“Trade-off theory of capital structure: evidence from estimations of non-parametric and semi-parametric panel fixed effect models”

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Trade-off theory of capital structure: evidence from estimations of non-parametric and semi-parametric panel fixed effect models

Abstract

A firm's capital structure decisions constitute an essential research topic academically and practically. In this study, the author uses the data of US listed firms to test the traditional trade-off theory of capital structure, which posits that firms should balance the benefit of tax shields and costs of financial distress to purse an optimal debt ratio. Therefore, to determine the complex relationship between firm value and debt ratio and avoid the problem of model misspecification, the author adopts the non-parametric fixed effect model and semi-parametric (partially linear) fixed effect model. Our empirical results reveal that a nonlinear and asymmetric relationship exists between firm value and market debt ratio, thus, considerably supporting trade-off theory. Moreover, the use of different definitions of key variables and various kernel functions engenders robust results. Overall, the author suggests that firm managers should employ financial leverages appropriately to maximize firm value.

Keywords: firm capital structure, trade-off theory, optimal debt ratio, non-parametric and semi-parametric panel fixed effect model, partially linear model.
JEL Classification: G32, G33, C23.

Introduction

A firm's capital structure decisions, including the choice of debt financing or equity financing, the pursuit or maintenance of an optimal debt ratio, and the various determinants of financing factors have consistently constituted an essential topic in academic research. In general, they can be summarized into two major capital structure theories depending on the existence of an optimal debt ratio: trade-off theory and pecking-order theory. However, most of the previous studies use only traditional estimation techniques, such as the linear regression model or the dynamic adjustment model, which may not adequately determine or show the complex, nonlinear effects of debt financing on firm value. Hence, this study is conducted primarily to test the extent to which trade-off theory or pecking-order theory is supported by applying the framework of non-parametric and semi-parametric (i.e., partially linear model) estimation techniques.

Academic studies on capital structure can be traced back as early as the theoretical framework of Modigliani and Miller (1958, 1963). Subsequent research can be summarized into two major theories. First, regarding trade-off theory, studies argue that the use of debt financing has its own advantages and disadvantages; therefore, firms should balance these two opposite effects to seek and maintain an optimal debt ratio. For example, Modigliani and Miller (1963) and Shyam-Sunder and Myers (1999) illustrate the benefits of tax shields under an optimal debt ratio and the costs of financial distress over the optimal debt ratio, respectively. In addition, Jensen and Meckling (1976), Myers (1977), Stulz (1990), Hart and Moore (1995), and Morellec, Nikolov, and Schurhoff (2012) propose the perspective from managers' agency problems. Overall, firms should, thus, maintain an optimal debt ratio to balance these benefits and costs. In addition, Fischer, Heinkel, and Zechner (1989), Leary and Roberts (2005), Hennessy and Whited (2005), Flannery and Rangan (2006), Hennessy and Whited (2007), Strebulaev (2007), Huang and Ritter (2009), and Elsas and Florysiak (2015) subsequently investigate whether firms adjust toward an optimal debt ratio, which may imply that trade-off theory is supported. They use various partial adjustment models to determine the speed of such adjustments, revealing that firms indeed adjust toward their own debt targets.

Second, in the traditional pecking-order theory, the earliest research is that by Donaldson (1961), who illustrates that managers prefer the initial use of internal funding such as retained earnings to fund investments, followed by the use of debt financing as a source of external funding, and finally the use of equity financing as a source of external funding. In addition, Myers and Majluf (1984) and Myers (1984) propose the modified pecking-order model; they reveal that because of the information asymmetry between better-informed managers and less-informed outside investors, outside investors often view equity financing as an unfavorable signal. Therefore, to avoid the negative impact associated with such an unfavorable signal, firm managers should choose their financing decisions as follows: the first option is retained earnings, the second option is debt financing, and the final option is equity financing.

Finally, in addition to these two traditional capital structure theories, Baker and Wurgler (2002) propose the argument of market timing, which describes firms' behavior of timing the market to make

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their financing decisions. Moreover, Jenter (2005), Huang and Ritter (2005), Alti (2006), and Kisgen (2006) examine the effect of market timing on firms financing decisions. Lemmon, Roberts, and Zender (2010) also reveal that most firms' debt ratio is affected by unobserved time-invariant effects. Frank and Goyal (2009) investigate the main determinants of capital structure, and they identify the main factors to include median industry leverage, market-to-book assets ratio, tangibility, and profits. Fan, Titman, and Twite (2012) conduct a study on the firms of developed and developing countries to compare their capital structure and debt maturity internationally. Robb (2014) examines the capital structure choices for new firms and determines that most of such firms use external debt financing. Focusing on the data of US firms, Graham, Leary, and Roberts (2015) find that the use of debt financing by such firms has increased significantly in the past 50 years.

According to these mixed findings in the literature, we can observe that the determinants of firm capital structure are complex and that firm capital structure decisions still constitute a topic that is not entirely conclusive. Therefore, in this study, we examine whether there exists an optimal capital structure considering the benefits of tax and the costs associated with financial distress and agency problems, according to trade-off theory; this implies that the use of debt financing should have a positive (negative) effect on firm value under (over) the optimal debt ratio. Hence, we use the non-parametric and semi-parametric estimation methods, which have the advantages of obviating the necessity of restricting functional forms to avoid incorrect preassumptions about the relationship between the debt ratio and firm value. The empirical results of both the non-parametric and semi-parametric estimations reveal that firm value increases (decreases) with an increase in the debt ratio under (over) the optimal debt ratio by approximately 20% on average, thus supporting trade-off theory.

Overall, our contribution to the literature is threefold. First, we provide new insights into the controversy regarding the trade-off and pecking-order theories in the literature. Second, the optimal debt ratio found in this study can be used as a reference for future research and practical operations. Third, our framework may serve as a reference for other financial studies that explore nonlinear relationships among financial variables.

The remainder of this paper is organized as follows. Section 1 presents the datasets used in this study and provides summary statistics. Section 2 describes the empirical methodology, including the fixed effect model, and the non-parametric and semi-parametric estimation methods in panel data. Section 3 presents our main empirical results and the robust estimations. Final section provides the conclusion.

1. Data

The datasets used in this study comprise annual data regarding publicly traded US corporations and are derived from the Standard and Poor's Compusat database. Financial firms (SIC 6000-6999) and regulated utilities (SIC 4900-4999) are excluded because of their specific financial capital structure. Because we adopt balanced panel data, we exclude variables with gaps during our sample period that starts from 1971[1]. All variables used in this study are defined mainly by referring to the literature (Rajan and Zingales, 1995; Hovakimian, 2003; Hovakimian et al., 2001; Fama and French, 2002; Flannery and Rangan, 2006). For example, we define our key variable used to measure debt financing by following the definition of Flannery and Rangan (2006), who use five definitions ofthe variable of market or book debt ratio (namely *MDR*, MDR_a, MDR_b, MDR_c, and *BDR*) to obtain acorrect inference regarding the determinants of capital structure and, thus, derive robust results. In addition, for measuring firm value (*FirmValue*), we use the natural log of total firm value as its proxy. We also use a set of firm characteristics ($X_{i,t}$) as control variables, which are commonly used in the described literature. Such variables include the variable of earnings before interest and taxes (*EBIT*), which is used to control for profitability; the ratio of depreciation to total assets (*Dep*); the ratio of property, plant, and equipment to total assets, which is used to measure the proportion of fixed assets (*FA*); a dummy variable for R&D expenses (*R&D_DM*); the ratio of R&D expenses to total assets (*R&D_Ratio*); financial deficit (*Findep*); and the ratio of market to book assets (*M/B*). Detailed definitions of variables and descriptive statistics are presented in Appendix A and Table 1. All variables are centered at the 1st and 99th percentiles to avoid the influence of extreme observations.

Table 1. Summary statistics

This table reports the summary statistics used in our study. *MDR*, MDR_a, MDR_b, and MDR_c represent the four definitions of market debt ratio, and BDR represents the book debt ratio. *EBIT* denotes the earnings before interest and taxes, which is used to control for profitability; *FirmValue* denotes the proxy for firm value; *Dep* denotes the ratio of depreciation to total assets; *FA* denotes the ratio of property, plant, and equipment to total assets, which is used to measure the proportion of fixed assets; *R&D_DM* denotes the dummy variable for R&D expenses; *R&D_Ratio* denotes the ratio of R&D expenses to total assets; *Findep* denotes financial deficit; and *M/B* denotes the ratio of market to book assests. All variables are centered at the 1st and 99th percentiles to avoid the influence of extreme observations.

	Mean	Median	Std. Dev.	Min.	Max.
MDR	0.281	0.260	0.197	0.000	0.990

[1] We collect datasets associated with active firms to increase the time dimension and reduce the bias of a short time dimension (Anderson and Hsiao, 1981; Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell, Bond, and Windmeijer, 2000; Hsiao, Pesaran, and Tahmiscioglu, 2002). However, to some extent, these may result in a selection bias problem, but this is not very severe.

Table 1 (cont.). Summary statistics

	Mean	Median	Std. Dev.	Min.	Max.
BDR	0.255	0.247	0.158	0.000	1.642
MDR_a	0.160	0.144	0.127	0.000	1.830
MDR_b	0.432	0.437	0.198	0.019	0.997
MDR_c	0.243	0.172	0.625	0.000	12.847
FirmValue	20.444	20.573	1.902	15.396	25.513
EBIT	0.119	0.117	0.078	-0.289	0.494
DEP	0.046	0.042	0.023	0.002	0.203
FA	0.428	0.403	0.224	0.005	0.950
R&D_Ratio	0.008	0.000	0.017	0.000	0.162
R&D_DM	0.010	0.000	0.077	-0.836	0.766
FINDEF	0.374	0.000	0.484	0.000	1.000
MB	1.179	0.963	0.765	0.121	11.680

2. Empirical methodology

2.1. Non-parametric fixed effect model. According to the described issue, we construct our empirical model by using the non-parametric fixed effect (NFE) model, which is specified as follows:

$$FV_{i,t} = \alpha_i + m(MDR_{i,t-1}) + \varepsilon_{i,t}, \quad (1)$$

where $i = 1, \ldots, N$ represents firm 1, firm 2,..., firm N; $t = 1,\ldots, T$ represents year 1, year 2,..., year T; $\alpha_1,\ldots, \alpha_N$ represents the fixed effect used to measure individual-specific effects, which are treatedas individual constant terms; and $\varepsilon_{i,t}$ represents the error term. Moreover, $FV_{i,t}$ denotes *FirmValue*, which is our dependent variable, and the lagged variable $MDR_{i,t-1}$ denotes the market debt ratio (*MDR*), which is our key independent variable; the error term $\varepsilon_{i,t}$ is an independent and identically distributed variable. In addition, $m(MDR_{i,t-1})$ is an unknown functional form representing the effect of *MDR* on *FirmValue*. This functional form is expected to capture a nonlinear effect of debt ratio on firm value, according to trade-off theory. However, if $m(MDR_{i,t-1}) = X'_{i,t-1}\beta$, in linear parametric form, it is degenerated to the traditional parametric fixed effect linear model, which implies the existence of a linear relationship between firm value and debt ratio; this is inconsistent with trade-off theory. First, according to the procedure presented by the method of Ullah and Roy (1998), we apply the local linear estimation approach involved in non-parametric estimation techniques to remove the constant term α_i and, then, yield the local fixed effect estimator of $\gamma(MDR_{i,t-1})$ by minimizing the following expression:

$$\sum_{i=1}^{N}\sum_{t=1}^{T}\left(FV_{i,t} - \overline{FV}_{i,\bullet} - \left(\overline{MDR}_{i,\bullet} - MDR_{i,t-1}\right)\gamma\left(MDR_{i,t-1}\right)\right)^2 K\left(\left(MDR_{i,t-1} - MDR\right)/h\right), \quad (2)$$

where $K(MDR_{i,t-1} - MDR)/h$ is a kernel function in our study[2]. Specifically, $K(u) = K\left((MDR_{i,t-1} - MDR)/h\right) = 1/\sqrt{2\pi}\exp(-0.5\mu^2), \mu \in [-\infty, +\infty]$, where h is the optimal band width. Subsequently, according to Ullah and Roy (1998), we can obtain the estimator of the marginal effect (i.e., the derivative term) of the *MDR* on *FirmValue* as follows:

$$v_{NFE}\left(MDR\right) = \sum_{i=1}^{N}\sum_{t=1}^{T}\frac{\left(FV_{i,t} - \overline{FV}_{i,\bullet}\right)\left(\overline{FV}_{i,\bullet} - FV_{i,t-1}\right)K\left(\left(FV_{i,t-1} - FV\right)/h\right)}{\sum_{i=1}^{N}\sum_{t=1}^{T}\left(\overline{FV}_{i,\bullet} - FV_{i,t-1}\right)^2 K\left(\left(FV_{i,t-1} - FV\right)/h\right)}. \quad (3)$$

Moreover, before the estimation of Equation (3) is performed, the optimal band width selection approach must be determined. Accordingly, by following the approaches of Yatchew (2003) and Li and Racine (2007), we apply across-validation function for determining the band width, which can be expressed as follows:

$$\min_h CV\left(h\right) = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\left[FV_{i,t} - \hat{f}_{-i,-t}\left(MDR_{i,t-1};h\right)\right], \quad (4)$$

where $\hat{f}_{-i,-t}(MDR_{i,t-1};h)$ denotes a non-parametric estimator obtained by omitting the (i,t) th observation. Specifically, we must estimate the cross-validation function and, then, use the derived value to estimate the marginal effect of the *MDR* on *FirmValue*.

2.2. Semi-parametric fixed effect model. The NFE model presented in the preceding section has some shortcomings. In particular, the model cannot incorporate other control variables, and this may engender the omitted-variable bias. Therefore, we further consider the following model:

$$FV_{i,t} = \alpha_i + m\left(MDR_{i,t-1}\right) + X'_{i,t-1}\beta + \varepsilon_{i,t},$$
$$i = 1,\ldots,N,\ t = 1,\ldots,T, \quad (5)$$

where the definitions of all variables are the same as those in Equation (1), apart from the additional variable $X_{i,t-1}$, which is a control variable in linear form and is used to control other firm characteristics[3] including profitability (*EBIT*); the ratio of depreciation to total assets (*Dep*); the fixed asset proportion (*FA*); dummy variable for R&D expenses (*R&D_DM*); the ratio of R&D expenses to total assets (*R&D_Ratio*); financial

[2] We apply other kernel functions, namely Triangular, Quartic, Epanechnikov, and Triweight functions, and obtain similar findings. Therefore, we adopt the Gaussian kernel function as our main function in this paper.

[3] The SFE model is also called the partially linear model in this paper.

deficit (*Findep*), and the ratio of market to book ratio of assets (*M/B*). By following the approaches of Li and Stengos (1996) and Ullah and Roy (1998), we use the procedure of Robinson (1998) and transform equation (5) as follows:

$$R_{i,t}^{FV\cdot MDR} = R_{i,t}^{X\cdot MDR}\beta + \varepsilon_{i,t} \quad (6)$$

where $R_{i,t}^{FV\cdot MDR} = FV_{i,t} - E(FV_{i,t}\left|MDR_{i,t}\right.)$

and $R_{i,t}^{X\cdot MDR} = X_{i,t} - E(X_{i,t}\left|MDR_{i,t}\right.)$.

We can then use the ordinary least squares method to directly obtain the following equation:

$$\hat{\beta}_{SFEL} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} R_{i,t}^{X\cdot MDR\prime} R_{i,t}^{X\cdot MDR}\right)^{-1} \cdot \cdot \sum_{i=1}^{N}\sum_{t=1}^{T} R_{i,t}^{X\cdot MDR\prime} R_{i,t}^{FV\cdot MDR}, \quad (7)$$

where the subscript *SFEL* represents the semi-parametric fixed effect (SFE) linear estimator. However, $E(FV_{i,t}\left|MDR_{i,t}\right.)$ and $E(X_{i,t}\left|MDR_{i,t}\right.)$ must first be specified to obtain the estimator $\hat{\beta}_{SFEL}$. By referring to the procedure of Li and Stengos (1996), we use the kernel estimator of Nadaraya (1964) and Watson (1964)[4]. Once $\hat{\beta}_{SFEL}$ is obtained, we apply the approach of Ullah and Roy (1998) to reformulate the function as an alternative of the NFE model, which is expressed as follows:

$$FV_{i,t}^{*} = FV_{i,t} - \widehat{FV}_{i,t} = \alpha_i + m\left(MDR_{i,t-1}\right) + \varepsilon_{i,t} \quad (8)$$

Finally, we can also obtain the SFE estimator of the derivative of $m(MDR)$, $\gamma(MDR)$, by using identical procedures to those in the preceding section, which can be expressed as follows:

$$\gamma_{SFE}\left(MDR\right) = \sum_{i=1}^{N}\sum_{t=1}^{T} \frac{\left(MDR_{i,t} - \overline{MDR}_{i,\cdot}\right)\left(FV_{i,t}^{*} - \overline{FV}_{i,\cdot}^{*}\right)K\left(\left(MDR_{i,t-1} - MDR\right)/h\right)}{\sum_{i=1}^{N}\sum_{t=1}^{T}\left(MDR_{i,t} - \overline{MDR}_{i,\cdot}\right)^{2} K\left(\left(MDR_{i,t-1} - MDR\right)/h\right)} \quad (9)$$

3. Empirical results

In this section, we test the trade-off theory that states that firms should balance the benefits of tax shields and costs of financial distress, thus, implying a nonlinear effect of debt ratio on firm value. Hence, we apply the non-parametric and semi-parametric approaches to the panel data to determine this nonlinear and asymmetric relationship between debt ratio and firm value.

3.1. NFE model estimation. First, we apply Equation (1), representing the NFE model:

$$FM_{it} = \alpha_i + m(MDR_{i,t-1}) + \varepsilon_{i,t},$$
$$i = 1,...,N, t = 1,...T.$$

In particular, $m(MDR_{i,t-1})$ is an unknown function form representing the effect of the *MDR* on *FirmValue*. First, the kernel function must be determined and the band width must be selected. In this tudy, we use the Gaussian density as the main kernel function[5], and we apply the cross-validation function for selecting the optimal band width. Figure 1 indicates that a minimum value of 0.15 is the most appropriate for the band width in this NFE estimation.

After the band width selection, we can evaluate the function form $m(MDR_{i,t-1})$ and its derivative $\gamma(MDR_{i,t-1})$, which describes the marginal effect of the *MDR* on *FirmValue*. The values of the derivative of $m(MDR_{i,t-1})$, $\gamma(MDR_{i,t-1})$, are summarized in Figure 2. Notably, the solid line for each point on the X-axis represents the individual marginal effect of the *MDR*. For example, when the *MDR* is 0.1 (on the X-axis), the derivative of $m(MDR_{i,t-1})$, $\gamma(MDR_{i,t-1})$, is approximately 0.3 (on the Y-axis); this indicates that if *MDR* is 10%, a positive marginal effect (0.3) is exerted on *FirmValue*. Specifically, the Y-axis is not a direct measurement of *FirmValue*; instead, it represents the values of the derivative of $m(MDR_{i,t-1})$, $\gamma(MDR_{i,t-1})$.

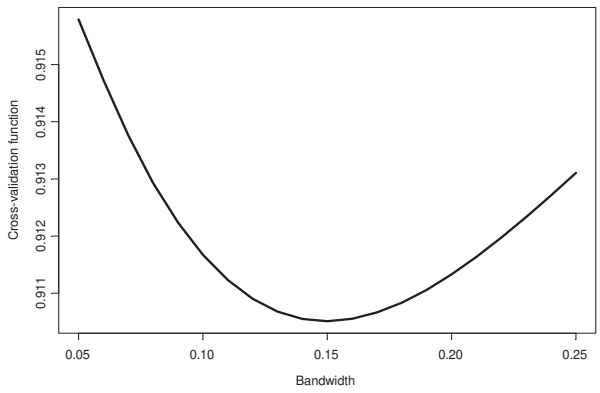

Fig. 1. Cross-validation function for the NFE model

[4] We also use the cross-validation function to specify the optimal band width for each estimator.
[5] We apply other kernel functions, namely Triangular, Quartic, Epa-nechnikov, and Triweight functions, and obtain identical findings.

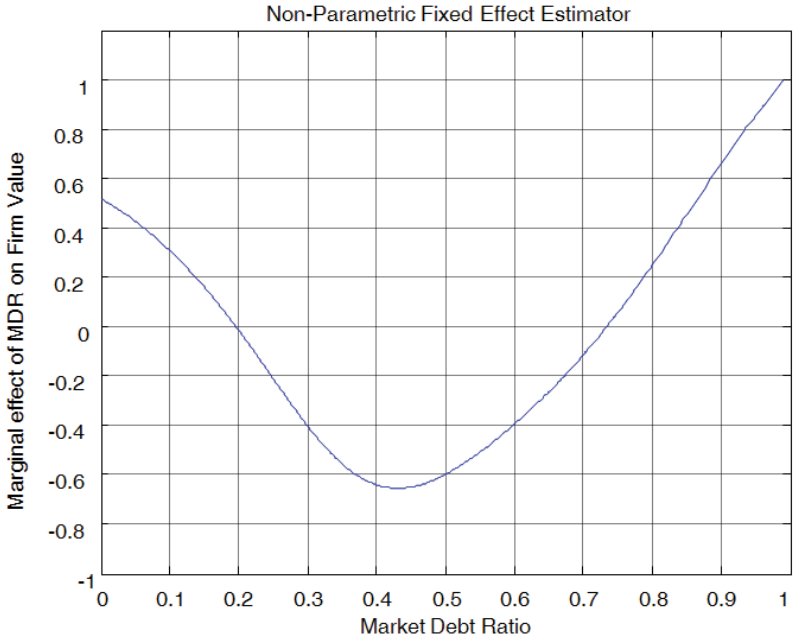

Fig. 2. Marginal effect of the *MDR* on *FirmValue*, as determined from the NFE model

The results illustrated in Figure 2 provide some major implications, which are described as follows. First, as the *MDR* increases from 0 to 0.2, its marginal effect on *FirmValue* exhibits a positive drop (from approximately 0.55 to 0). Specifically, during this stage, firms can fully enjoy the tax advantages of debt interests; nevertheless, as the debt ratio increases, this marginal effect decreases because of the increase in the costs associated with financial distress and agency problems.

Second, as the MDR increases from 0.2 to 0.45, its marginal effect on *FirmValue* demonstrates a negative increase (from approximately 0 to -0.62). This negative effect may be because the cost of financial distress far exceeding the tax advantages of debt interests. Specifically, the burden of debt financing is higher than the tax shield.

Third, as the MDR increases from 0.45 to 1, its marginal effect on *FirmValue* demonstrates a negative drop first, and, then, a positive increase (from approximately -0.62 to 1). We provide two possible explanations for these two findings. The first explanation is based on the perspective of debt capacity (Lemmon and Zender, 2010). From this perspective, firms should have their own debt capacity and firms with high leverage should lower their debt capacity; therefore, firms with high leverage face difficulty in financing their capital with debt, even if they certainly need funding capital for their operations. Therefore, if firms can obtain new debt financing during this stage, their operations can be considerably improved and facilitated. The second explanation is based on the extreme situation of debtor-in-possession financing (DIP financing). That is, when firms are in financial distress, the new debt financing provides considerable assistance to the firms.

In addition to the overall results illustrated in Figure 2, we provide the detailed marginal effects of the *MDR* on *FirmValue* in each regime in Table 2, which presents the same results as those in the figure, but reports them numerically. To sum up, we can infer that firms actually simultaneously enjoy the benefits of tax shields and face the costs associated with financial distress and agency problems; hence, their capital structure determinants are consistent with trade-off theory.

Table 2. NFE model for marginal effect estimation

This table presents the marginal effect of the *MDR* on *FirmValue*, which is the mean derivative of $m(MDR)$ in each regime estimated by the NFE model: $FV_{it} = \alpha_i + m(MDR_{i,t-1}) + \varepsilon_{it}$. The Gaussian kernel function is used in this study, and the results derived using other kernel functions, namely Triangular, Quartic, Epanechnikov, and Triweight functions, are also robust. The optimal band width is 0.15, as determined by the minimum value of the cross-validation function.

0 ≤ MDR < 0.05	0.4872
0.05 ≤ MDR < 0.1	0.3688
0.01 ≤ MDR < 0.15	0.2370
0.15 ≤ MDR < 0.2	0.0742
0.2 ≤ MDR < 0.25	- 0.1130
0.25 ≤ MDR < 0.3	-0.3062
0.3 ≤ MDR < 0.35	-0.4821
0.35 ≤ MDR < 0.4	-0.6024
0.4 ≤ MDR < 0.45	-0.6504
0.45 ≤ MDR < 0.5	-0.6295
0.5 ≤ MDR < 0.55	-0.5619
0.55 ≤ MDR < 0.6	-0.4511
0.6 ≤ MDR < 0.65	-0.3298
0.65 ≤ MDR < 0.7	-0.1878
0.7 ≤ MDR < 0.75	-0.0479
0.75 ≤ MDR < 0.8	0.1371
0.8 ≤ MDR < 0.85	0.3630

Table 2 (cont.). NFE model for marginal effect estimation

0.85 ≤ MDR < 0.9	0.5553
0.9 ≤ MDR < 0.95	0.7922
0.95 ≤ MDR	0.9184

3.2. Semi-parametric estimation. The NFE estimation provided in the preceding section supports trade-off theory. However, the NFE model still has shortcomings, in that it does not consider the effect of other control variables, which may engender the problem of model misspecification. Therefore, we estimate the SFE model presented in Equation (5):

$$FV_{i,t} = \alpha_i + m\left(MDR_{i,t-1}\right) + X'_{i,t-1}\beta + \varepsilon_{i,t},$$
$$i = 1,...,N, t = 1,...,T,$$

where the definitions of all variables are the same as those in Equation (1), except for the additional control variable function $X'_{i,t-1}$, which is used to control other firm characteristics including profitability (*EBIT*); the ratio of depreciation to total assets (*Dep*); the fixed asset proportion (*FA*); dummy variable for R&D expenses (*R&D_DM*); the ratio of R&D expenses to total assets (*R&D_Ratio*); financial deficit (*Findep*); and the ratio of market to book ratio of assets (*M/B*).

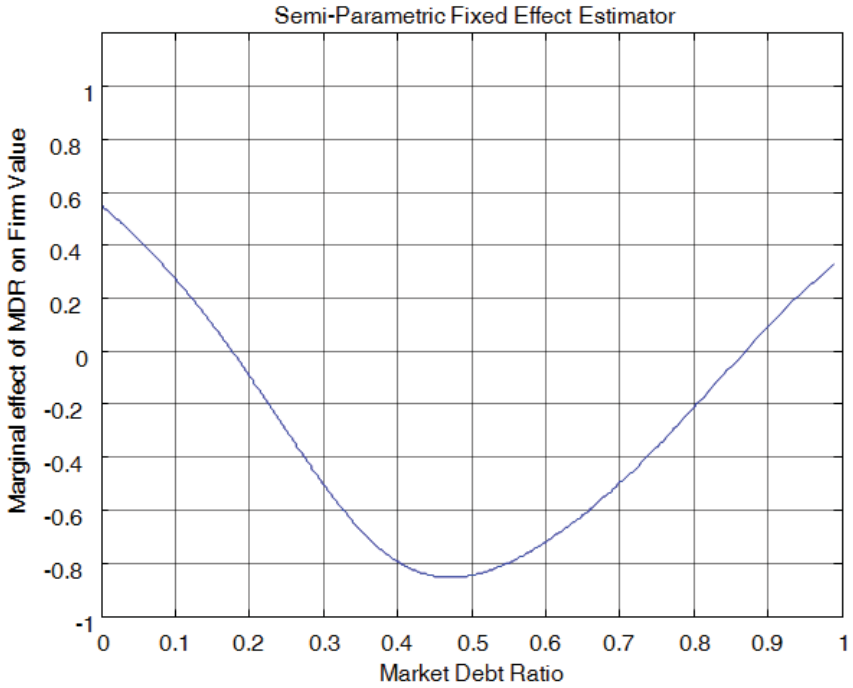

Fig. 3. Marginal effectof the *MDR* on *FirmValue*, as determined from the SFE model

We also adopt apply the Gaussian kernel function here and it is robust to use other kernel functions. The optimal band width determined through the cross-validation function is 0.15[6]. Figure 3 presents the marginal effect of the *MDR* on *FirmValue*, and Table 3 presents an analysis of the marginal effect in each regime. This figure and table indicate that even if other firm characteristics are controlled for, identical results to those in Figure 2 and Table 2 can still be derived, thus, again, supporting trade-off theory. Table 4 also presents the empirical results derived for the control variables in the SFE model, which are the components of partial linear estimation. The results reveal that most of these control variables are significant at 5%, indicating the necessity of controlling them. Overall, the empirical results of the SFE estimation again demonstrate that trade-off theory is supported.

[6] For brevity, we do not show the figures of the cross-validation function for the SFE model in this paper, and the figures will be provided upon request.

Table 3. SFE model for marginal effect estimation

This table presents the marginal effect of *MDR* on *FirmValue*, which is the mean derivative of m(*MDR*) in each regime as estimated by the NFE model: $FV_{i,t} = \alpha_i + m\left(MDR_{i,t-1}\right) + X'_{i,t-1}\beta + \varepsilon_{i,t}$. $X'_{i,t-1}$ represents the control variables including profitability (*EBIT*); the ratio of depreciation to total assets (*Dep*); the fixed asset proportion (*FA*); dummy variable for R&D expenses (*R&D_DM*); the ratio of R&D expenses to total assets (*R&D_Ratio*); financial deficit (*Findep*); and the ratio of market to book ratio of assets (*M/B*). The Gaussian kernel function is used in this study, and we also adopt other kernel functions, namely Triangular, Quartic, Epanechnikov, and Triweight functions, and yield identical results. The optimal band width is 0.15, as determined from the estimation of the cross-validation function.

0 ≤ MDR < 0.05	0.4075
0.05 ≤ MDR < 0.1	0.2520
0.01 ≤ MDR < 0.15	0.1026
0.15 ≤ MDR < 0.2	-0.0591
0.2 ≤ MDR < 0.25	-0.2247
0.25 ≤ MDR < 0.3	-0.3803
0.3 ≤ MDR < 0.35	-0.5150

Table 3 (cont.). SFE model for marginal effect estimation

0.35 ≤ MDR < 0.4	-0.6097
0.4 ≤ MDR < 0.45	-0.6594
0.45 ≤ MDR < 0.5	-0.6686
0.5 ≤ MDR < 0.55	-0.6458
0.55 ≤ MDR < 0.6	-0.5930
0.6 ≤ MDR < 0.65	-0.5244
0.65 ≤ MDR < 0.7	-0.4355
0.7 ≤ MDR < 0.75	-0.3426
0.75 ≤ MDR < 0.8	-0.2164
0.8 ≤ MDR < 0.85	-0.0609
0.85 ≤ MDR < 0.9	0.0709
0.9 ≤ MDR < 0.95	0.2315
0.95 ≤ MDR	0.3157

Table 4. Section of partial linear estimation in the SFE model

This table presents the regression estimates of a section of those control variables (i.e., partially linear estimates), including profitability (*EBIT*); the ratio of depreciation to total assets (*Dep*); the ratio of property, plant, and equipment to total assets to measure fixed asset proportion (*FA*); dummy variable for R&D expenses (*R&D_DM*); the ratio of R&D expenses to total assets (*R&D_Ratio*); financial deficit (*Findep*); and the ratio of market to book ratio of assets (*M/B*). The Gaussian kernel function[7] is used in this study, and optimal band width is 0.15, as determined from the cross-validation function. Significance levels are indicated as follows: * is 10%, ** is 5%, *** is 1%.

	Estimates	t-statistics
EBIT	0.3121	(1.3359)
Dep	-1.0411	(-0.5081)
FA	1.6918***	(7.9494)
Findep	-1.7218***	(-3.5368)
R&D_Dum	-0.5404***	(-6.5159)
R&D_Ratio	-5.2779**	(-2.2190)
M/B	0.1193**	(2.0777)

3.3. Robustness checks. To obtain robust inferences about the capital structure determinants, we perform two types of robustness checks. First, we follow the procedure of Flannery and Rangan (2006), who provide five definitions of the variable of debt ratio (*MDR*, MDR_a, MDR_b, MDR_c, and *BDR*) to reestimate the NFE and SFE models. Second, we also apply other kernel functions in our model, namely Triangular, Quartic, Epanechnikov, and Triweight functions. All of these functions still yield identical results, demonstrating the robustness of our findings[8].

Conclusions

Previous studies involve two notable but mixed theories of capital structure: pecking-order theory and trade-off theory. Pecking-order theory indicates that the choice between debt financing and equity financing is in the following order: initially, using retained earnings for internal funding; then, executing external funding, involving early debt financing; and finally equity financing. This implies that no optimal debt ratio is available. Trade-off theory posits that firms should have their own optimal debt ratio to balance the benefits and costs of debt financing; therefore, debt financing and firm value should exhibit a nonlinear or asymmetric relationship. Using only the traditional linear parametric model to test this issue may lead to the imposition of incorrect functional forms regarding the real relationship between debt ratio and firm value, thus, engendering the problem of model misspecification. Hence, to determine this complex relationship correctly, we apply the NFE and SFE models, which obviate the necessity of imposing specific functional forms and, thus, avoid the problem of model misspecification. Our empirical results reveal that the relationship between the *MDR* and *FirmValue* is positive (negative) when the *MDR* is low (high), which implicitly involves an optimal debt ratio. We also use various definitions of debt ratio and kernel functions and obtain robust results. Overall, our study findings support trade-off theory. We suggest that firm managers simultaneously consider both the benefits and costs of debt financing appropriately to adjust toward their firms' optimal debt ratio.

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[7] We apply other kernel functions, namely Triangular, Quartic, Epanechnikov, and Triweight, which yield identical results.
[8] For brevity, we do not report these results here and they will be provided upon request.

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Appendix

Table A1. Variables definition

Variable	Definition
MDR	Market Debt Ratio = book value of short-term and long-term debt / market value of assets
BDR	Book Debt Ratio = (long-term + short-term debt) / total assets
MDR_a	(long term debt + short term debt) / (total assets – book equity + market equity)

Table A1 (cont.). Variables definition

Variable	Definition
MDR_b	(total liabilities) / (total liabilities + market equity)
MDR_c	(long term debt) / (total assets – current liabilities – book equity + market equity)
FrmValue	The natural log of total firm value
EBIT	Profitability: earnings before interest and taxes / total assets
DEP	Depreciation / total assets
FA	Fixed Asset proportion: property, plant, and equipment / total assets
R&D_DM	Dummy variable is 1 if firm did not report R&D expenses
R&D_Ratio	R&D expenses / total assets
FINDEP	"financial deficit" variable constructed as per, used to test the pecking order hypothesis, which represents dividend payments + investments + change in working capital – internal cashflow
MB	Market to Book ratio of Assets: (book liabilities + market value of equity) / book value of total assets