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## Article

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*Suggested Citation:* Oliveira, Guilherme Resende; Tabak, Benjamin Miranda; de Lara Resende, José Guilherme; Cajueiro, Daniel Oliviera (2013) : Determinants of the level of indebtedness for Brazilian firms: A quantile regression approach, EconomiA, ISSN 1517-7580, Elsevier, Amsterdam, Vol. 14, Iss. 3-4, pp. 123-138,  
<https://doi.org/10.1016/j.econ.2013.11.002>

This Version is available at:

<https://hdl.handle.net/10419/179551>

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# Determinants of the level of indebtedness for Brazilian firms: A quantile regression approach

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## Abstract

We investigate the determinants of the capital structure of Brazilian companies between 2000 and 2009. We use a quantile regression model and compare its results with the ones provided by conventional models (least squares and fixed effects). We show that the effects of the capital structure determinants change depending on the quantile. This can be explained by bankruptcy and agency costs associated to the amount of debt leverage of firms, relative to each quantile. Based on these results, we analyze the predicted effects of the two leading capital structure theories, namely pecking order and trade-off, conditioned on the determinant, type of debt and quantile analyzed. Our results for the size and profitability variables indicate that the pecking order theory is more suitable to the data as the quantile increases.

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*JEL classification:* G3; G32; G34; C21

*Keywords:* Capital structure; Quantile regression; Pecking-order; Trade-off

## Resumo

Este estudo examina os determinantes da estrutura de capital das empresas brasileiras entre os anos de 2000 e 2009. Nós usamos um modelo de regressão quantílica e comparamos seus resultados com aqueles fornecidos por modelos convencionais (mínimos quadrados e efeitos fixos). Nós obtemos um melhor entendimento da estrutura de capital de empresas Brasileiras. Nós mostramos que os efeitos dos determinantes da estrutura de capital variam com o quantil analisado. Essa influência pode ser explicada por custos de falência e agência associados ao nível de endividamento das empresas, em cada quantil. Tomando como base esses resultados, nós analisamos as previsões dos efeitos das principais teorias da estrutura de capital, *pecking order* e *trade-off*, dependendo

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Peer review under responsibility of National Association of Postgraduate Centers in Economics, ANPEC.



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determinante, tipo de dívida e quantil analisado. Nossos resultados para as variáveis tamanho e lucratividade mostram que a teoria da *pecking order* se torna mais relevante à medida que os quantis aumentam.

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*Palavras-chave:* Estrutura de capital; Regressão quantílica; Pecking order; Trade-off

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## 1. Introduction

This paper investigates the determinants of capital structure for Brazilian companies. We identify and analyze the determinants of the Brazilian firms' level of indebtedness through a quantile regression (QR) approach. We show that determinants change with the quantiles suggesting providing a better understanding of these dynamics.

The empirical identification of these determinants led to the formulation of two theories, namely trade-off and the pecking order. While these two theories have a many features in common, they also have marked differences. For example, the trade-off theory accepts the idea of optimal capital structure (Jensen and Meckling, 1976), whereas pecking order (Myers, 1984) rejects this idea. On the other hand, some empirical studies Titman and Wessels (1988), Rajan and Zingales (1995), Frank and Goyal (2003b) (for international companies), and Procianny and Schnorrenberger (2004), Cesar and Brito (2005), Medeiros and Daher (2008) (for Brazil) indicate that firms tend to behave as if their capital structure affects their value.

In this paper we test the validity of these theories and extend the empirical work into two forms. First, we explore an empirical model based on QR, which is scarce in the literature and for the Brazilian case. Second, we consider the determinants of capital structure in three ways: total, short and long term.

The QR provides a better diagnosis of the problem, since it analyzes the variable of interest, i.e. debt leverage, by a quantile analysis. This is essential to investigate the existence of heterogeneity among firms. In addition, this method is robust to outliers and does not discard data, which is different in comparison with other estimation methods, that exclude outliers or extreme quantiles (Rajan and Zingales, 1995; Frank and Goyal, 2003a), and therefore only represent the central tendency parameters. The QR methodology was applied to capital structure by Fattouh et al. (2005) for South Korean companies, and Qiu and Smith (2007) for UK companies. Both of these works show more robust results than studies that have used traditional methodologies like ordinary least square (OLS), panel data, and the method developed by Fama and Macbeth (1973).

The results show that the effects of the determinants on the level of debt leverage between quantiles for Brazilian companies between 2000 and 2009 are not homogeneous. According to the bankruptcy costs and agency costs theories, these levels of debt can affect the behavior of the firm. For example, the lower the quantile, the lower the cost of bankruptcy, suggesting that a firm can easily take out loans from banks. Since QR allows the estimation of coefficients to vary according to the degree of leverage, differences between these coefficients may emerge, which may explain capital structure of the Brazilian firms in a new light.

The results are used to verify the validity for the Brazilian case according to the two main capital structure theories, pecking order and trade-off. They show that the differences between quantiles are significant, which justifies the use of the QR and proves that the conditional distribution is not homogeneous for the three forms of leverage. We have found, in particular, that the negative effect of profitability on the capital structure increases gradually with the quantile, i.e., the sensitivity of leverage related to a company's profitability is lower in companies that have a lower level of indebtedness than in firms that are highly leveraged. In this case, we agree with the pecking order theory and found that its predictions become more accurate as the quantile increases.

The paper is organized as follows. The next section presents a literature review of capital structure theories and predictions of each determinant. Section 3 introduces the empirical methodology, which is based on QR, and the data. Section 4 reports the estimated values for each factor analyzed. Finally, Section 5 presents the conclusions.

## 2. Literature review

Modern research of capital structure began with the work of Modigliani and Miller (1958), who showed that when a company is under certain conditions, such as the absence of taxes, it is unable to change its value by changing

its capital structure. This work led to several studies examining the impact of capital structure on firm value, which investigated the benefits and costs associated with the issuance of debt or stocks. The divergence between the subsequent theories on capital structure is remarkable. Some studies accept the idea that an optimal capital structure exists (Jensen and Meckling, 1976) while, others reject this (Myers, 1984). These studies initially questioned the assumptions of Modigliani and Miller (1958), such as the assumption that individuals borrow at the same cost as companies. Other hypotheses that have been criticized refer to market imperfections, taxation, and differences in risk between leveraged and non-leveraged firms. This discussion motivated our choice of the capital structure determinants used in our analysis.

Empirical studies indicate that companies today behave as if the debt level were an important factor in determining its value. However, there is no consensus regarding the factors that affect the leverage (Rajan and Zingales, 1995; Fama and French, 2002; Frank and Goyal, 2003a; Qiu and Smith, 2007).

## 2.1. Theories of capital structure

Capital structure refers to the proportion of equity and other capital that firms use to finance its operations. Thus, debt may be considered a critical variable when determining a firm's capital structure. According to conventional theories, a combination of adequate financial sources can define a minimum value for a firm's total capital cost to maximize shareholder wealth (Harris and Raviv, 1991).

In general, the cost of equity would exceed the cost of debt, given the tax benefits for using debt, or because the probability of failure impacts the creditors' funding (Modigliani and Miller, 1958). In cases in which debt may be deductible, it is expected that companies seek to maintain a capital structure with maximum leverage. In addition, there are other benefits associated with debt, as it induces a more efficient behavior for managers (Stulz, 1990).

However, the debt ratio for Brazilian and American firms is usually not too high (Brito and Lima, 2005; Medeiros and Daher, 2008; Jensen, 1986). One reason for this is that the use of debt increases financial risk. In other words, the higher the leverage, the higher the risk of bankruptcy, motivating lenders to increase loan premiums. Since there are both benefits and risks arising from level of indebtedness, Graham (2000) affirms there is an optimal capital structure.

### 2.1.1. Trade-off

Trade-off theory (TO) is one of the most important theories supporting the existence of an optimal capital structure (Jensen and Meckling, 1976). It argues that due to the trade-off between the benefits and costs of debt, firms choose optimal debt and stock levels. This model considers market imperfections which were ignored by Modigliani and Miller (1958), such as taxes, bankruptcy costs, and agency costs. Thus, the optimal degree of leverage minimizes costs and maximizes the value of the firm (Stulz, 1990).

According to the trade-off theory, companies have a debt target, which depends on certain variables. Miller (1977) states that the two main determinants of this target are taxes and bankruptcy costs associated with a company's higher debt leverage. Jensen and Meckling (1976) analyze another class of determinant, agency costs, which result from two types of conflicts: one between shareholders and managers, and another between shareholders and creditors.

Studies, such as DeAngelo and Masulis (1980), show that a company's debt affects its value and is also sensitive to factors such as bankruptcy and agency costs. According to these authors,<sup>1</sup> factors such as size, social incentives, depreciation and structure of assets (tangibility) also influence these costs. For example, larger companies and/or those with more tangible assets have lower bankruptcy costs.

### 2.1.2. Pecking order

The pecking order theory (PO) (Myers and Majluf, 1984) is based on the existence of asymmetric information between managers and investors, where managers use inside information to finance the firm when the companies assets are overvalued.<sup>2</sup> However, investors anticipate this action and discount the value of the firm, i.e., the firm's value drops when a stock offering is announced. In turn, managers anticipate this discount and do not make certain investments, preferring to defer potential investments until the company has cash resources. Thus, information asymmetry leads to

<sup>1</sup> Other studies: Titman and Wessels (1988), Rajan and Zingales (1995) and Brito and Lima (2005).

<sup>2</sup> Ross (1977) presents a signaling model in which the manager knows the distribution of returns of firms. The empirical result is contrary to the one provided by the PO, in which profitability and debts are negatively correlated.

Table 1  
Forecasts on capital structure.

Variable	Effects predicted	
	Trade-off	Pecking order
Size	+	+/-
Profitability	+	-
Growth opportunity	-	-/+ <sup>a</sup>
Tangibility	+	-
Volatility	-	-

<sup>a</sup> The PO in the weak form admits opportunity of growth positively correlated with leverage.

share undervaluation, and therefore managers are reluctant to issue new stocks on the market. This causes the hierarchy of financial sources.

Therefore, companies usually prefer internal financing. If external financing is needed, debentures or securities (debt) would be issued, before opting to issue shares. This theory holds that more profitable companies are less indebted, since they can finance new projects without needing to take loans or issuing stocks.

The trade-off theory competes with the pecking order theory in certain aspects and both offer an explanation about companies capital structure. One such aspect that they differ is profitability. For this variable, [Shyam-Sunder and Myers \(1999\)](#) found evidence in favor of the PO in a study of U.S. companies, which shows that more profitable firms are less leveraged. In Brazil, [Medeiros and Daher \(2008\)](#) tested both theories, and confirmed the PO prediction. [Cesar and Brito \(2005\)](#) also evaluated the trade-off and pecking order theories, obtaining results similar to [Fama and French \(2002\)](#), who concluded: “confirming the pecking order model but contradicting the trade-off model, more profitable firms are less leveraged”.

These theories however, converge regarding other aspects, such as the prediction of the relation between leverage and risk (volatility). The higher a company’s financial volatility, the riskier the company is, and hence, would have higher borrowing costs.

### 2.1.3. Market timing

For a long time the debate on capital structure determinants was restricted to variables directly linked to the firms, such as profitability, size, asset structure, among others. However, in the past decade, some studies have investigated the effects of capital market variables ([Baker and Wurgler, 2002](#); [Alti, 2006](#)), motivating the emergence of an influential theory about capital structure; the market timing theory.

[Baker and Wurgler \(2002\)](#) developed the market timing theory (MT), which investigates some points not addressed by traditional theories, like the issuance of stocks at opportune times with a relatively low capital cost compared to other sources of capital. Their empirical tests showed that such behavior is recurrent in companies and therefore constitutes another determinant of the degree of leverage. The authors define market timing as the practice of issuing stocks when they are overvalued and buying them back when they are undervalued.

[Baker and Wurgler \(2002\)](#) investigated the use of MT analyzing the relationship between the issuance of stocks and the use of proxies such as market-to-book ratio, i.e., the proportion of book value in relation to the market value of the company. In Brazil, [Rossi and Marotta \(2010\)](#) tested the MT theory for Brazilian IPOs for 2004–2007. They confirmed that companies adopted an opportunistic behavior by issuing a larger volume of stocks in “hot” times.<sup>3</sup>

## 2.2. Capital structure forecasts

This subsection presents the main theoretical predictions based on the above-mentioned capital structure theories. Despite similarities between trade-off and pecking order, these have different predictions on the effects of certain variables. For example, for tangibility variable, these theories predict opposite effects regarding leverage. In order to investigate the validity of these theories, we compare the empirical results with predictions made by each. [Table 1](#)

<sup>3</sup> Terminology adapted from the literature.

Table 2  
Proxies and empirical evidence of capital structure determinants.

Determinant	Proxy	Reference
Size	<i>log(Total asset); log(Total receipt)</i>	FSH, TW, RZ, HR, BL, PF, CB, GF
Profitability	<i>EBITD/Total asset; EBITD/Equity</i>	RZ, GL, PF, BL; FSH
Opportunity of growth	<i>Market-to-book; Variation % in total asset; (Total asset – Equity + Market value)/Total asset</i>	FSH, RZ, GL, TW, FG, PF, BL, HR
Asset structure (tangibility)	<i>Permanent/Total asset; (Fixed asset + Stock)/Total Asset</i>	TW, PF, BL; FSH, RZ, Myers
Volatility of operational results (risk)	<i>Short term debt/Long term debt; SD EBITD/Average EBITD</i>	FF, BL

The variables in italic were used in our regressions. The acronyms of the last column refer to the initials of the authors previously cited. EBITD: earnings before interest, tax and depreciation; SD: standard deviation.

shows the predictions of both the trade-off and pecking order theories for each factor affecting the level of indebtedness. In order to understand the effect of each determinant, we examine separately each determinant, in order to determine which theory is better suited to.

Although MT has not been tested directly, certain inferences may be made. The MT theory has the same prediction of PO regarding the market-to-book variable: when stocks are overvalued, the preference for profit in financing investments is replaced by stock issuance. This variable was used and accepted by [Baker and Wurgler \(2002\)](#) as a significant determinant of leverage.

On the other hand, QR allows the effects of determinants on capital structure to vary across quantiles. For example, it could be the case that the lower the quantile, the smaller the profitability effect on the level of indebtedness. The QR also allows that the signal of the determinants to change according to the quantile, which would alter the variable's logical interpretation. The bankruptcy costs and agency costs are the probable causes of changes in the coefficients determinants. Thus, the main focus of our analysis falls on the highest and lowest debt ratio quantiles, since the central tendencies have been analyzed previously by other authors ([Rajan and Zingales, 1995](#); [Frank and Goyal, 2003b](#)).

The type of debt, short or long term, can also affect results. Therefore, certain studies focus on different time frames, assessing the advantages and disadvantages of each. [Moreira and Brito \(2006\)](#) have reviewed the literature for Brazil.

It must be pointed out that there are certain characteristics of the Brazilian market that directly affect capital structure decisions and should be considered in studies like such as this, namely the high cost of stock issuance and the low liquidity of small- and mid-sized firms. In addition, high interest rates make short-term financing unfeasible, especially for small- and mid-sized firms ([Medeiros and Daher, 2008](#)). [Gomes and Leal \(2001\)](#) also mention that long-term credit is scarce, and that the Brazilian long-term interest rate remains high by international standards.

### 2.2.1. Determinants

Table 2 presents the key variables that have been investigated in the empirical literature on the determinants of capital structure. This table contains information on the proxies used in other works. Each of these determinants has effects on the capital structure predicted by the pecking order and trade-off theories. Our study then verifies whether the predictions of each theory are compatible with the results reported in Section 4.

- Size – Empirical evidence confirms that firm size directly influences the level of debt ([Frank and Goyal, 2003b](#); [Cesar and Brito, 2005](#)). Large firms have greater access to funding and take out loans more easily and at more favorable rates. They are also less likely to fail because of their greater business diversity. Thus, these lower bankruptcy costs increase their debt capacity. Another factor linked to size is their lifetime. Older companies usually have a larger volume of information and greater investor confidence, which provides greater market access and lower costs for loans ([Harris and Raviv, 1991](#)).

However, as [Titman and Wessels \(1988\)](#) and [Fama and French \(2002\)](#) pointed out, according to PO, smaller firms take on more debt, due to their weaker cash flows and difficulty to issue stocks. In Brazil, the main justifications for this point are higher costs of issuance and lower liquidity in the financial market ([Medeiros and Daher, 2008](#)).

- Growth opportunity – Our proxy for growth opportunity is the market-to-book variable, which indicates the value of the stock at a given moment in time, indicating the best time to issue stocks/debt ([Rajan and Zingales, 1995](#)). For TO, the greater the opportunity for growth, the more incentives there are to invest in the future and to prepare to

disburse resources, as reflected by a lower leverage's ratio. Therefore, the expected relation with debt is negative. Moreover, in relation to quantiles, it is expected that more leveraged firms have higher bankruptcy costs and lower opportunity for growth, because reducing the bargaining power of the borrowing firm.

In PO and MT, the same relation is expected, where the first assumes that firms with high market-to-book value prefer to issue stocks than to take on debt. On the other hand, PO also asserts that greater opportunities for growth increase the debt, since there are greater incentives to borrow. Fama and French (2002), who used the same proxy, called it a simple or weak version of the PO theory. In Brazil, a factor that reinforces this preference for debt are the high costs of issuance of stocks (Medeiros and Daher, 2008).

- Profitability – We have seen that trade-off is based on the theories of bankruptcy costs and agency costs. The first holds that the risk of insolvency in profitable firms is smaller. The latter says that higher profits lead to serious conflicts between shareholders and managers, which may induce managers to take on more debt. Therefore, trade-off predicts a positive relationship between profitability and debt.

As for the PO theory, due to the hierarchy of sources of financing, the greater the profitability, the more internal resources companies have to invest, thus lowering the need for borrowing. Therefore, the relation with the debt is negative. Fama and French (2002) empirically corroborated this negative relation, refuting the trade-off theory. Cesar and Brito (2005) and Medeiros and Daher (2008) also empirically confirmed the negative relation in the Brazilian case.

- Structure of assets (tangibility) – It is expected that tangible assets be used as collateral for loans, reducing the costs of bankruptcy, and therefore increasing the incentive to take on more debt, in accordance with the trade-off theory (Rajan and Zingales, 1995).

Harris and Raviv (1991), in contrast to other studies, found that firms with fewer tangible assets face major problems due to asymmetric information, as stated by the PO theory, which leads these companies to borrow rather than issue stocks, *ceteris paribus*.

Firms with more tangible assets are more able to take on long term debt (Brito and Lima, 2005). Given this preference for long-term, less leveraged firms can lead to shorter maturity periods, making its relation to short-term debt negative.

- Volatility of operational results: risk – Diversified firms usually are less volatile in terms of cash flows and therefore less prone to fail. More volatile firms take on more short-term debt, increasing instability and the risk of bankruptcy, which reduces their debt capacity (Moreira and Brito, 2006). For this reason, we use the short-term debt/long-term debt ratio as a proxy for volatility, since an increase in this ratio reflects the increase in the firm's risk.

At the same time, the asymmetry of information between lenders and investors increases with volatility. This risk raises the price of the loan and reduces the power of the debt, leading to a preference for equity, according to the PO theory.

### 3. Methodology

The relationship between capital structure and its determinants is examined in the theoretical and empirical sections of this study. Thus, in this section, we present the main tool used in this article, the quantile regression (QR), along with the model and the database.

#### 3.1. Quantile regression

Studies on the capital structure of Brazilian companies use methods such as OLS regression (Medeiros and Daher, 2008; Procianny and Schnorrenberger, 2004), panel data (Medeiros and Daher, 2008; Brito and Lima, 2005) with fixed effects (FE) or random effects, and the method proposed by Fama and Macbeth (1973) (Cesar and Brito, 2005). The QR method is more robust to outliers (Hallock et al., 2010) and therefore more suitable for the analysis of the degree of leverage, since it considers the conditional distribution of the dependent variable that, in our case, is not homogeneous.<sup>4</sup>

<sup>4</sup> Homogeneity refers to the uniformity of the estimated coefficients between the quantiles, which must be constant.

Koenker and Basset (1978) introduced QR<sup>5</sup> and showed that this method is an extension of classical linear regression. The OLS estimator focuses solely on a measure of central tendency, while QR describes data better, because it analyzes the level of leverage, by quantile.

For example, many studies use OLS to estimate the variable effects on capital structure. The estimate obtained is a value that summarizes the relationship between the dependent and independent variables, assuming that the conditional distribution is homogeneous. In this case, the level of leverage is irrelevant and the estimates of the determinants are always the same. Other studies exclude the extreme quantiles so as to eliminate outliers that distort the estimations (Rajan and Zingales, 1995; Frank and Goyal, 2003b; Prociandy and Schnorrenberger, 2004). However, ignoring such observations is not the best form of analysis (Hallock et al., 2010). QR estimates each quantile using the entire sample and attributes weights to the observations, by incorporating all available information. The discussion in Section 2 suggests that if there is a difference between the effects of bankruptcy costs and agency costs in each quantile, this would lead to changes in the estimated coefficients for each quantile.

We now present the methodology for QR. Let  $(y_i, x_i)$ ,  $i = 1, 2, \dots, N$  be the population of  $n$  sample companies in period  $t(t = 1, 2, \dots, T)$ , where  $x_i$  is the vector of the capital structure determinants (regressors), and  $y_i$  the debt level of company  $i$ . Assuming that the  $\theta$ th quantile of the conditional distribution of  $y_i$  is linear in  $x_i$ , we can write the conditional quantile in the regression model as:

$$y_i = x_i' \beta_\theta + u_{i\theta} \quad (1)$$

$$Quant_{y_i}(\theta|x_i) \equiv \inf [y : F_i(y|x) \geq \theta] = x_i' \beta_\theta \quad (2)$$

$$Quant_{u_i}(\theta|x_i) = 0 \quad (3)$$

where  $Quant_{y_i}(\theta|x_i)$  denotes the  $\theta$ th conditional quantile of  $y_i$ , conditional on the regressor  $x_i$ ;  $\beta_\theta$  is the vector of unknown parameters to be estimated for the different value of  $\theta$  in  $(0,1)$ <sup>6</sup>;  $u_{i\theta}$  is the error term, and  $F_i(y|x)$  is the cumulative distribution function, conditional on  $x$ . By varying the value of  $\theta$  between  $(0, 1)$ , we can obtain the full distribution of  $y$ , conditional on  $x$ . The estimator,  $\beta_\theta$ , is obtained by solving the problem:

$$\min_{\beta_\theta} \sum_{i=1}^n \rho_\theta(y_i - x_i' \beta_\theta), \quad (4)$$

where  $\rho_\theta$  is the loss function, defined as:

$$\begin{cases} \theta u, & \text{if } u \geq 0 \\ (\theta - 1)u, & \text{if } u < 0 \end{cases} \quad (5)$$

The function (4) calculates the residual terms and multiplies the values in (5). This estimator is found using linear programming techniques (Koenker and Basset, 1978).

The standard method for estimating the covariance matrix of the parameters is the bootstrap method, available in most computer programs. Typically, the methods of inference overestimate the sample variance of the median and are not consistent. In such cases, the asymptotic distribution converges to the empirical distribution of the original sample, and the bootstrap method rectifies that. For these reasons, we use this method to estimate the covariance matrix. There is a vast literature on the use of bootstrap resampling techniques.

### 3.2. Empirical methodology

We analyze the capital structure determinants for Brazilian companies using the OLS, FE and QR models.<sup>7</sup> The QR method was estimated for the quantiles 0.05, 0.25, 0.50, 0.75 and 0.95. The OLS and FE regressions are performed to update the Brazilian literature and verify the robustness of the QR results.

<sup>5</sup> Several previous studies have introduced the ideas used by Koenker, in particular, the work of Boscovich and Laplace, who used a combination of mean and median.

<sup>6</sup>  $F^{-1}(1/2)$  is related to the median and can be seen as a regression model of minimum absolute deviations.

<sup>7</sup> R was the software used in the OLS, FE and QR estimates.



Table 3  
Types of debt.

Dependent variable	Measure of debt	Mathematical formula
totdeb	Total debt	(Long term liability + Current liability)/Total asset
ltdeb	Long term debt	Long term liability/Total asset
stdeb	Short term debt	Current liability/Total asset

The sample consisted of 394 publicly traded Brazilian companies. The data set available in Economática was built from the consolidated financial statements of non-financial companies listed on the BM&FBovespa,<sup>8</sup> between the years 2000 and 2009.

Regarding the data matrix, we chose to use balanced data, i.e., we excluded firms with data missing for the entire period, a procedure adopted in other works (Rajan and Zingales, 1995; Medeiros and Daher, 2008), and we used the average values of the selected period in most of the results.<sup>9</sup>

The empirical evidence for Brazil (Perobelli and Famá, 2001; Gomes and Leal, 2001; Procianoy and Schnorrenberger, 2004; Brito and Lima, 2005; Cesar and Brito, 2005; Medeiros and Daher, 2008) suggests that size, profitability, growth opportunities, leverage and volatility are the main determinants of capital structure, and the proxies of these variables are described in Table 2.

As Titman and Wessels (1988), Rajan and Zingales (1995), Brito and Lima (2005), Cesar and Brito (2005), and others have showed, the regression analyzes leverage according to different definitions: short-term, long-term, and total debt. Thus, it is possible to analyze the effect of determinants in more detail and to verify differences between the results. The dependent variable, debt, in its different forms, can be seen in Table 3.

Fattouh et al. (2005) found heterogeneity in the capital structure determinants using QR. Qiu and Smith (2007) performed a similar analysis and found that the determinant effects vary according to the degree of debt analyzed. These two studies show that the QR inference is more robust and complete. In addition, it provides a better understanding of the firms' behavior with respect to leverage, allowing to test other theories, such as bankruptcy and agency costs. This analysis has not been performed for the Brazilian case and is the main contribution of this article.

The OLS, FE and QR regressions are described below. The estimations are performed for different dependent variables listed in Table 3, where  $N = 1, 2, \dots, 394$ ; and  $T = 2000, 2001, \dots, 2009$  on the longitudinal case::

$$End_i = \beta_0 + \beta_1 \ln(Size)_i + \beta_2 Prof_i + \beta_3 Growth_i + \beta_4 Tang_i + \beta_5 Vol_i + u_i \quad (6)$$

$$End_{it} = \beta_0 + \beta_1 \ln(Size)_{it} + \beta_2 Prof_{it} + \beta_3 Growth_{it} + \beta_4 Tang_{it} + \beta_5 Vol_{it} + \alpha_i + u_{it} \quad (7)$$

$$End_i = \beta_{0\theta} + \beta_{1\theta} \ln(Size)_i + \beta_{2\theta} Prof_i + \beta_{3\theta} Growth_i + \beta_{4\theta} Tang_i + \beta_{5\theta} Vol_i + u_i \quad (8)$$

where  $End$  are the types of debts listed in Table 3;  $\ln(Size)$  is the logarithm of the size of firm  $i$  in period  $t$ , measured by the natural logarithm of total assets in thousands of reais<sup>10</sup>;  $Prof$  is the profitability, measured by the ratio of EBIT (earnings before interest and taxes, or operating profit minus administrative costs) and total assets;  $Growth$  is the proxy for the company's annual growth opportunity, given by their market-to-book value;  $Tang$  is the tangibility of assets, determined as the proportion of tangible assets (permanent) to total assets,  $Vol$  is the operational result volatility, measured as the ratio of short-term debt to total debt<sup>11</sup>;  $\alpha_i$  is the unobservable time-invariant effect of firm  $i$ , and the last term is the error.

<sup>8</sup> Financial companies were excluded because of their peculiar capital structure, since they have an accounting structure that is different from other types of firms.

<sup>9</sup> We used the average between 2000 and 2009 in all analyses and regressions, except for FE, with annual values deflated by the IPCA issued by IBGE, for the case of nominal variables. The analysis for a single year was not included in the study because of the specific context and time effect, which could skew the results in a comparative case. Therefore, we do not present the results obtained with this estimation because they were similar to those reported below.

<sup>10</sup> In real terms, deflated by the IPCA-IBGE. This was the only variable transformed into logarithms.

<sup>11</sup> In order to enhance the robustness of the results and check for endogeneity problems, regressions were made without this variable, which obtained similar results to those found in the above regression.

Table 4  
Descriptive statistics of the data.

Variables	Average	Median	Standard deviation	Minimum	Maximum
totdeb	.6341	.5935	.3246	.09301	2.9042
ltdeb	.3057	.2669	.2302	0	1.7791
stdeb	.3284	.2886	.1928	.01410	1.5678
ln(Size)	13.3159	13.429	1.6679	8.4270	18.8739
Growth	2.1037	1.2991	3.1136	−6.1000	22.2412
Prof	.05715	.07204	.1040	−.83963	.3613
tang	.4449	.4683	.2164	.0022	.9876
vol	48.6746	45.2	24.2734	0	100

Table 5  
Correlation between variables. Average for the years 2000–2009.

	totdeb	ltdeb	stdeb	ln(Size)	Prof	Growth	tang	vol
totdeb	1.000							
ltdeb	0.8108	1.000						
stdeb	0.7155	0.1713	1.000					
ln(Size)	−0.2286	−0.0991	−0.2665	1.000				
Prof	−0.4493	−0.3609	−0.3256	0.3478	1.000			
Growth	0.0798	0.0984	0.0168	0.0035	0.1125	1.000		
tang	0.0624	0.2372	−0.1781	0.1313	−0.0093	0.0093	1.000	
vol	0.1339	−0.1402	0.3927	−0.5083	−0.2927	0.0113	−0.2680	1.000

The above equations are expected to measure the effects and magnitudes of the capital structure determinants. The next section presents the results, discusses their significance and interprets these results in light of the theories discussed in Section 2.

#### 4. Empirical results

Table 4 presents the descriptive statistics of the data. Table 5 shows the cross-correlation between variables, where we see the positive correlation of size with profitability, which is a consensus in the capital structure literature, and is negative with volatility, in accordance with the theory of DeAngelo and Masulis (1980) and the results of Titman and Wessels (1988).

Fig. 1 shows the evolution of the average level of leverage for Brazilian firms (total, short and long term). Over the years, companies have kept about half of their total debt in long-term debt. We also see that there was a decrease, as of 2002, in the rates of total and long-term until in 2007, the year of the crisis, when they rose. The following year, when the effects of the crisis were lower in Brazil, these rates dropped again.

Table 6 contains regression equations 9–11. OLS and quantile regressions were run on the average values for the entire period of the study, and FE<sup>12</sup> was ran using a panel from 2000 to 2009, where the Hausman test was used to define the panel method. The regressions were performed for the three forms of debt leverage. All estimates were statistically significant at 1%. The power of explanation of the models, the  $R^2$ s, generally decreased, similar to literature. In the OLS case, the  $R^2$ s varied between 20 and 25% for the three types of debt. In the FE regression (similar in concept to  $R^2$ s) ranged between 15 and 25%. And in the QR it varied between 5 and 35%.

Through the variance analysis and the parameter slope inequality test, we found that most of the QR coefficients were statistically different from each other between the quantiles analyzed, for the three forms of leverage. This justifies the use of the QR method, which shows there are differences between quantiles for the determinants of the level of leverage.

<sup>12</sup> The results of regressions for 2009 were similar to those showed in Table 6.

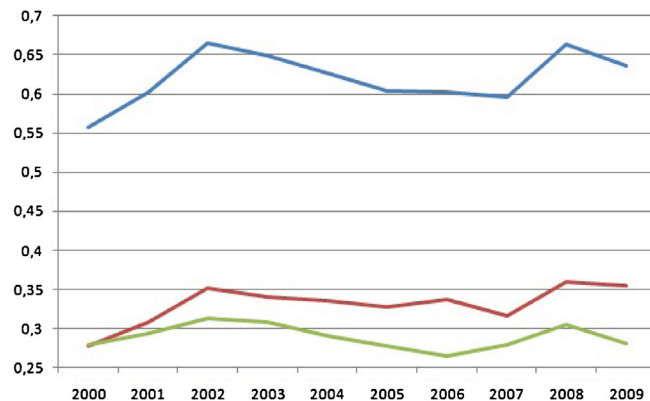


Fig. 1. Evolution of the average rate of indebtedness of companies between 2000 and 2009. Total debt (totdeb): blue, long-term debt (ltdeb): red; short-term debt (stdeb): green. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

We present the graphic results of the QR estimation (Figs. 2–4 in the Annex) in quantiles  $q = (0, 02 ; 0, 04 ; \dots ; 1)$  for the independent variables, in addition to the OLS estimates and their respective confidence intervals (CI). These graphs are a useful way of reading and interpreting the QR results, illustrating clearly the difference to the OLS results. QR is statistically different from OLS for all variables, in at least one quantile. This is reflected in the magnitude of the effects, which changes between quantiles, and reveals different interpretations for capital structure models. This result was also found for other countries by Fattouh et al. (2005) and Qiu and Smith (2007).

On the other hand, there are also similarities between the estimates. For example, equal sign effects for most regressions between the QR's 0.50 quantile and the OLS, which captures the central tendency of the estimates. As discussed in the previous section and confirmed by the results, the effects of the determinants on the short and long-term debt leverage are distinct, if not opposite.

#### 4.1. OLS, FE and QR

The OLS regression showed in most cases that the estimates had significant determinants according to the trade-off and pecking order theories. These results are in line with the results obtained by most FE regression with equivalent signs. A case in point is the study of Titman and Wessels (1988), where most of the OLS and FE estimators are in agreement with the prediction of these theories, for both the short and long-term.

The measured effects were small and statistically insignificant for certain coefficients. Particularly, for size and growth for short-term debt, and leverage and volatility for total debt. The effects on leverage of short and long-term add up to total debt. In some cases, such as tangibility and volatility, the effects on short and long-term debt are opposite.

The estimated parameters oscillated in QR, indicating that the magnitudes of the effects vary with the quantile, and therefore, with the degree of leverage. Moreover, their sign changes in some cases, making the explanatory power of the trade-off or pecking order theories depend on the leverage of the firm.

For example, for the last quantile (0.95), the long-term debt determinants are size, profitability, and tangibility, i.e., volatility and growth opportunities have no effect on the long-term debt leverage. This result is intuitive, because it is probable that highly leveraged firms, and therefore, with high bankruptcy costs, are unable to pay back/borrow in the long-term, even if they become more/less volatile or prone to grow. On the other hand, size, tangibility or profit can influence the level of debt in the long-term, because if firms grow, they become less leveraged (by definition). However, if they increase their guarantees, they become more able to borrow, and if they realize more profits they may reduce debt.

Next, we present the results of the OLS, FE and QR regressions for each determinant, verifying the significance, magnitude and effect of the estimators. Table 1 shows the prediction of each theory with respect to each variable, which allows testing the consistency of the predictions of each theory.

Table 6  
 Regressions: OLS/QR (average 2000–2009)/FE (2000–2009).

Regression	Intercept	ln(Size)	Growth	Prof	tang	vol
<b>ltdeb</b>						
OLS	.60010*** (.1145)	−.01640** (.00739)	.01088*** (.00333)	−.91949*** (.10805)	.18421*** (.04968)	−.0026*** (.00051)
FE	.32838*** (.02277)	1.5e−10 (4.7e−10)	−.00030 (.00081)	−.24397*** (.03267)	.24549*** (.03569)	−.00235*** (.00019)
QR 0.05	−0.060 (0.063)	0.011** (0.004)	0.007*** (0.001)	−0.047 (0.067)	0.081*** (0.027)	−0.001*** (0.000)
QR 0.25	0.121* (0.072)	0.011*** (0.004)	0.005* (0.003)	−0.367*** (0.089)	0.089*** (0.032)	−0.002*** (0.000)
QR 0.50	0.334*** (0.093)	0.004 (0.006)	0.008*** (0.002)	−0.665*** (0.109)	0.139*** (0.044)	−0.003*** (0.000)
QR 0.75	0.540*** (0.153)	−0.007 (0.009)	0.016*** (0.005)	−1.126*** (0.211)	0.218*** (0.063)	−0.003*** (0.001)
QR 0.95	1.338*** (0.325)	−0.057*** (0.020)	0.031 (0.023)	−2.200*** (0.447)	0.485*** (0.159)	−0.001 (0.002)
<b>stdeb</b>						
OLS	.32170*** (.09865)	−.00312 (.00636)	.00257 (.00287)	−.44372*** (.09304)	−.09077** (.04278)	.00223*** (.00044)
FE	.19803*** (.01960)	−2.5e−10 (4.1e−10)	−.00061 (.00072)	−.23272*** (.02890)	.03249 (.03076)	.00273*** (.00017)
QR 0.05	−0.136 (0.095)	0.019*** (0.006)	0.003 (0.004)	0.112 (0.089)	−0.105*** (0.040)	0.001* (0.000)
QR 0.25	−0.010 (0.060)	0.013*** (0.004)	0.009*** (0.001)	0.048 (0.077)	−0.106*** (0.030)	0.002*** (0.000)
QR 0.50	0.151** (0.062)	0.007* (0.004)	0.007*** (0.002)	−0.251*** (0.092)	−0.151*** (0.035)	0.003*** (0.000)
QR 0.75	0.350*** (0.092)	−0.004 (0.005)	0.010** (0.005)	−0.294* (0.154)	−0.176*** (0.046)	0.004*** (0.000)
QR 0.95	1.109*** (0.151)	−0.045*** (0.011)	0.011 (0.018)	−1.004*** (0.382)	−0.096 (0.111)	0.003*** (0.001)
<b>totdeb</b>						
OLS	.92180*** (.16447)	−.01953* (.01061)	.01345*** (.00478)	−1.3632*** (.15510)	.09344 (.07132)	−.00039 (.00073)
FE	.52609*** (.03308)	−1.3e−10 (7.0e−10)	−.00089 (.00121)	−.48326*** (.04838)	.27919*** (.05191)	.00038 (.00028)
QR 0.05	0.093 (0.294)	0.020 (0.018)	0.022*** (0.002)	−0.284 (0.405)	−0.090 (0.125)	−0.001 (0.001)
QR 0.25	0.237** (0.120)	0.022*** (0.008)	0.019*** (0.006)	−0.715*** (0.176)	−0.041 (0.054)	−0.001 (0.001)
QR 0.50	0.488*** (0.123)	0.011 (0.007)	0.017*** (0.004)	−1.204*** (0.131)	0.016 (0.064)	0.000 (0.001)
QR 0.75	0.923*** (0.164)	−0.015 (0.011)	0.014*** (0.003)	−1.384*** (0.211)	0.148 (0.067)	0.001 (0.001)
QR 0.95	1.926*** (0.314)	−0.061*** (0.017)	0.020 (0.011)	−2.089*** (0.160)	−0.059 (0.156)	0.001 (0.001)

Obs: standard errors in parentheses.

\*\*\*  $p$ -Value  $\leq 1\%$ .

\*\*  $p$ -Value  $\leq 5\%$ .

\*  $p$ -Value  $\leq 10\%$ .

#### 4.1.1. Size

The OLS estimation indicates a negative effect for size for the three debt leverage variables. The forecasts of [Titman and Wessels \(1988\)](#) and [Fama and French \(2002\)](#) are partially confirmed, since we found that size is negatively correlated with short-term debt in last quantile, being the case of the most leveraged firms. Thus, the prediction of both

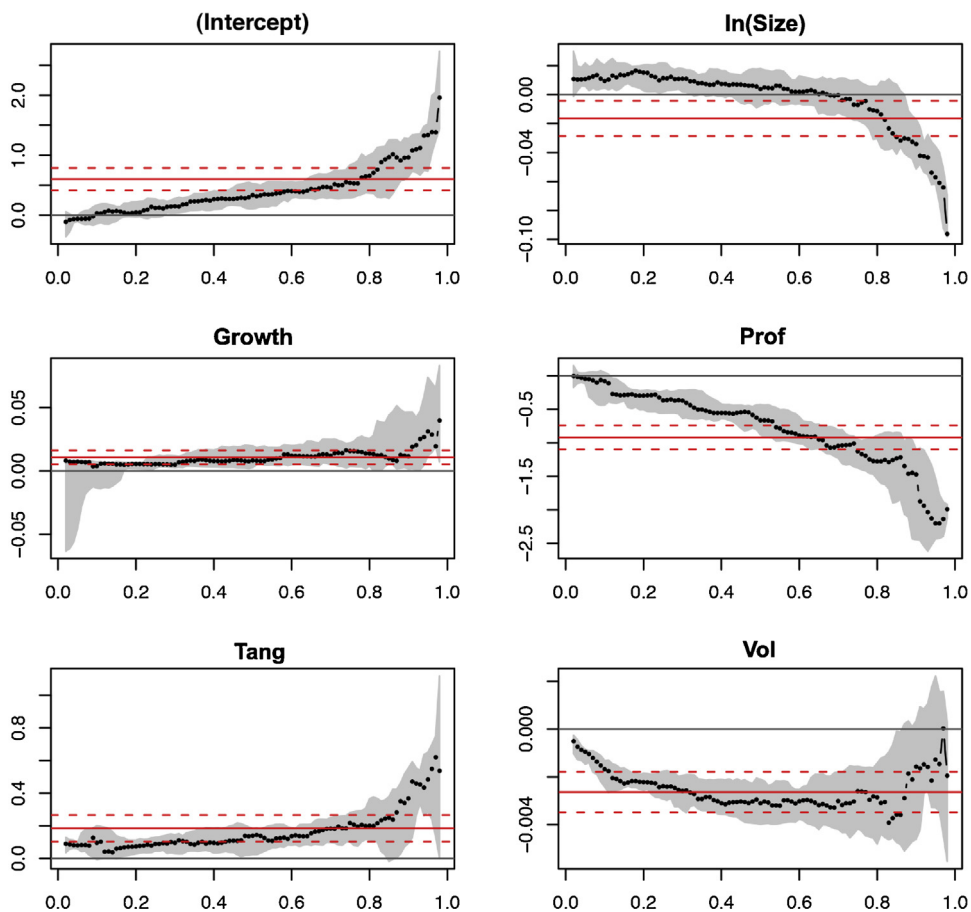


Fig. 2. QR (average 2000–2009 – Itdeb). Itdeb: black dots (QR); shaded area (95% of QR), red line (OLS) and dashed (95% OLS). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

theories, trade-off and pecking order, are partially corroborated by the results. Therefore, our prediction is confirmed, because the size effects on leverage for the last quantiles are greater on magnitude.

The QR captures distinct effects on the same variable, and indicates the validity of the three theories for the same variable, enriching our results since they offer unprecedented contributions to the Brazilian literature. The relationship between size and debt decreases with the quantile, but the effects have the same behavior for all three forms of debt leverage. They are positive for the lower quantiles and negative for the higher quantiles (and statistically significant), as accepted by the pecking order theory.

#### 4.1.2. Growth opportunity

For the OLS and QR estimates, this variable was significant for the total and long-term debt and had a positive relationship with all three forms of debt leverage. This result corroborates the study of [Moreira and Brito \(2006\)](#) and indicates the acceptance of the weak/simple version of the PO theory, which was also found by [Fama and French \(2002\)](#) for U.S. firms.

QR estimates were not qualitatively different from those of the OLS, which indicates that the coefficients follow a general trend. For the highest quantile, the estimates were not significant. The effect of growth disappears, probably because it is difficult for highly leveraged companies to take on new debt due to the high costs of bankruptcy. As for the lowest quantile, low leveraged companies have a higher borrowing margin thus the coefficient is positive and significant for the total and long term debt, showing that the opportunity for growth increases debt.

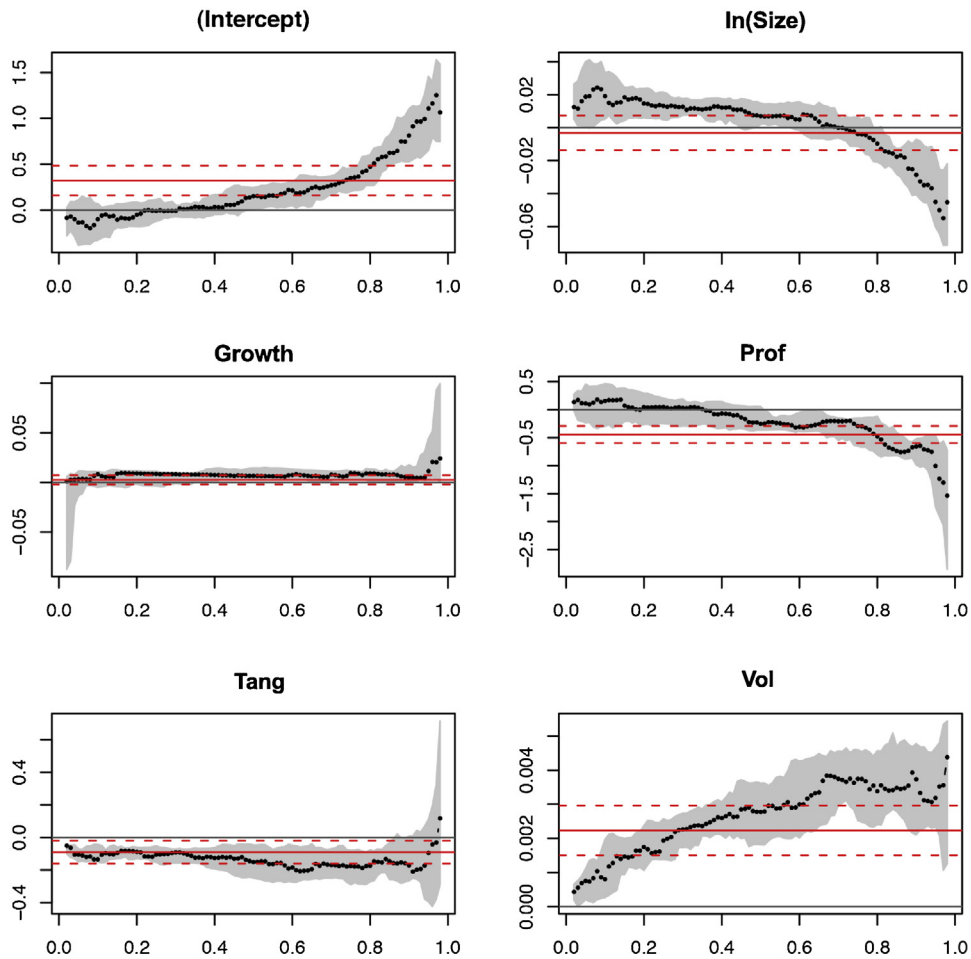


Fig. 3. QR (average 2000–2009 – stdeb). stdeb: black dots (QR); shaded area (95% of QR), red line (OLS) and dashed (95% OLS). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

#### 4.1.3. Profitability

The OLS, FE and QR estimates reveal that profitability has a negative relation with debt in all forms. Thus, we accept the PO theory, a consensus among both Brazilian (Brito and Lima, 2005; Moreira and Brito, 2006; Medeiros and Daher, 2008) and foreign studies (Rajan and Zingales, 1995; Fama and French, 2002; Frank and Goyal, 2003b).

We found that the absolute effect of profitability increases gradually with quantiles. The sensitivity of profitability is higher in most leveraged companies. In Brazil, profit in the most leveraged companies leads to greater debt reduction in comparison with lower leveraged firms. We speculate that the reason for this is that in most leveraged companies profits are directed toward the payment of debt, because they have greater urgency in decreasing such leverage. We can conclude that PO theory is strengthened as the quantile increases, i.e., profitability increases reluctance to use debt to finance the firm. This is another new result for Brazil, which was obtained with the use of QR method.

#### 4.1.4. Structure of assets: tangibility

Tangibility has distinct effects on the short and long-term leverage, for both the OLS and QR estimates. In FE, tangibility is positively correlated with debt in its three forms. For the long term, the OLS, FE and QR estimates are positive and statistically significant, as also shown by Brito and Lima (2005), providing empirical evidence for the trade-off theory. But in the short-term the effect is the opposite: the OLS and QR results were negative, in accordance with the PO theory. We note that the coefficient of tangibility on short and long-term debt increased with the quantiles (except for the last one, for the short-term). This result was expected, showing that the effect of guarantees is higher

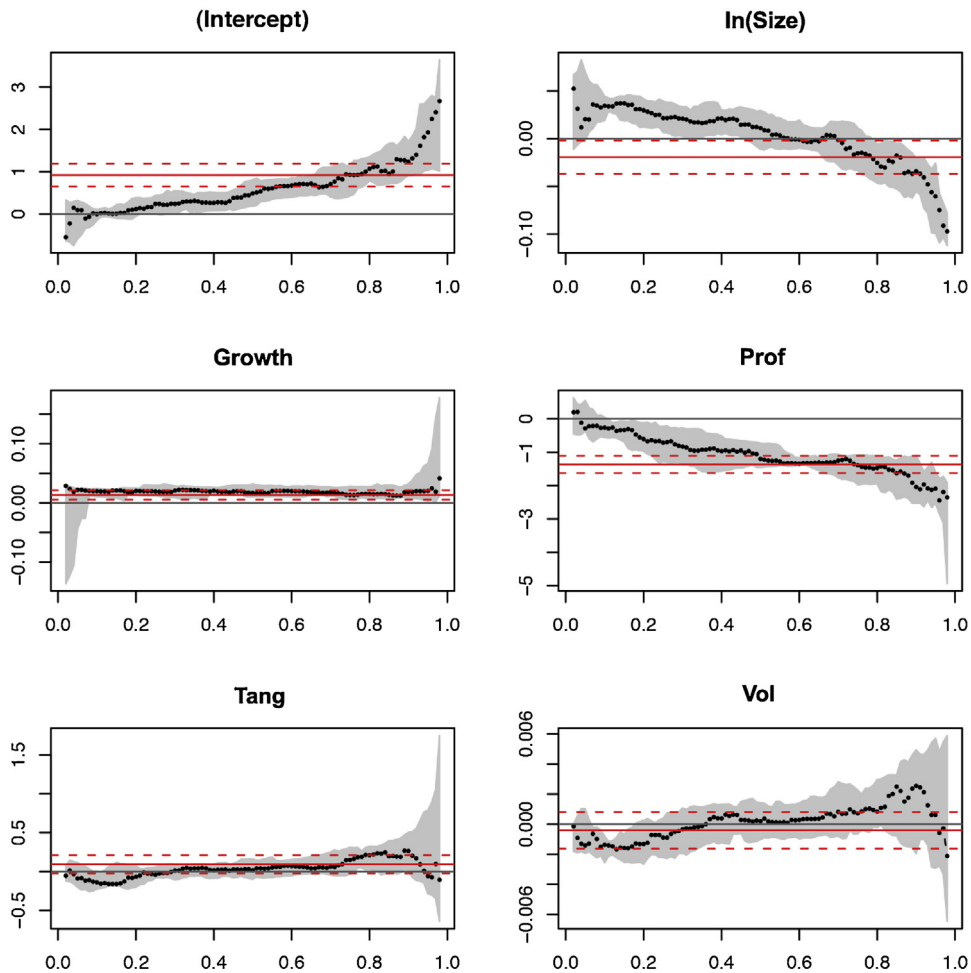


Fig. 4. QR (average 2000–2009 – totdeb). totdeb: black dots (QR); shaded area (95% of QR), red line (OLS) and dashed (95% OLS). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

for most leveraged companies. The effect is ambiguous for the total leverage, because the effects of the short and long-term add up, losing their statistical significance. In particular, QR estimates range widely across quantiles.

#### 4.1.5. Volatility of operational results: risk

The coefficients estimated by the OLS, FE and QR methods for volatility were statistically significant for the short and long-term leverages. For the total leverage, all estimates lost their significance. Long-term estimates were in accordance with the trade-off and pecking order theories: higher risk leads to a decrease in long-term leverage, because given the increase in volatility, firms must lower their bankruptcy costs. The QR estimates showed that the magnitude of the effect increases with the quantile up to the 0.75 quantile, and then decreases. For highly leveraged companies, this effect disappears in all leverage forms. We speculate that in the last quantile (not statistically significant) the risk does not matter – companies do not take on/pay off loans, as they are highly leveraged. The short-term relation is positive and increases with the quantile. The more leveraged the firm, the greater the effect of risk on short-term leverage, because these firms cannot rely on long-term debt.

## 5. Concluding remarks

This paper used the quantile regression (QR) method to investigate the determinants of debt leverage for Brazilian companies. Significant differences were found in the estimates between quantiles and between OLS and FE. The

difference between the QR and OLS estimators mainly indicates that QR does not follow the general trend observed in previous studies, which demonstrates the importance of using this method.

QR better described the distribution of Brazilian company borrowing. Coefficients that are usually assumed to be constant are distinguished by quantile and showed significant statistical differences. Thus, debt issuance policies vary according to the degree of leverage of the company. Up until now, this point has been disregarded in Brazilian studies that examined the relationship between capital structure with their determinants. Thus, we bring new insights to the analysis of Brazilian forms of capital structure. For example, in most Brazilian studies, profitability has a negative effect on leverage, i.e., the estimator is calculated independent form the company's level of leverage. Through the QR method, we found that the effect of profitability is lower for companies with lower debt leverage (lower quantile) and higher for more leveraged firms (higher quantile). We infer that the main reasons for this difference are the costs of bankruptcy and agency corresponding to debt levels, as represented by quantiles.

In previous Brazilian studies, most estimates support the pecking order theory. In this study, the competing underlying assumptions and predictions of the trade-off and pecking order theories may be accepted simultaneously, since the variable effects change with quantiles. Nevertheless, the results for variations in size and profitability showed that the pecking order theory becomes stronger as the quantile increases.

However, other factors also influence the acceptance of the above theories, i.e., different types of debt can support more than one theory. For example, in the case of tangibility, it corroborates the trade-off theory for long-term leverage and the pecking order theory for the short-term leverage. Thus, the analysis of variables, determined by type of debt, particularly quantile, provides support for both the trade-off and pecking order theories.

## Acknowledgements

The authors are grateful to financial support from CNPQ and CAPES (9207-11-2) foundation. The opinions expressed in this paper are those of the authors and do not necessarily reflect those of the *Banco Central do Brasil* or its members. The authors would also like to thank David Haxton Jr for suggestions made to this paper.

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