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RESEARCH ARTICLE

The behavior of capital structure: evidence from fast calibrated additive quantile regression

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Abstract

In finance, capital structure decisions are crucial due to their impact on the value of a firm. Some theories assert that the value of a firm is irrelevant to those decisions. However, there is a growing literature that criticizes this idea. Those studies are constructed on some modern theories, which are called trade-off theory, agency cost theory, signaling theory, and pecking order theory. This paper investigates the relationship between optimal capital structure and capital structure components. The annual data gathered from 195 firms traded in Borsa Istanbul for the period 2011-2020 is used. The fast calibrated additive quantile regression approach is chosen because of its superior properties. In that method, there is not a strong assumption about the functional form of the relationships between the dependent variable and the explanatory variables. The results indicate that the relationships between the debt ratios and the capital structure components differ for each quantile and these relations are nonlinear. Furthermore, evidence is provided for the fact that the relationships might be explained with the modern theories of capital structure.

Keywords: *Capital structure, Additive quantile regression, Non-parametric regression, Borsa Istanbul.*

JEL Codes: *G30, G31, C50*

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1. INTRODUCTION

Capital structure decisions of firms are a topic of discussion in the financial literature for a half a century. The modern theory of capital structure started with Modigliani and Miller (1958) and was studied by many researchers (Bradley et al. 1984; Albayrak and Akbulut 2008; Demirhan 2009; Mac an Bhaird 2010; Brusov et al. 2011; Aboura and Lépinette 2013; Ahmeti and Prenaj 2015; Chang 2015: 17; Jaros and Bartosova 2015; Krstevska, et al. 2017; Al-Kahtani and Al-Eraij 2018; Onyinyechi 2019; Sibarani 2020). The firm's capital structure decision is based on the proportion of the debt and equity mix used in financing the assets. Reaching an optimal capital structure that maximizes the value of the firm is the main purpose of that research. While some of the studies argue that there is no optimal capital structure that maximizes firm value, others emphasize that debt and equity mix is directly related to the firm value (Baker and Martin 2011: 2). The pioneering researchers Modigliani and Miller show that the value of a firm is irrelevant of its capital structure under stringent conditions of competitive, frictionless, and complete capital markets. Therefore, financial managers cannot maximize the firm value by the capital structures that they choose. The counter idea of Modigliani and Miller indicates that managers might decide and calculate a firm's optimal capital structure. The assumptions of Modigliani and Miller are criticized after they proposed their theory. Thus, researchers have relaxed the restrictive assumptions and proposed new theories: trade-off theory (Kraus and Litzenberger 1973), agency cost theory (Ross 1973; Mitnick 1974), signaling theory (Ross 1977), and pecking order theory (Myers 1984; Myers and Majluf 1984). These theories relate directly to taxes, asymmetric information, agency problems, and bankruptcy costs. These theories may fail to explain absolute facts about the capital structure. Even though the existence of extensive research into the area of capital structure, determining the accurate dept and equity mix that maximizes the firm's market value is still incomprehensible.

The trade-off theory indicates that there is an optimal debt and equity mix where firm value is maximized. This can be reached by identifying a balance between several benefits of issuing debt and equity. One of these benefits is lower issuance costs, another is the tax shield. The agency cost theory provides a further theoretical scheme that supports the influence of diversification strategy on capital structure (Kochhar and Hitt 1998). Based on this theory, debt has a consistent role in lightening the overinvestment behavior of financial managers. Therefore, this situation supports diversification on the debt and equity and leads the managers to an optimal capital structure. The signaling theory suggests that profitable firms should run into debt more to convince investors of how high the firm's future profits will be. The theory predicts that a firm's stock price should rise when it issues debt and fall when it issues equity (Gitman and Zutter 2012: 534). The pecking order theory propose a hierarchy of financing that begins with retained earnings, which is followed by debt financing and finally external equity financing. The theory posits that there is no optimal debt ratio, by contrast, firms will not use debt when there is still sufficient internal financing (Wei 2014).

Although the validity of those theories is tested many times in the literature, they cannot provide a clear relationship between the decisions and optimal capital structure. The studies, which tested the efficacy of those theories, have an important problem. They have a strong linearity assumption between optimal capital structure and factors that affect capital structure decisions. Yet, in nonparametric methods, there is not a strong assumption about the functional form of the relationships between the dependent variable and the explanatory variables. Especially, the fast-calibrated additive quantile regression approach avoids the model specifications errors arising from determining the wrong functional form.

The purpose of the study is to examine the capital structure of 195 firms traded in Borsa Istanbul for the period 2011-2020. The fast calibrated additive quantile regression approach is chosen due to its some superior properties against parametric approaches. We focus to explore whether the theories of firm financing (trade-off theory, agency cost theory, signaling, and pecking order theory) can explain the capital structures. We employ the total debt and long-term debt in our models as dependent variables because the theories have various empirical implications regarding various types of debt instruments.

This study is organized as follows: the literature review about the topic is given in Section 2. Section 3 presents the methodology. Data are introduced in Section 4. Section 5 presents the findings; and the conclusions are given in the last section.

2. LITERATURE REVIEW

Searching for the optimal capital structure on firm value is a challenge in finance literature. The topic is studied many times by researchers. The existing literature points out some capital structure components that might impact the value of firms. They are profitability, size, tangibility, and growth rate.

Profitability variable is a proxy for earning power of a firm. In the literature, return on assets is used as profitability variable. It can be calculated by dividing net income by total assets of a firm. While a positive relationship is expected between leverage and profitability according to the trade-off and signaling theories, a negative relationship is excepted according to the pecking order theory (Kester 1986; Friend and Lang 1988; Titman and Wessel 1988; Barton et al. 1989; Demirguc-Kunt and Maksimovic 1994; Rajan and Zingales 1995; Jordan et al. 1998; Booth et al. 2001; Al-Sakran 2001; Bevan and Danbolt 2002; Bauer 2004; Chen 2004; Huang and Song 2006; Allen and Powell 2013; Sakti et al. 2017; Al-Hunnayan 2020; Assfaw 2020; Harun et al. 2020).

Size variable is indicated as the natural logarithm of the total assets in finance. It is usually used to fit firms into a common size measure because firms in the different sectors can vary greatly in terms of size. Although a negative relationship is expected between debt ratios and size of a firm in term of pecking order theory, the expected relationship is positive according to the other theories (Kester 1986; Kim and Sorensen 1986; Titman and Wessels 1988; Friend and Lang 1988; Barton et al. 1989; MacKie-Mason 1990; Rajan and Zingales 1995; Barclay and Smith 1996; Kim et al.1998; Wiwattanakantang 1999; Booth et al. 2001; Al-Sakran 2001; Bevan and Danbolt 2002; Hovakimian et al. 2004; Huang and Song 2006; Al-Mutairi and Naser 2015; Sakti et al. 2017; Ghosh and Chatterjee 2018; Assfaw 2020; Harun et al. 2020).

Tangibility is calculated by dividing net fix assets by total assets of a firm. Net fix assets in the formula indicate the noncurrent assets minus depreciation. According to the trade-off and pecking order theory, the relationship between leverage and tangibility is positive. However, the agency cost theory states that the relationship might be positive or negative (Titman and Wessels 1988; Van der Wijst and Thurik 1993; Rajan and Zingales 1995; Wiwattanakantang 1999; Booth et. al. 2001; Drobetz and Fix 2003; Hall et. al. 2004; Huang and Song 2006; Heyman et. al. 2008; Al-Mutairi and Naser 2015; Alkhazaleh and Almsafir 2015; Sakti et al. 2017; Ghosh and Chatterjee 2018; Al-Hunnayan 2020; Assfaw 2020; Harun et al. 2020).

Growth rate is measured as the annual change of the last three years of a firm's total assets. It is a major indicator for characterizing a firm as aggressive or conservative. The relationship between debt ratios and growth rate is negative according to all theories except for the pecking order theory (Kim and Sorensen 1986; MacKie-Mason 1990; Barclay and Smith 1996; Kim et al. 1998; Friend and Lang 1998; Al-Sakran 2001; Bevan and Danbolt 2002; Cai et. al.2008; Allen and Powell 2013; Al-Mutairi and Naser 2015; Alkhazaleh and Almsafir 2015; Sakti et al. 2017; Al-Hunnayan 2020; Assfaw 2020; Harun et al. 2020).

Nearly all studies in the literature use parametric models in their analyses. Moreover, most of them set up their methodologies under the linearity assumption. However, the relationship between capital structure components and leverage might not be linear, especially for the financial data. In these circumstances, making an assumption about the functional form of the relationship between variables might not be correct. Nonparametric approaches do not make any assumption about the functional form and they can be useful to find the appropriate relationship.

3. METHODOLOGY

In this study, we use the fast calibrated additive quantile regression approach introduced by Fasiolo et al. (2020). The methodology grounds on the traditional quantile regression approach introduced by Koenker and Bassett (1978). Traditional quantile regression allows us to examine the relationship between the dependent variable (y) and k-dimensional vector of explanatory variables (x) for the different parts (quantiles, $\tau \in (0,1)$) of the dependent variable's conditional distribution. When $F(y|x)$ is the conditional cumulative distribution function (c.d.f.) of y, the τ^{th} quantile of the conditional distribution of y or τ^{th} conditional quantile is defined as. $\mu = F^{-1}(\tau|x) = inf\{y : F(y|x) \geq \tau\}$ The aim is to obtain the τ^{th} conditional quantile estimation which minimizing the following function called expected loss:

$$L(\mu|x) = E\{\rho_\tau * (y-\mu)|x\} = \int \rho_\tau * (y-\mu)dF(y|x) \quad (1)$$

where μ=μ(x) and is the control function or pinball loss that might be defined as follows:

$$\rho_\tau = (\tau-1)(y-\mu(x))I(y-\mu(x)<0) + \tau I(y-\mu(x) \geq 0) \quad (2)$$

In the context of the linear regression model, since $\hat{\mu}(x)$ is equal to $x'\hat{\theta}$, expected loss function is revised and the quantile estimator in Eq. 3 is obtained:

$$\hat{\theta} = \underset{\theta}{argmin}\frac{1}{n}\sum_{i=1}^{n}\rho_\tau\{y_i - x_i{}'\hat{\theta}\} \quad (3)$$

where x_i is the i^{th} vector of explanatory variables and θ is the vector of regression coefficients.

While traditional quantile regression assumes that the relationship between y and x is linear, the additive quantile regression does not make an assumption about the functional form of the relationship between variables. Thus μ(x), has an unknown functional form in the additive quantile regression. In the latter approach, inferences about the functional form are made from the data, that it provides a flexible approach about determining the functional form. Furthermore, μ(x) has an additive structure and so the effect of each explanatory variable on dependent variable for each quantile is assumed separate:

$$\mu(x) = \sum_{j=1}^{m} f_j(x) \quad (4)$$

In Eq. 4, the *f* function refers to the nonparametric functions of the explanatory variables. These nonparametric functions can be defined in terms of spline basis:

$$f_j(x) = \sum_{i=1}^{r} \beta_{ji} b_{ji}(x_j) \quad (5)$$

where, β_{ji} the coefficients to be estimated and $b_{ji}(x_j)$ are the spline basis functions. Spline is one of the nonparametric methods that consider nonlinear relationships between dependent variable and explanatory variables. It is based on a piecewise linear regression model. In this model, the regression line is estimated for each sample subgroup by dividing the sample into subgroups. The piecewise linear regression model is obtained by combining these lines. However, the first-order derivatives of functions used in definition of regression lines are not continuous since the junction points of combined lines, that is, the jumping points, are discrete. To eliminate this problem, spline basis functions are used.

In Eq. 5, is the spline basis dimension and chosen that we guarantee avoiding over-smoothing. f_j is controlled by penalizing the deviations from f_j and the penalty term is applied on β_{ji} Thereafter, penalized pinball loss can be defined as follows

$$V(\beta,\lambda,\sigma) = \sum_{i=1}^{n}\frac{1}{\sigma}\rho_\tau\{y_i - \mu(x_i)\} + \frac{1}{2}\sum_{j=1}^{m}\lambda_j\beta' S_j\beta \quad (6)$$

where $\lambda=\{\lambda_1,\lambda_2,\ldots,\lambda_m\}$ is the vector of smoothing parameters. $1/\sigma$ is the learning rate which balances between the loss and the penalty. S_j's are positive semidefinite matrices, and they penalize the oscillations of the corresponding effect . The minimization of Eq. 6 with respect to β for fixed λ and gives the maximum a posteriori (MAP) estimator, that is β Consequently, in the additive quantile regression approach, the estimation of the nonparametric functions or f_j for each quantile is obtained by minimizing the Eq. 6. The optimal selection of λ and is discussed detailed in Fasiolo et al. (2020).

One of the important problems that can be encountered in the studies on panel data is poolability problem. Poolability problem is related to the question of whether the relationships between variables change over time. Some parametric tests have been developed regarding whether the panel data can be pooled (Hsiao's F test (2007), etc.). However, the nonparametric poolability test developed by Baltagi et al. (1996) is defined as a robust test against model identification errors caused by a wrong functional form. In this study, the nonparametric poolability test developed by Baltagi applied to test whether the panel data can be pooled or not. The hypotheses of the nonparametric poolability test can be expressed as follows:

$$H_0: f_{it}(x) = f_i(x) \text{ , } H_1: f_{it}(x) \neq f_i(x) \quad (7)$$

where H_0 hypothesis states that the relationship between dependent and explanatory variables does not change with time. The test statistic has a standard normal distribution, N (0, 1), and the test is one-sided. According to the result of this test, when the null hypothesis cannot be rejected, the models to be estimated are shown in Eq. 8 and 9, respectively:

$$TD_{it} = \gamma + f_{5it}(PROFIT_{it}) + f_{6it}(SIZE_{it}) + f_{7it}(TANG_{it}) + f_{8it}(GROWTH_{it}) + u_{it} \quad (8)$$

$$LTD_{it} = \alpha + f_{1it}(PROFIT_{it}) + f_{2it}(SIZE_{it}) + f_{3it}(TANG_{it}) + f_{4it}(GROWTH_{it}) + \varepsilon_{it} \quad (9)$$

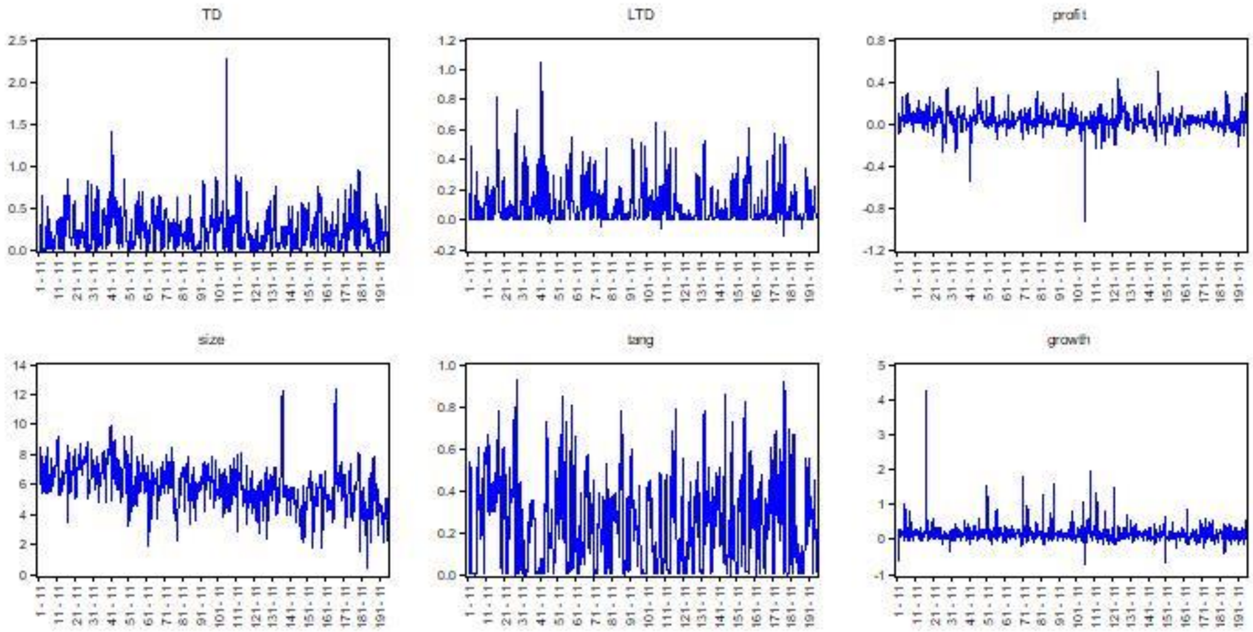
4. DATA

The panel dataset contains the financial information from 195 firms traded in Borsa Istanbul for the period 2011-2020. Financial and insurance sector firms are excluded from the data due to the different financial statement structures. To examine the capital structure, while the debt ratio and long-term debt ratio are used as dependent variables; profitability, size, tangibility, and growth rate are used as explanatory variables. Each variable gathered from the financial statements of firms. Calculations are done based on the previous three years' average amounts of each account. The descriptive statistics of variables are presented in Table 1. Also, the graphics are demonstrated in Figure 1.

Table 1. Descriptive Statistics

	Debt ratio (TD)	Long-term debt ratio (LTD)	Profitability (PROFIT)	Size (SIZE)	Tangibility (TANG)	Growth (GROWTH)
Mean	0.2320	0.0980	0.0339	5.8806	0.2419	0.1611
Median	0.1774	0.0383	0.0236	5.8523	0.2304	0.1318
Maximum	2.2721	1.0531	0.4909	12.329	0.9302	4.2683
Minimum	0.0000	-0.1126	-0.9386	0.4201	0.0000	-0.7016
Std. Dev.	0.2262	0.1340	0.0936	1.4456	0.2108	0.2317
Skewness	1.5311	1.8947	-1.0155	0.3549	0.5813	6.8150
Kurtosis	8.5150	7.3842	17.3355	4.5687	2.5780	95.7788
Jarque-Bera	3233.28	2728.52	17032.78	240.90	124.2982	714487.3
Observations	1950	1950	1950	1950	1950	1950

Figure 1. Graphics of All Variables



When summary statistics in Table 1 are examined, the maximum value of debt ratios is remarkable. If the debt ratio has a value over one, that means liabilities are exceeding the equities for some firms. It means that some of firms have overdose debt, so, those observations might create outliers in the sample. Moreover, high standard deviations indicate the existence of outliers for all variables. The outliers might be observed in graphics of all variables in Figure 1, as well. Another remarkable result is the maximum value of tangibility. The maximum value of the tangibility variable is 93% and it means that nearly all assets of some firms consist of fixed or noncurrent assets. Considering that the data contains firms from different sectors, this result might be evaluated as an expected situation. However, the summary statistics provide us some evidence that we should use quantile regression to estimate a model with our dataset. On the other hand, the calculation formulas of each variable are shown in Table 2.

Table 2. Formulas for Variables

Debt ratio (TD)	Long-Term Debt / Total Assets
Long-term debt ratio (LTD)	Total Debt / Total Assets
Profitability (PROFIT)	Net Income / Total Assets
Size (SIZE)	Logarithmic Total Assets
Tangibility (TANG)	Net Fixed Assets / Total Assets
Growth (GROWTH)	Ln(Total Assets$_t$) - Ln(Total Assets$_{t-1}$)

5. FINDINGS

In this section, firstly the theoretical sign expectations related to the capital structure components are summarized on the grounds that the literature review section (Table 3). Then, we examine whether the panel data is poolable or not by applying the poolability test introduced by Baltagi et al. (1996). Finally, the nonparametric estimation results are depicted in Figure 1 to 4. Panel A in all Figures shows the nonparametric estimation graphs for each explanatory variable in Eq.8, while Panel B in all Figures demonstrates the nonparametric estimation graphs for each explanatory variable in Eq.9. Moreover, for different quantiles, the nonparametric estimation graphs of profitability, size, tangibility, and growth are given from Figures 1 to 4, respectively. In the Figures, while Q25 represents the firms in the 25% quantile with the lowest debt level, Q75 represents the firms in the 75% quantile with the highest debt level.

Table 3. The Theoretical Expectations of Variables

Variables	Trade-Off Theory	Agency Cost Theory	Signaling Theory	Pecking Order Theory
Profitability	+	?	+	-
Size	+	+	+	-
Tangibility	+	+/-	?	+
Growth	-	-	-	+

Note: (+) sign indicates that there is a positive relationship between debt ratios and variables, (-) sign indicates a negative relationship, and (?) indicates that there is no certainty about the direction of the relationship.

Source: Frank and Goyal 2009.

The nonparametric poolability test statistics for debt ratio and long-term debt ratio are 0.588 and 0.460, respectively. When these values are compared with the critical value of 1.645 in the standard normal distribution table, it can be suggested that H_0 hypothesis cannot be rejected. Therefore, panel data generated for both debt ratio and long-term debt ratio can be pooled. The models in Eq. 8 and 9 can be used for estimation.

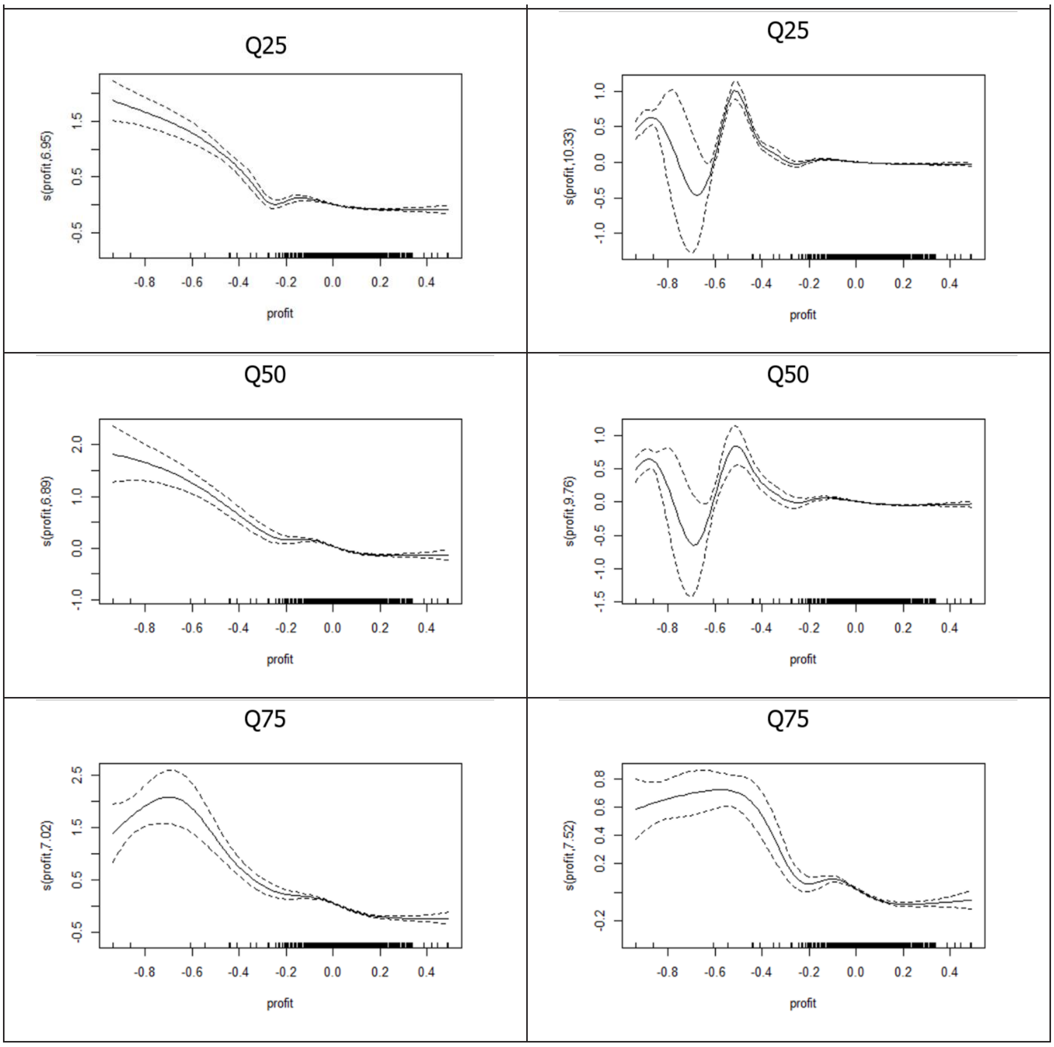
Figure 2. Estimation Results for Profitability

Panel A:

Dependent variable is Debt Ratio

Panel B:

Dependent variable is Long-Term Debt Ratio



In Figure 2, both for Panel A and B, there are negative and non-linear relationships between profitability and debt and long-term debt ratios for each quantile. In Panel A, the negative relationship is obvious and is consistent with the Pecking Order Theory. However, there is a sudden rising debt ratio in Q50 and Q25 while the lost level of firms increases. The same path can observed in Panel B and this finding is related to the Signaling Theory. There is a threshold in Q75 when the firms' profitability level reaches deep. The 75th quantile represents the firms that have very high-level debt ratios. Thus, firms with both high debt ratios and low profitability must reduce their debt level after a certain level due to the increased risk. This finding is related to the Trade-Off Theory. In Panel B, as the profitability level of firms increases, they choose the lower borrowing path. This finding is also consistent with the Pecking Order Theory. Moreover, the debt level is rising for the firms in the lower quantile (Q25). The reason for this is due to the desire of companies that want to give a strong company signal in accordance with the Signaling Theory, not to increase their total debt level, but to increase their long-term debt level. They are trying to send a signal to the market "We are a strong firm, and we can find easily debt". On the other hand, there are thresholds in each quantile when the firms' long-term debt level decreased. The reason for those findings is the Trade-Off Theory, as well.

Figure 3. Estimation Results for Size

Panel A: **Dependent variable is Debt Ratio**	**Panel B:** **Dependent variable is Long-Term Debt Ratio**

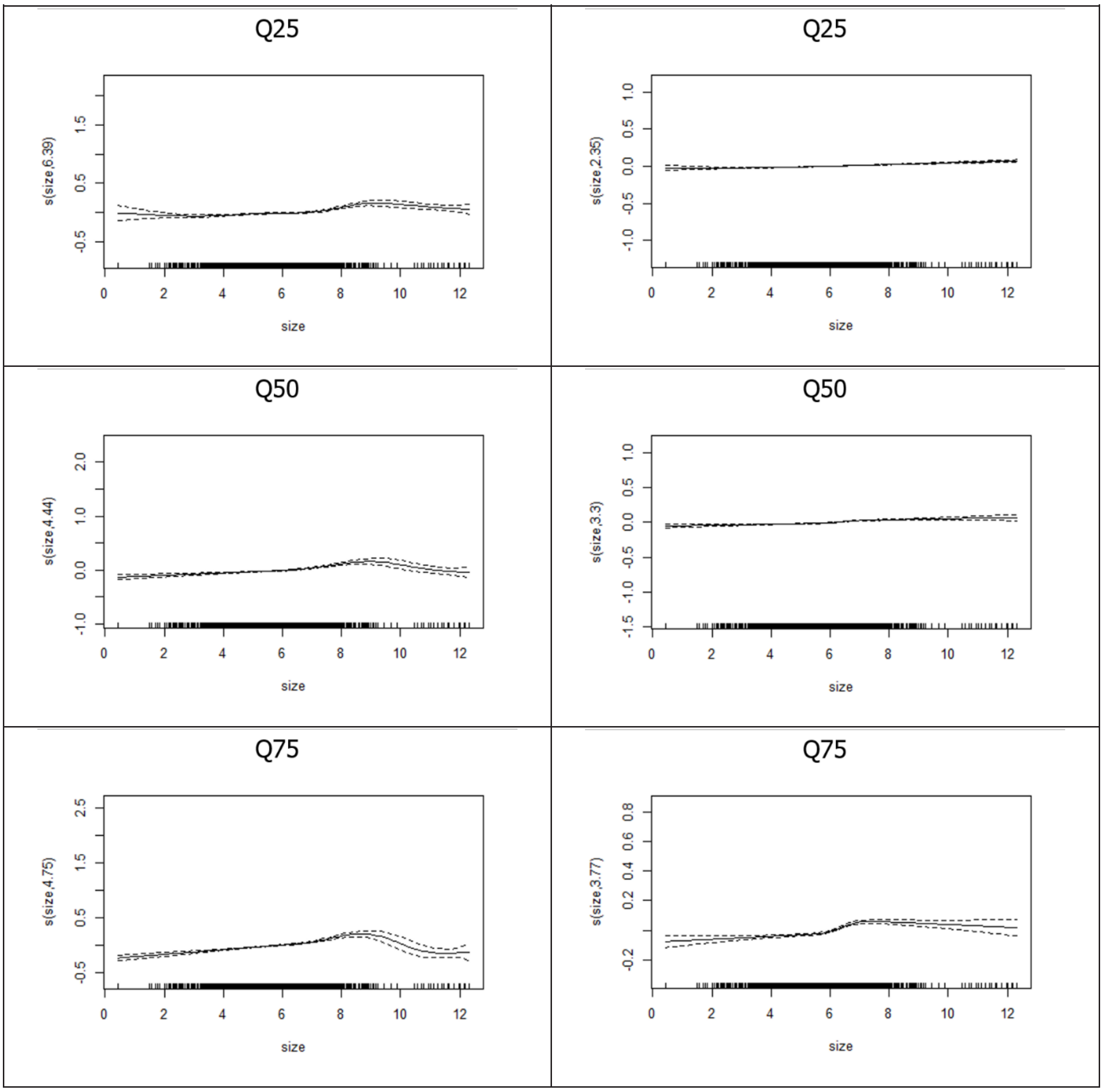
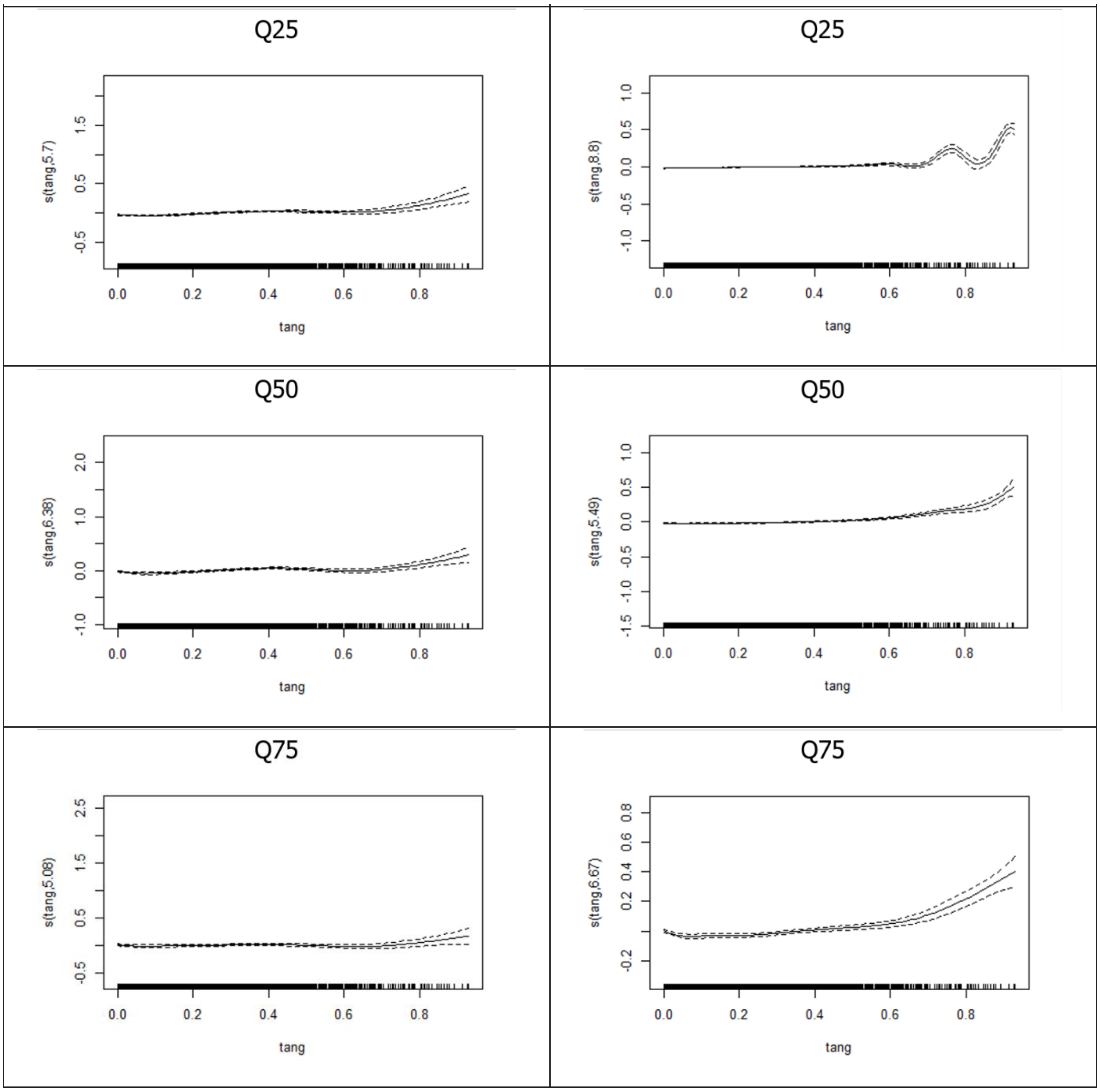


Figure 3 (both Panel A and B) suggests that there are slightly positive relationships between size and debt and long-term debt ratios in all quantiles. In Panel A, the positive relationship is clear. Growing firms increase their debt level in order to show themselves financially strong (related with the Signaling Theory) and gain the benefit of the tax advantage of debt (related with the Trade-off Theory). There are also thresholds in each quantile when the firms reached a certain size level. Those firms need a high debt ratio to finance their growth, however, the debt ratio is falling after a sufficient level because of increased risk. This finding is consistent with the Pecking Order Theory. In Panel B, the positive relationship between size and long-term debt ratio seems weak, except for Q75. One can easily observe the existence of the Pecking Order Theory in Q75.

Figure 4. Estimation Results for Tangibility

Panel A: Dependent variable is Debt Ratio | **Panel B: Dependent variable is Long-Term Debt Ratio**



In Figure 4, there is a flat and nonlinear relationship between the tangibility and the debt ratio in all quantiles of Panel A. In lower tangibility levels, the magnitude is nearly zero for the Q50. However, the debt ratio is rising when the firms reached high tangibility levels in all quantiles. This finding is consistent with all theories in the literature (Table 3). In Panel B, there is a positive and nonlinear relationship between the tangibility and the long-term debt ratio in all quantiles. The positive relationship is very clear in high tangibility levels. The tangibility variable represents the proportion of fixed (long-term) assets in total assets. One might expect that the investment of long-term assets is financed by long-term liabilities. Thus, the increase in long-term debts in proportion to the increase in tangibility level is interpreted as a situation which is suitable for the financing logic. Those findings are consistent with the Trade-Off, the Agency Cost, the Pecking Order Theories.

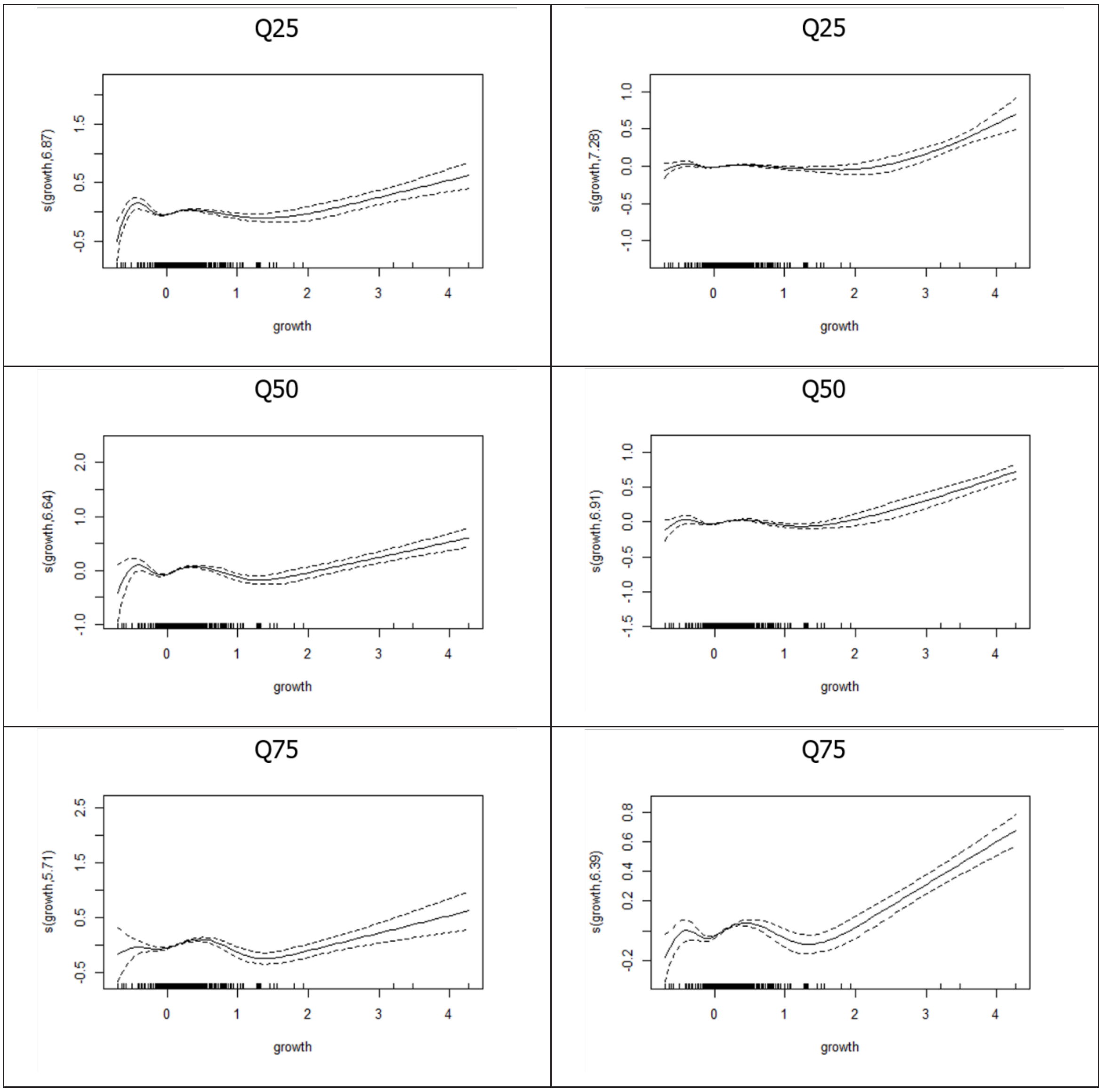
Figure 5. Estimation Results for Growth

Panel A:

Dependent variable is Debt Ratio

Panel B:

Dependent variable is Long-Term Debt Ratio



In Figure 5, there is a positive and nonlinear relationship between the growth rate and the debt and long-term debt ratio in all quantiles of Panel A and B. The relationship between debt and long-term ratio and growth, which is flat up to a certain level, becomes positive afterward. High growth rates have an increasing effect on debt ratios. The findings show that companies are ordered hierarchically from internal resources (retained earnings) to external resources (debts), according to the Pecking Order Theory.

6. CONCLUSION

One of the questions that have plagued the finance literature for a long time is whether there exists an optimal capital structure, or not. The pioneering research about the topic is by Modigliani and Miller (1958). They indicate a new perspective on optimal capital structure in their paper. Using arbitrage arguments, they state that the capital structure decisions do not matter under very restrictive assumptions. However, many theories reveal that the opposite of this idea exists. The major ones are the trade-off theory, the agency cost theory, the signaling theory, and the pecking order theory. The validity of these theories has been tested many times in the financial literature. Yet, they fail to execute a certain and clear relationship between capital structure decisions and optimal capital structure. The methods testing the validity of these theories have a crucial problem. They have a strong assumption that the relationship between optimal capital structure and the factors that affect capital structure decisions is linear.

In nonparametric methods, there is no a priori assumption regarding the functional form of the relationships between the dependent variable and the explanatory variables. Functional form flexibility in the fast calibrated additive quantile regression approach averts model specification errors arising from the wrong functional form. In this regard, this approach has superior features to the traditional quantile regression approach.

The aim of the study is to investigate the optimal capital structure of 195 firms traded in Borsa Istanbul for the period 2011-2020. Particularly, we would like to examine whether the theories of firm financing (trade-off theory, agency cost theory, signaling, and pecking order theory) can explain the optimal capital structures or not. According to the existing literature, the total debt and long-term debt ratios are selected as dependent variables; profitability, size, tangibility, and growth rate (which called capital structure components) are used as explanatory variables.

The results show that the relationships between the debt ratios and the capital structure components differ for each quantile and these relations are obviously nonlinear. Moreover, the relationships might be explained with the modern theories of capital structure. While the behavior of growth rate variable is related to the Pecking Order Theory, the behavior of profitability and size variables are consistent with the Trade-Off, the Signaling, and the Pecking Order Theories. Furthermore, the behavior of the tangibility variable is consistent with the Trade-Off, the Agency Cost, the Pecking Order Theories.

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