0.58	0.58	0.59	0.60	0.61	0.64	0.66	0.60	0.62	**0.59**

Note: HHI is the Herfindahl–Hirschman Index; CP is the ratio between commercial paper to total debt; RC is the ratio between revolving credit an total debt; BD is the ratio between bank debtand total debt; SEBN is the ratio between senior bonds and notes and total debt; SUBN is the ratio between subordinated bonds and notes and total debt; CL is the ratio between capital leasing an total debt; total debt is the sum of CP,RC, SEBN, SUBN, CL and othets. DM is the debt maturity; rdd1 is the ratio between the dd1 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd2 is the ratio between the dd2 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd3 is the ratio between the dd3 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd4 is the ratio between the dd4 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); rdd5 is the ratio between the dd5 and the sum of long term debt (dd1+dd2 + dd3 + dd4 + dd5); SND is the ratio between senior debt and the sum of senior and subordinated debt, SUD is the ratio between subordinated debt and the sum of senior and subordinated debt; COND is the ratio between convertible debt and the sum of convertible, secured and unsecured debt; SED is the ratio between secured debt and the sum of convertible, secured and unsecured debt; UND is the ratio between unsecured debt and the sum of convertible, secured and unsecured debt;
Source: elaborated by the authors (2023)

According to Tirole (2006), lending 'against cash flow' simply means that your loan is unsecured, so the expectation of recovering money is purely based on the assessment that the borrower will be able to generate sufficient cash flow. ‘Lending against assets' means that creditors are partially protected against non-repayment of interest or principal by pledging assets, i.e. creditors can repossess (seize) the specified assets in the event of default. Loans are then 'secured' (Tirole, 2006). Therefore, secured debt gives creditors title to the pledged assets until the bonds are paid in full. In liquidation, secured creditors have seniority over the pledged assets, unlike creditors, who have no collateral

In the historical series, a point worth mentioning is the proportion of secured debt (with guarantee) and unsecured debt (without guarantee) in the period from 2008 to 2010 in which the values of the first reached their maximum values in this 17-year historical series. Thus, in 2008 the secured debt reached 56%, in 2009 it reached 52% and in 2010 it reached 54%, thus being the only years that this debt exceeded the 50% barrier. We believe that this behavior was due to creditors' demands given the subprime financial crisis.

From now, in Table 2, we seek to show the descriptive statistics of default risk for the groups highlighted in our methodological procedures both for the pre-crisis (2004-2006) and for the crisis (2007-2010). Initially, we can observe that companies that tend to specialize their debts (DS – HHI > =0.7) practically did not change their default risk between periods, and between 2004 and 2006 their average default risk was 2.33 and during the subprime crisis this risk was 2.3. Thus, according to Altman's (1968) definitions, companies were in a gray zone of default risk.

Regarding the rollover risk, we can observe that the companies that have a higher rollover risk (i.e. RR > = 20%, 30% or 40%) increased their default risk (decreased their z-score) leaving the proximity of the zone safe for gray zone. For example, we can observe that companies that had a rollover risk greater than 20% had, on average, a default risk of 2.9 and during the crisis this risk peaked at 2.56, that is, an increase of 12% in default risk (=2.56/2.9 -1) approximately. Finally, we can observe how the risk of default has changed according to the debts that represent the seniority of receiving creditors. Regarding subordinated debts, we can identify that Brazilian companies that had high representation (i.e. SUD > = 20%, 30% or 40%) were in the danger zone with imminent risk of bankruptcy both before the subprime crisis and during it.

Regarding secured debt (with guarantee), we observed that Brazilian companies that had their receiving seniority secured with amounts above the defined levels (i.e. SED > = 20%, 30% or 40%) reduced their risk of default during the crisis, the guarantee therefore mitigating the risk of default. For example, Brazilian companies that had more than 40% of their debts secured had a z-score of 2.56 before the crisis and during the crisis we observed that their z-score was increased to 2.93, so companies Brazilian companies significantly approached the safe zone (Z >= 2.99). Therefore, companies managed to mitigate around 13% of their default risk (= 2.99/2.56 -1).

Finally, regarding unsecured debts, we observed results opposite to those of secured debts. Thus, we observed that Brazilian companies that had unsecured seniority receipts with amounts above defined levels (i.e. SUD > = 20%, 30% or 40%) increased their risk of default during the crisis. For example, Brazilian companies that had more than 40% of their debts unsecured had a z-score of 2.06 before the crisis and during the crisis we observed that their z-score dropped to 1.93, thus, Brazilian companies significantly approached the danger zone (Z <= 1.88). Therefore, companies increased their default risk by around 6.31% (= 1.93/2.06 -1).

We can also observe that companies that had amounts of unsecured debt lower than those defined (i.e. SUD < = 20%, 30% or 40%) also increased their default risk during the subprime crisis, but remained in the safe zone (i.e. Z > 2.99).

Table 2 - Default Risk descriptive statistics by groups

Default Risk	1. Pré-crise (2004-2006)	2. Crise (2007-2010)
Geral	2.33	2.30
DS – HHI >= 0.7	2.85	2.35
RR > 20%	2.90	2.56
RR < 20 %	4.48	3.51
RR > 30%	2.87	2.54
RR < 30 %	4.16	3.50
RR > 40%	2.89	2.56
RR < 40 %	4.48	3.51
SUD > 20%	0.54	0.71
SUD < 20%	3.71	3.13
SUD > 30%	0.54	0.71
SUD < 30%	3.71	3.122
SUD > 40%	0.53	0.71
SUD < 40%	3.71	3.11
SED > 20%	2.60	2.93
SED < 20%	3.13	2.00
SED > 30%	2.59	2.93
SED < 30%	3.11	2.13
SED > 40%	2.57	2.91
SED < 40%	3.10	2.24
UND > 20%	2.10	1.92
UND < 20%	4.33	3.63
UND > 30%	2.07	1.91
UND < 30%	4.38	3.38
UND > 40%	2.06	1.93
UND < 40%	4.29	3.16

Note: DE represents the debt structure through the HHI in which the treatment group is composed of companies that have a tendency to specialization of their structure (HHI >= 0.7) and the control group is composed of companies that tend to diversify their debts structures. RR represents the lag of the rollover risk through the long-term debt maturing in t + 1 (lag dd1) in which the treatment group (control) are the companies that have a rollover risk greater (less) than 20%, 30% or 40%. SUD represents the debt seniority through subordinated debts in which the treatment group (control) are the companies that have a representation of their subordinated debt greater (less) than 20%, 30% or 40%. SED represents debt seniority through secured debt, in which the treatment group (control) are companies that have a representativeness of their secured debt greater (less) than 20%, 30% or 40%. UND represents debt seniority through unsecured debt, in which the treatment group (control) are companies that have a share of their unsecured debt greater (less) than 20%, 30% or 40%.
Source: elaborated by the authors (2023)

4.2 Influence of the debt structure on default risk.

As pointed out in the methodological procedures, we sought to test our hypotheses through differences-in-differences, testing inter-group difference (treatment and control) both before and during the subprime crisis. The results of our analyzes can be seen in Table 3 below.

In the upper part of Table 3, we showed the regressions of DiD according to the groups defined in our methodological procedures. Thus, we seek to test the relationship of debt specialization (H1), debt maturity (H2) and also debt seniority (H3, H4 and H5) ND default risk during the subprime crisis.

Initially, we can observe the debt specialization model. This model reveals a positive impact of debt specialization on the z-score of Brazilian companies. Thus, companies that tended to specialize their debts during the subprime crisis (treatment group - HHI >= 0.7) had a lower probability of default compared to Brazilian companies that did not have this tendency (i.e. control group - HHI <= 0.4). This relationship is statistically significant at 1%.

Our result is in line with the result of Colla et al. (2013, 2020) who theorized that one of the reasons why companies seek to specialize their debt structure by composing it with few creditors is the reduction of expected bankruptcy costs. Therefore, our results show for Brazil that a high degree of debt specialization helps to minimize expected default costs. In this sense, we do not reject our H1 hypothesis that companies with greater debt specialization had a lower risk of default during the subprime crisis.

Regarding rollover risk, our analyzes revealed a negative impact of rollover risk on the z-score of Brazilian companies. Thus, companies that had high rollover risk during the subprime crisis (treatment group - RR > = 20%, 30% or 40%) increased their probability of default compared to Brazilian companies that did not have these same levels of rollover risk. rollover (i.e. control group - RR < = 20%, 30% or 40%). We can also observe that the greater the rollover risk, the greater the propensity of Brazilian companies to incur high risk of default (i.e. RR >= 20% - DiD of -0.98; RR>= 30% - DiD of -5, 39; RR>=40% - DiD of -6.49). These relationships are statistically significant at 10% for analyzes with rollover risk greater than 20% and 1% for analyzes with rollover risk greater than 30% or 40%.

Thus, we identified that Brazilian companies, during the subprime crisis, faced difficulties in rolling over short-term debt maturities, especially since this maturity represented the main maturity within the debt maturity structure, as seen in the descriptive statistics. Therefore, we identified that rollover risk was an additional source of credit risk for Brazilian firms given the increase in their default risk.

Our result is in line with the result of Gopalan et al. (2014), Almeida et al. 2011) and Wang et al. (2017) who postulated that short-term or long-term debt payable within a year exposes borrowers to rollover risk and, therefore, may increase the risk of default and amplify the impact of financial crises. In this sense, we do not reject our H2 hypothesis that companies with higher rollover risk had a higher risk of default during the subprime

Table 3 - *DiD* Kernel *Propensity Score Matching* estimation

Model	DS	RR 20%	RR 30%	RR 40%	SUD 20%	SUD 30%	SUD 40%	SED 20%	SED 30%	SED 40%	UND 20%	UND 30%	UND 40%
Before													
Control	2.22	4.69	5.73	4.61	-0.60	-0.99	-1.70	2.44	2.48	2.37	3.31	2.36	3.15
Treatment	2.05	2.22	2.16	2.10	0.51	0.49	0.49	1.26	1.30	1.27	2.86	2.57	2.67
Diff	-0.17	-2.47	-3.57	*-2.51*	*1.117*	1.48	2.19	-1.18	-1.17	-1.09	-0.45	0.21	-0.48
SD	0.32	0.42	0.37	*0.37*	*0.39*	*0.42*	*0.41*	*0.36*	*0.37*	*0.37*	*0.39*	*0.52*	*0.52*
t	-0.54	***-5.81******	***-9.49******	***-6.78******	***2.82******	***3.50******	***5.32******	***-3.22******	***-3.17******	***-2.91******	*-1.15*	*0.40*	*-0.92*
After													
Control	0.45	5.75	11.24	11.24	0.34	1.22	1.22	2.09	1.96	1.57	3.16	*2.69*	3.02
Treatment	2.06	2.30	2.26	2.23	0.75	0.75	0.76	1.94	1.87	1.84	2.39	*2.40*	2.39
Diff	1.60	-3.45	-8.97	-9.00	0.41	-0.469	-0.46	-0.15	-0.08	0.26	-0.76	-0.29	-0.63
SD	0.35	0.42	0.37	0.37	0.43	0.46	0.45	0.34	0.34	0.35	0.41	0.54	0.54
t	***4.54******	***-8.10******	***-23.77******	***-24.26******	*0.94*	*1.01*	1.03	*0.45*	*0.26*	*0.75*	***1.86****	*0.55*	*1.15*
Differences-in-Differencess – DiD													
DiD	1.78	-0.98	-5.39	-6.49	-0.70	-1.95	-2.66	1.031	1.09	1.36	-0.31	*-0.50*	*-0.15*
SD	0.47	0.60	0.53	0.52	0.58	0.63	*0.61*	0.50	0.50	0.51	0.57	0.75	0.75
t	***3.73******	***-1.63****	***-10.12******	***-12.39******	**-1.20**	***-3.10******	***-4.34******	***2.05******	***2.14****	***2.63******	- 0.55	- 0.67	- 0.20
R squared	20%	6%	31%	32%	10%	2%	4%	10%	10%	10%	10%	10%	10%
observations	1487	1639	1623	1608	1372	1359	1363	1577	1552	1533	1200	944	931

Note: SD represents standard error; t represents the t-test. Regressions were estimated using Kernel-PSM. The covariates are total assets, net income, and industry. ***, ** and * represent significance at 1%, 5% and 10%, respectively. DS represents the debt structure through the HHI in which the treatment group is composed of companies that have a tendency to specialization of their structure (HHI >= 0.7) and the control group is composed of companies that tend to diversify their debts structures. RR represents the lag of the rollover risk through the long-term debt maturing in t + 1 (lag DD1) in which the treatment group (control) are the companies that have a rollover risk greater (less) than 20% , 30% or 40%. SUD represents the debt seniority through subordinated debts in which the treatment group (control) are the companies that have a representation of their subordinated debt greater (less) than 20%, 30% or 40%. SED represents debt seniority through secured debt, in which the treatment group (control) are companies that have a representativeness of their secured debt greater (less) than 20%, 30% or 40%. UND represents debt seniority through unsecured debt, in which the treatment group (control) are companies that have a share of their unsecured debt greater (less) than 20%, 30% or 40%.
Source: elaborated by the authors (2023).

Regarding the risk arising from the debt seniority structure, we divided our analyzes into the ratio of subordinated debt (SUD) (H3), secured debt (SED) (H4) and unsecured debt (UND) (H5) over the default risk.

Initially, we can observe that companies that had a representative part of their subordinated debt negatively impacted their z-score, making them more prone to default during the subprime crisis. When we tested our different cutoffs of 20% (DiD of -1.20), 30% (DiD of -3.10) or 40% (DiD of -4.34), we observed that the only model that this relationship is not significant is for the lowest cutoff (20%). In the other two models, we can observe that there is a significant and negative impact of subordinated debts on default risk. Thus, Brazilian companies that structure their debt seniority with significant portions of subordinated seniority debt seem to increase their propensity to default in times of crisis, as we have hypothesized.

As noted in our benchmark, for larger proportions of subordinated debt, it resembles equity such that subordinated debt holders are quasi-residual claimants once the senior debt is repaid. Subordinated debt must, therefore, generate a higher yield than senior debt, to compensate for the higher default risk (Tirole, 2006). Therefore, a subordinated debt, whose payment will only take place if the debts with payment preference (senior) are settled, presents a greater risk than the debts with the same payment seniority of the others and, therefore, must be negotiated with a premium for compensate the investor for the greater risk (Securato et al., 2004).

Therefore, the lower the creditor is in the debt seniority structure, the less likely it is to receive its compensation in case of default and, therefore, the stronger its incentives to ensure that the borrower does not take excessive risks (Adler & Triantis, 2017). In this context, the debt contract contains provisions that specify the seniority of credit in case of default (Tirole, 2006).

Based on this, our results are in line with the results of Adler & Triantis, (2017) and Securato et al. (2004) who postulated that subordinated debt exposes borrowers to the most prominent default risk, being exacerbated in times of financial crisis. Therefore, we do not reject our hypothesis that Brazilian companies that have more subordinated debt increased their default risk during the subprime crisis (H3).

In relation to secured debts, that is, debts that have a collateral guarantee (i.e. 'loan against assets') it is theorized that creditors are partially protected against non-repayment of interest or principal by pledging assets, or that is, creditors can repossess (seize) the specified assets in the event of default. In our results, we can see that there is a positive relationship between secured debts and our default risk measure (z-score). Thus, companies that have significant portions of their debt secured distance themselves from a probable default during crises, as we can see in our results.

Our cutoffs are significant at both the lowest and highest levels of secured debt. Thus, the positive relationship between secured debt and z-score (lower propensity to default) can be confirmed in statistical terms both with a cutoff of 20% (DiD of 2.05) and a cutoff of 30% (DiD of 3.14) and a cutoff of 40% (DiD of 2.63), all of these relationships being significant at 1%.

As we theorized in our review, secured debt gives creditors ownership of pledged assets until the bonds are paid in full, giving them seniority over pledged assets, unlike creditors, who have no collateral. Based on this, our results are in line with the results of Barclay and Smith (1995) and Tirole (2006) who postulated that secured debt exposes borrowers to less prominent default risk, being mitigated in times of financial crisis. Thus,

therefore, we do not reject our hypothesis that Brazilian companies that have more secured debt, decreased the risk of default during the subprime crisis (H4).

Finally, regarding unsecured debts, despite observing the expected relationship that was hypothesized in our review, that is, a negative relationship between the unsecured debts and the z-score (greater propensity to default) we did not observe statistical significance for the cutoffs tested, which does not give us subsidy to reject (or not) our hypothesis H5. In our unreported tests, we found that the relationships are only significant for cutoffs above the 70th percentile onwards, that is, for higher levels of unsecured debt.

5. Conclusions

This article sought to analyze the relationship between the debt structure and the default risk of Brazilian companies during the subprime crisis. By debt structure, we understand both the composition of the typologies that compose it and the maturity structure of the debts, as well as the seniority structure of receipt. As far as we have identified, this article has one of the most comprehensive databases for the Brazilian context. In temporal terms, we can analyze the debt structure with a coverage of 17 years, between 2004 and 2020, allowing us to identify the relationship between the debt structure over time as well as analyze its relationship with the risk of default in a specific window that was the subprime crisis (2004 to 2010).

Based on this, our data allowed us to explore the debt structure in a substantial way, making it possible for the debt composition to break it down into 7 different types of debt: a) Bank debt; b) Titles and senior notes; c) Titles and subordinate notes; d) Promissory notes; e) Capital leasing; f) Revolving credit; and, g) Other sources. This segregation is available in the Capital IQ database and allowed identifying which Brazilian firms concentrate or diversify their debt composition.

Our historical evolution results for the debt structure composition, Brazilian firms have an average HHI of 0.55 (higher HHI values indicate a tendency for specialization) for the general sample. However, when analyzing the debt structure over the years, as well as the types of debt, we can identify trends and issues revealed recently by Granzotto et al. (2023) in the literature on Brazilian firms. First, firms had an average overall HHI of 0.63 in 2004 and, after 17 years, the HHI dropped to 0.52 (-21.21%), demonstrating an expressive decline in the specialization of debt sources. The authors explain that this trend can be justified by a mechanism to reduce financial constraints (cost of debt) as the reduction of dependence on a single creditor.

Regarding the impact of debt composition (in terms of specialization) on default risk, we can observe a positive impact for Brazilian companies. Thus, companies that tended to specialize their debts during the subprime crisis (treatment group - HHI >= 0.7) had a lower probability of bankruptcy compared to Brazilian companies that did not have this tendency (i.e. control group - HHI <= 0.4). This relationship is statistically significant at 1%. Our result is in line with the result of Colla et al. (2013, 2020) who theorized that one of the reasons why companies seek to specialize their debt structure by composing it with few creditors is the reduction of expected bankruptcy costs. Therefore, our results show for Brazil that a high degree of debt specialization helps to minimize expected default costs. In this sense, we do not reject our hypothesis H1.

Additionally, the data allow us to analyze the debt structure in relation to its maturity in detail, as it is possible to specifically analyze the maturity of debts in the following types:

a) Short-term debt; b) Long-term debt maturing in t + 1; c) Long-term debt maturing in t + 2; d) Long-term debt maturing in t + 3; e) Long-term debt maturing in t + 4; f) Long-term debt maturing in t + 5; g) Long-term debt maturing after 5 years. Again, this segregation allowed advances in the analyzes given the possibility of estimating the maturity of the debts more reliably, compared to previous studies, in which they only segregate between short and long term debt. Thus, for example, one can measure the rollover risk in a less endogenous way, given that long-term debt maturing in the coming years (instead of short-term debt) was financed in previous years, having a low relationship with the characteristics of the firms. in the contemporary period. This lower endogeneity makes it possible to capture the effect of rollover risk on default risk more reliably.

Our results on the historical evolution of the debt maturity structure reveal that Brazilian companies have an average debt maturity of 1.55 years. Furthermore, we can observe that the average maturity of Brazilian companies is stable over time, given that in 2004 the average maturity of companies was also 1.55 years. Thus, throughout the series we observed small variations in the average maturity of Brazilian prey. In addition, a look at the maturity structure reveals some significant variations.

The first of these is found in long-term debt maturing in one year (dd1), which represents a significant part of the debts due by Brazilian companies. In general, long-term debts maturing in one year represent 34% of total debts maturing, with variations being possible over the series in question. In 2009, for example, this representativeness has its maximum value, i.e. 37% and in the following two years, they have significant drops culminating in 25% in 2010 (representing a drop of 32.43%) and 28% (representing a drop of 17.64%) in 2011.

Based on these results, we can understand that companies sought to renegotiate the portion of their long-term debt falling due in 2010 and 2011 as this increased their risk of debt rollover. A possible justification for this is the subprime crisis of 2007/2008, in which rollover risk suggests that companies with high amounts of long-term debt payable in one year are more likely to suffer a deterioration in their credit quality.

After these descriptive statistics, our differences-in-differences models confirm the above given that we identified a negative impact of rollover risk on the z-score of Brazilian companies. Thus, companies that had high rollover risk during the subprime crisis (RR > = 20%, 30% or 40%) increased their probability of bankruptcy compared to Brazilian companies that did not have these same levels of rollover risk. Thus, we identified that Brazilian companies, during the subprime crisis, faced difficulties in rolling over short-term debt maturities, especially since this maturity represented the main maturity within the debt maturity structure, as seen in the descriptive statistics. Therefore, we identified that rollover risk was an additional source of credit risk for Brazilian firms given the increase in their default risk. In this sense, we do not reject our hypothesis H2

Finally, the data also allowed us to analyze the debt structure in relation to its receipt seniority, as it can be analyzed in the following types: a) Senior Debt; b) Subordinated Debt; c) Secured Debt; and, d) Unsecured Debt. Our historical evolution results revealed that Brazilian companies that, between senior debt and subordinated debt, on average, companies almost entirely have the senior modality. Still in relation to receiving seniority, we have that between secured, unsecured and convertible debts, Brazilian companies access the first two modalities in a very similar way, with a slight tendency towards unsecured debt. Thus, on average, debts that have some collateral for the debt contract reach 41% while debts without any collateral reach 59%.

Regarding the regression models, we identified that companies that had a representative part of their subordinated debt negatively impacted their z-score, making them more prone to default during the subprime crisis. Thus, Brazilian companies that structure their debt seniority with significant portions of subordinated seniority debt seem to increase their propensity to default in times of crisis, as we hypothesized. Thus, therefore, we do not reject our hypothesis H3.

In relation to secured debts, that is, debts that have a collateral guarantee (i.e. 'loan against assets') we can observe that there is a positive relationship between secured debts in relation to our measure of default risk (z-score). Thus, companies that have significant portions of their debt secured distance themselves from a probable default during crises, as we can see in our results. Therefore, we do not reject our hypothesis H4. Finally, regarding unsecured debts, despite observing the expected relationship that was hypothesized in our review, that is, a negative relationship between unsecured debts and the z-score (greater propensity to default), we did not observe statistical significance for the cutoffs tested, which does not allow us to reject (or not) our hypothesis H5.

This study presents theoretical and empirical contributions. Theoretically, the present research contributes to the studies on the debt structure that are scarce for the Brazilian reality. In this context, this study provides evidence on how firms structure their debts in terms of composition, maturity and seniority and how these structures relate to their default risk in times of crisis, as was the subprime crisis.

Our analyzes allowed us to significantly explore the different types of debt over a 17-year series, giving us a broad temporal dimension of the Brazilian reality. Based on this, we have more robustness to be able to theorize about the relationship between the debt structure and the default risk of Brazilian companies. Furthermore, our results are robust to different cutoffs for debt maturity analyzes and also for debt seniority. Our results also reveal results still not observed for the Brazilian reality, such as the decrease in debt specialization, the decrease in long-term debt maturing in one year, 2010 and 2011, as well as the similarity in importance of secured and unsecured debts. Still, in the historical series, a point worth mentioning is the proportion of secured debt (with guarantee) and unsecured debt (without guarantee) in the period from 2008 to 2010 in which the values of the first reached their maximum values in this 17-year historical series. Thus, in 2008 the secured debt reached 56%, in 2009 it reached 52% and in 2010 it reached 54%, thus being the only years that this debt exceeded the 50% barrier. We believe that this behavior was due to creditors' demands given the subprime financial crisis. Empirically, an innovation of our study is the use of a differences-in-differences method that allows us to study an exogenous shock (subprime crisis) in a robust way, giving the quasi-natural procedure and with a propensity score matching to relate debt structure and risk by default. Along with this, we have variables that support us with regard to possible endogenous problems, such as the use of the debt maturity variable maturing in one year.

In this sense, the study of the impact of debt structure on the default risk of Brazilian companies can reveal new insights to the Brazilian financial market. As a limitation of the study, we do not have another Brazilian study to compare our results. Finally, as a suggestion for future work, there is the possibility of carrying out the study at the country level, thus comparing how the different levels of financial development.

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